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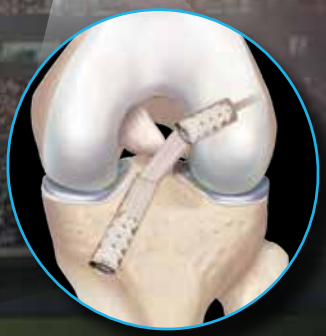

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Volume 5, May 2019

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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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References: 1. McGrath AF, McGrath AM, Jessop ZM, et al. A comparison of intra-articular hyaluronic acid competitors in the treatment of mild to moderate knee osteoarthritis. *J Arthritis*. 2013;2(1):108. doi:10.4172/2167-7921.1000108. **2.** Leighton R, Åkermark C, Therrien R, et. al. NASHA hyaluronic acid vs methylprednisolone for knee osteoarthritis: a prospective, multi-centre, randomized, non-inferiority trial. *Osteoarthritis Cartilage*. 2014;22(1):17-25. **3.** Zhang H, Zhang K, Zhang X, et al. Comparison of two hyaluronic acid formulations for safety and efficacy (CHASE) study in knee osteoarthritis: a multicenter, randomized, double-blind, 26-week non-inferiority trial comparing Durolane to *Artz. Arthritis Res Ther*. 2015;17:51. doi: 10.1186/s13075-015-0557-x. **4.** DUROLANE [package insert]. Durham, NC: Bioventus LLC; 2017.

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Letter from the Editor-in-Chief

S. Terry Canale, M.D.

Department Chair, Emeritus
UT-Campbell Clinic Department of Orthopaedic Surgery and Biomedical Engineering
University of Tennessee Health Science Center

May, 2019

Dear Colleagues,

I am honored to present the 5th volume of the Campbell Orthopaedic Journal (COJ). It is the result of a great deal of collaborative work, and several of the abstracts in these pages describe results of interim projects that are part of a larger body of clinical investigations.

As I reflect on these findings, I think back to early in my career when I had a fierce drive to "find better answers." I had the energy, drive, and naiveté reserved for someone new to the practice of orthopaedic surgery, before I had learned the old adage, "Nothing spoils good results like long term follow-up." Nevertheless, I was curious and determined and I started a lot of research projects. Even finished some of them. Learned some things. As one of my mentors, Fred Sage, MD, often said to me, "Canale you may be often wrong but you're never in doubt."

As I gained experience and patient volume, it became difficult to find time for research – data mining, analysis, reflection, and manuscript writing. Perhaps that's the way it goes – seasons of life and all that, but I enjoy seeing energetic surgeons in pursuit of a new discovery. I have great respect for the work that underlies even less significant research findings.

I also reflected on the research process - the way research projects begin. For clinical research at least, there often is either an anecdotal observation – "in my last several patients" – a finding that differs from earlier experience. This difference can be better – "these patients are getting better outcomes," or, sometimes worse, as in, "Hmmmm. Wonder why these last three patients struggled more than my earlier ones." This forms the basis of the research question and allows us to form our hypothesis. And, so we begin.

Study design is very important to ensure that we find the answers to the questions we pose. In a prospective study, researchers must carefully isolate the variables in order to study the hypothesis and work to determine causality. As one seasoned clinician scientist once told me, "Folks who carry matches in their pocket may be shown to have a higher incidence of lung cancer, but the savvy researcher knows that the matches are not the causal factor – rather, the behavior that drives the need for matches – smoking – is the culprit."

Thus, it occurs to me that orthopaedic clinical practice and orthopaedic clinical research are in some ways diametrically opposed. In our practice, we learn to assess all inputs of the situation – the patient's health history, the description of their symptoms and their onset, the images (X-rays, MRIs, etc.) and any other inputs that we may have. We then begin to problem-solve. If the clinical condition is one requiring surgical intervention, we approach the surgery with a great deal of thought and planning. However, at times, in the operating room, things don't go as we planned, in which case our training kicks in and we "do what it takes to solve the problem," using every tool in our kit. Our objective is to relieve the patient's pain, restore their function, and allow a return to activities of daily living – doing whatever it takes. Even for patients who present with very similar cases, health history, and images, the surgical intervention and post-operative recommendations may vary.

So, the prospective research approach - to "eliminate the variables" – goes completely against our training as orthopaedic surgeons. We may understand it intellectually, but our training, experience, and habits kick in and we divert from the protocol. This causes our results then to be murky. Conclusions we had hoped to draw can't be drawn.

This may be one of the reasons why clinicians often find research to be so challenging. It doesn't feel natural, and it is hard and time-consuming and tedious. However, it is so important. Only through diligent research can we hope to find better solutions to challenging clinical issues.

I encourage you to stay curious and pursue answers, even if it goes against everything you've been taught. While good results may lessen as follow-up lengthens, so too will success be gained with more experience. In research and in life.

As you enjoy the 2019 edition, I hope that you are inspired to pursue that nagging question you have, and to find others to join you in the pursuit. You will be better for the experience, and patients everywhere will benefit.

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

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

The UT-Campbell Clinic Department of Orthopaedic Surgery and Biomedical Engineering is committed to significant improvements in musculoskeletal health through the dedicated efforts of devoted faculty, researchers and scientists, and health care providers devoted to the pursuit of new discoveries. 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 2018 – 2019 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 127 scientific articles published in peer-reviewed publications, along with 68 podium presentations, and 21 posters highlighting our research presented at national and international meetings last year. We are expanding our participation in higher order Level 1 and Level 2 clinical trials, with randomization, to truly provide comparative evidence of therapeutic treatments. There is considerable breadth and variety in our work, examining the safety and efficacy of surgical procedures performed in an outpatient surgical setting, alternative methods of pain management (particularly timely in light of the opioid epidemic in the United States), and results with a number of operative interventions to build an impressive array of clinical evidence. Our work crosses all orthopaedic subspecialties in patients of all ages and races, and both genders. Notably, we have doubled our industry- and government-sponsored clinical research studies and grants over the prior year.

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

trained six clinical fellows this year, and have had one additional spine research fellow working with the team for much of this year on an interesting project funded by the Scoliosis Research Society that examines the orthopaedic impacts – particularly related to the spine – among long-term pediatric cancer survivors who had major surgical interventions related to chest wall or spinal tumors. This work, which is perhaps only available to us due to the geographic nexus of the Campbell Clinic and St. Jude Children's Research Hospital, a world-renowned pediatric oncology center, explores the 'natural' history of spinal pathology among patients who have undergone major surgery for pathological childhood cancers. The results of this work will be presented at this year's annual meeting of the Scoliosis Research Society.

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. Since 2014, we have sustained a Visiting Professor Lecture Series, funded with donor support. This important series, which is open to area orthopaedic surgeons, nurses, physicians assistants, engineers and researchers, allows us to supplement the educational experience since it 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 are hard at work on the latest (14th) edition of Campbell's Operative Orthopaedics, to be published in early 2020. The prior edition remains the leading orthopaedic textbook in the world, with worldwide sales in the first year that surpassed sales of all prior editions.

The department continues to make strong progress in education, research and innovation. This past March, we matched residents for the Class of 2024, our 101st. As we move into the 2nd century of our residency training program, we believe that 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

Since our organization was founded in 1909, the physicians at Campbell Clinic have worked to build upon the success of those who came before them for the betterment of our patients.

In 2019, we continue to build and expand our brand as a leader in orthopaedic medicine and research. It is not often this type of growth manifests itself literally before our eyes, but that is the case this year as we construct our new outpatient center in Germantown, Tennessee.

This state-of-the-art facility will cover four stories and 120,000 square feet and represents the next phase of expansion for Campbell Clinic. We designed this new center with future patients, staff and residents in mind. Not only will it be a world-class structure when it opens this fall – it's also the beginning of a new chapter for the clinic – a legacy for which we can all be very proud.

The new outpatient center will be a destination for musculoskeletal care around our region, and it will serve as a training ground for future orthopaedic surgeons who will shape our specialty worldwide for generations to come.

Located on five adjacent acres behind our existing Germantown clinic, the new facility will house a sports performance and wellness center, an expanded physical therapy floor, an outpatient clinic and an eight-suite ambulatory surgery center where our physicians will continue to perform innovative procedures ranging from joint replacement to minimally-invasive spine surgery to regenerative therapy.

On the research front, our staff continues to seek answers to challenging clinical issues. Over the past several months, we have examined new ways to help mitigate surgical patients' post-operative pain while greatly decreasing their dependence on the use of opioids. Over the last year, we have conducted prospective studies on innovative interventions such as cryoneurolysis, perioperative measures such as liposomal bupivacaine, and cold therapy. Preliminary results show that decreasing post-surgical pain is possible without opioids, and we are determined to be part of the solution to the U.S. opioid crisis.

In addition, we are working on several projects exploring novel regenerative medicine therapies to help patients battle the ravages of osteoarthritis by leveraging their bodies' ability to heal. The early results are most encouraging here, also. We continue to build on our earlier work defining the effects of patient factors on outcomes. This enables us to develop predictive models that are proving extremely useful in counseling with patients and managing expectations based on their unique physiology and health behaviors. We are finding this predictive ability is also useful in discussions with third party payers who seek better health for their patient groups.

We have also started offering a new alternative to thoracic and lumbar spine surgery at our ambulatory surgery centers using an endoscopic approach. Campbell Clinic is proud to be one of only 12 centers in the country offering access to this minimally invasive procedure. Additionally, our surgeons continue to expand access to outpatient total hip, knee, shoulder and ankle replacement in the ASC setting while delivering positive outcomes for patients.

We also welcomed a new physician to our staff. Dr. William J. Weller joined the Campbell Clinic family in August 2018. Dr. Weller specializes in orthopaedic surgery of the hand, wrist, elbow and shoulder. Dr. Weller is no stranger to Memphis, having completed his residency at the Campbell Clinic-UT Department of Orthopaedic Surgery in 2017. He then completed a one-year fellowship at the Indiana Hand to Shoulder Center.

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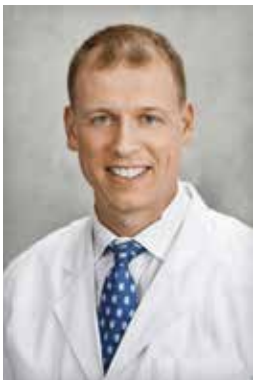
State of the Residency

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 575 orthopaedic surgeons have trained at our institution and our graduates include 7 presidents of the American Academy of Orthopaedic Surgeons (AAOS), 7 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 preparing its 14th 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 each orthopaedic subspecialty, 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 150 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 remain committed to sharing our research at regional, national, and international meetings, and in academic and scientific publications. In short, orthopaedic research has never been stronger at the Campbell Clinic.

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, Uganda, and the Dominican Republic. In this way, we imbue a commitment to community service within our residents.

This year, we will celebrate the graduation of our 95th residency class, whose members are profiled within this publication. We are very proud of these eight orthopaedic surgeons. 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 2024 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.


Alvin J. Ingram, MD

Dedicated Lectureship Series:

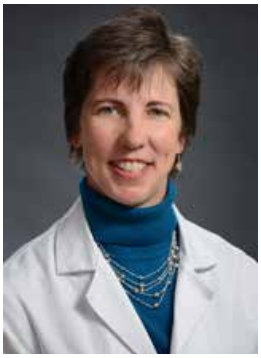
Alvin J. Ingram, MD Memorial Lecture

Each year, the Campbell Foundation proudly hosts 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. At this event, we also highlight prior scientific posters 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.

2018 Alvin J. Ingram, MD Memorial Lecture • May 18, 2018

Distinguished Professor: Kristy L. Weber, M.D.
Professor and Vice-Chair of Faculty Affairs
Chief - Division of Orthopaedic Oncology
Abramson Family Professor in Sarcoma Excellence
University of Pennsylvania Department of Orthopaedic Surgery
Director - Sarcoma Program at the Abramson Cancer Center
Philadelphia, Pennsylvania


Kristy L. Weber, MD

Kristy L. Weber, MD, is an attending surgeon with the Cancer Center and Division of Orthopaedics at Children's Hospital of Philadelphia (CHOP). She specializes in treating children, adolescents and adults with bone and soft tissue tumors.

Along with her work at CHOP, Dr. Weber is the Abramson Family Professor in Sarcoma Excellence in the Department of Orthopaedic Surgery at the University of Pennsylvania. She was recruited to Penn in 2013 to serve as Vice-chair of Faculty Affairs in the Department of Orthopaedic Surgery and Director of the Sarcoma Program in the Abramson Cancer Center.

Dr. Weber was named the first Vice President of the American Academy of Orthopaedic Surgeons (AAOS) in 2018. Now in her second year in a four-year term of volunteer service, Dr. Weber will serve as the first female president of the Academy in 2019-20.

Originally from St. Louis, MO, Dr. Weber attended college at the University of Missouri-Columbia. She earned her M.D. from Johns Hopkins School of Medicine, Baltimore, MD. Dr. Weber completed her orthopedic residency training at the University of Iowa, Iowa City, IA, and a two-year research/clinical fellowship in orthopaedic oncology at the Mayo Clinic, Rochester, MN. Dr. Weber joined the faculty at University of Texas/M.D. Anderson Cancer Center where she developed a large clinical practice in orthopedic oncology and developed a basic science research program related to osteosarcoma metastasis to lung and renal cell carcinoma metastasis to bone.

In 2003, Dr. Weber jointed the staff at Johns Hopkins as Chief of the Division of Orthopedic Oncology and director of the Sarcoma Program. She was promoted to professor in 2009. Dr. Weber received the Kappa Delta national orthopedic research award for her work at Johns Hopkins in 2006. Her laboratory was funded by private foundations, the Orthopaedic Research and Education Foundation (OREF), and the National Institutes of Health (NIH).

Dr. Weber has served on the boards of directors of many national orthopaedic and cancer organizations including the American Academy of Orthopaedic Surgeons (AAOS), American Orthopaedic Association (AOA), and the Connective Tissue Oncology Society. She spent four years as chair of the AAOS Council on Research and Quality where she oversaw initiatives related to clinical practice guidelines, evidence-based medicine, appropriate-use criteria, patient safety, biomedical engineering, biological implants and the development of orthopaedic clinician-scientists.

Currently, Dr. Weber is serving as President of the Musculoskeletal Tumor Society, vice president of the Ruth Jackson Orthopaedic Society (RJOS), and secretary-elect of the Orthopaedic Research Society.

Dr. Weber's Keynote Address will be "*AAOS: What's New and How to Get Involved,*" and she will also provide a short lecture entitled, "*Tips and Tricks for Evaluation/Treatment of Soft Tissue Masses.*"

2019 Alvin J. Ingram, MD Memorial Lecture • May 10, 2019

Distinguished Professor: Joseph A. Bosco, III, M.D.
Professor and Vice-Chair for Clinical Affairs
New York University School of Medicine
Department of Orthopaedic Surgery
Director, Quality and Patient Safety, NYU Langone Orthopaedic Hospital
New York, New York


Joseph A. Bosco, III, MD

Joseph A. Bosco, MD, is an attending surgeon at NYU Langone Medical Center in New York City. He specializes in knee and shoulder conditions, primarily sports-related injuries and total knee replacements. Along with his work at NYU Medical Center, Dr. Bosco is a Professor of Orthopaedic Surgery at the NYU School of Medicine.

Dr. Bosco was installed as the President of the American Academy of Orthopaedic Surgeons (AAOS) in 2019. Originally from Englewood, New Jersey, Dr. Bosco attended college at Union College (Schenectady, NY), and then earned his medical degree from the University of Vermont. He completed his Internship and residency in orthopaedic surgery at the University of North Carolina, Chapel Hill. Dr. Bosco completed a Fellowship in Adult Reconstructive Surgery at the University of Arizona, in Tucson, Arizona.

Dr. Bosco has served on the boards of directors of many national orthopaedic organizations including the American Academy of Orthopaedic Surgeons (AAOS), American Orthopaedic Society for Sports Medicine (AOSSM), as well as serving as the President of the Board of Directors for the Orthopaedic Learning Center (OLC) at AAOS. Dr. Bosco has also been active on the board of the New York State Society of Orthopaedic Surgeons, serving as both Treasurer and Secretary.

Dr. Bosco is an active researcher, with a focus on quality of care, treatment outcomes, health care disparities, and patient safety, particularly with regard to infection control. He has published more than 250 scientific peer-reviewed articles, book chapters and other important works, and has presented his research all over the world. His research earned numerous extramural grants, and he holds four patents for knee replacement implants.

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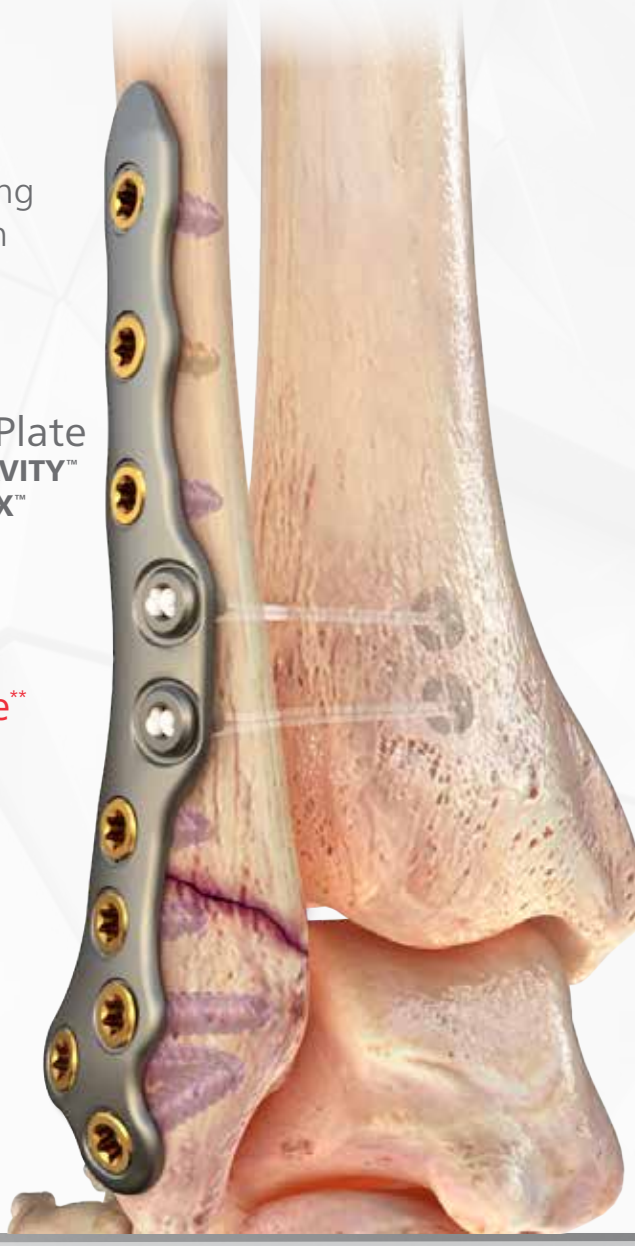

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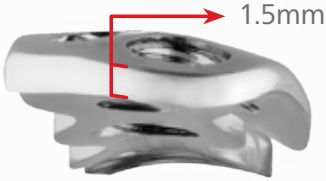

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Dedicated Lectureship Series:

The James H. Beaty, MD Visiting Professorship in Pediatric Orthopaedics

Sponsored by the Pediatric Orthopaedic Faculty of Campbell Clinic, with support from alumni and friends, the James H. Beaty, MD Visiting Professorship in Pediatric Orthopaedics was established to honor the lifetime contributions of James H. Beaty, MD, Chairman of the UT-Campbell Clinic Department of Orthopaedic Surgery, former Chief of Staff of Campbell Clinic, and Past President of the Pediatric Orthopaedic Society of North American and the American Academy of Orthopaedic Surgeons.

It has been a tradition for the Pediatric Orthopaedic Faculty of Campbell Clinic to bring a prominent Visiting Professor (such as the President of the Pediatric Orthopaedic Society of North America (POSNA)) to Memphis each year for an annual Lecture and extended Case Discussions. Since 2014, POSNA Presidents Peter Waters, MD, Lori Karol, MD, James McCarthy, MD, and Richard Schwend, MD have come to Memphis as Visiting Professors.

In 2019, this educational professorship was officially endowed and named in honor of Dr. James H. Beaty. The 2019 James H. Beaty Visiting Professor was Dr. Steven L. Frick, President of POSNA, and Professor of Orthopaedics at Stanford University. Dr. Frick began the Professorship with a fantastic interview of Dr. Beaty, which was done in the style of "Inside the Actors Studio." Dr. Beaty's family was able to be present for this important occasion.

The day progressed to include Dr. Frick's Keynote, *"Decision Making in Developmental Dysplasia of the Hip,"* during which he included pearls and pitfalls from his experience caring for children with DDH. Following the Keynote address, Campbell Foundation residents presented cases and Dr. Frick "Turned the Tables" with additional Case Presentations to test the residents' knowledge. It was a fantastic day of academic exchange, and a fitting way to honor a legend in the field of pediatric orthopaedics.

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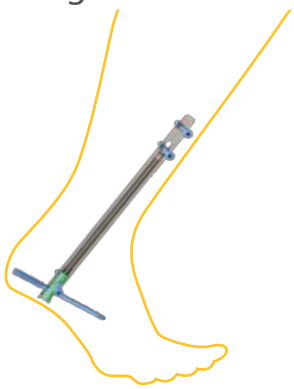

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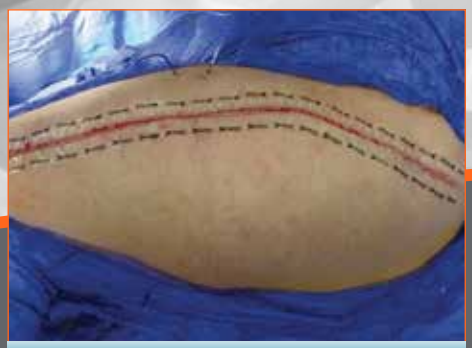

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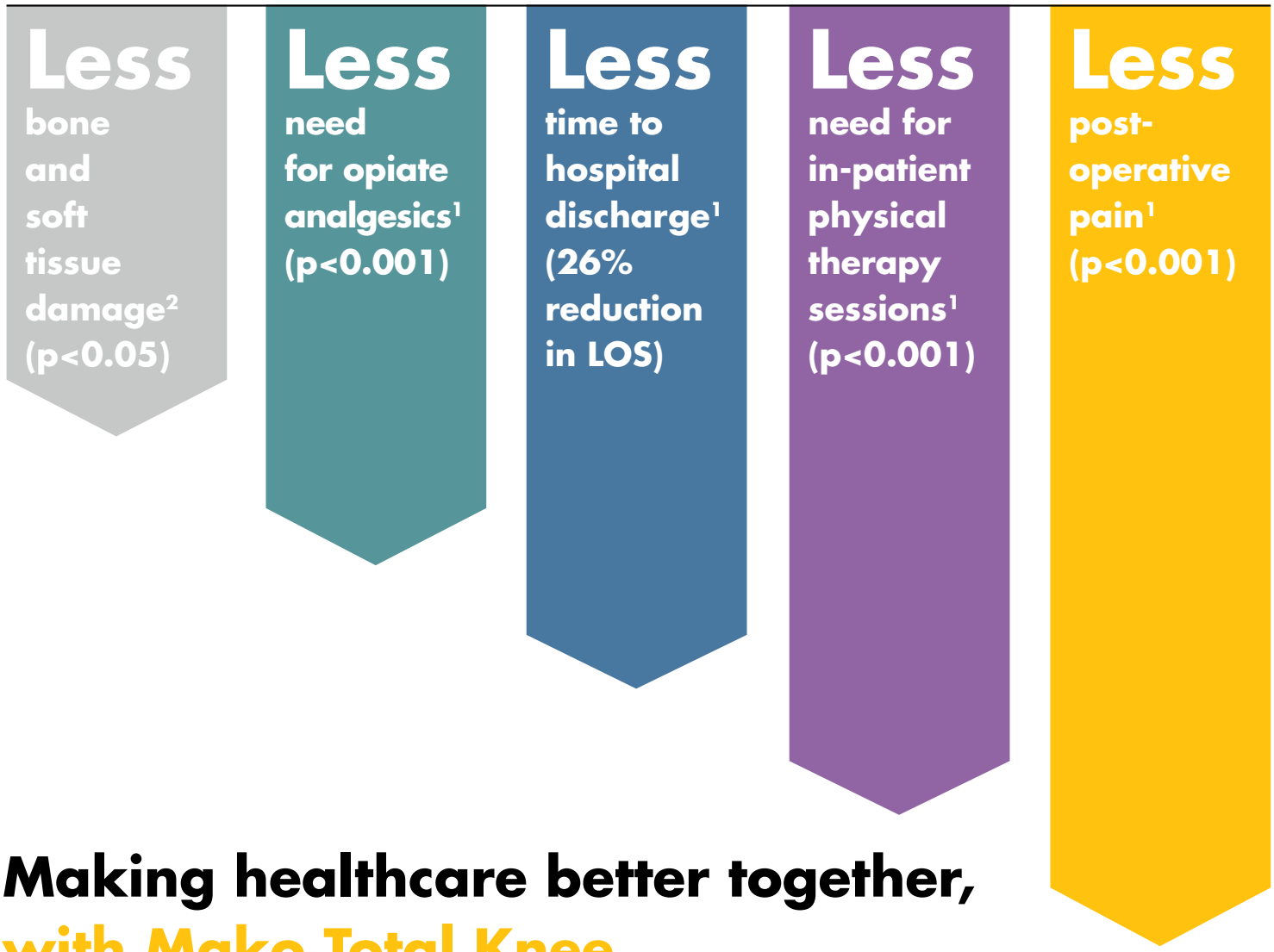

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Professor Fares S. Haddad is a consultant of Stryker. However, Dr. Haddad and the authors of these publications did not receive financial or in-kind compensation for the research or publications.

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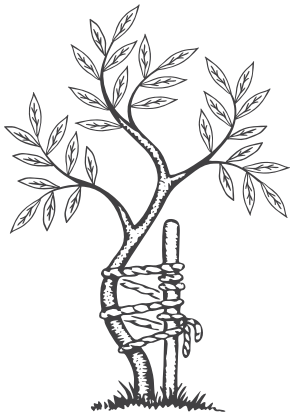

CLASS OF 2019 RESIDENT RESEARCH

Accessibility and Availability of Online Information for Orthopedic Surgery Residency Programs*

ABSTRACT

Background: Prospective orthopedic residency applicants commonly use one of three databases to identify potential programs: Accreditation Council of Graduate Medical Education (ACGME), American Medical Association (FREIDA), or Orthogate. org. In addition, institutional websites are typically the primary source of information once programs are identified. We sought to evaluate the databases and websites used by prospective orthopedic surgery applicants for content and accessibility. We hypothesized that information would be more available in comparison to previous studies but would still fail to provide complete, up to date program information for the prospective applicant.

Methods: Three online databases were queried in December 2014 to compile a list of orthopedic residency programs in the United States. This combined list was used as a basis for evaluating individual institution websites. Previously described criteria were used to evaluate the availability of information contained within orthopedic surgery residency websites.

Results: At the time of online review, 157 programs were identified. Depending on the database in question, up to 33% of programs either did not provide a link or listed a non-functioning link. Among the variety of evaluated criteria, inclusion of the information varied between 12% and 97% for the individual program websites.

Conclusions: Online databases are useful in listing programs, but individual program details and direct functional links are lacking. Most program websites contain varying degrees of desired information; however, not all programs maintain websites which consistently provide information to satisfy the evaluated criteria in this study. Improved online accessibility and availability of information for residency programs would increase their visibility and utility for prospective applicants.

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INTRODUCTION

Each year, more medical students apply for orthopedic residency. With this increase in number of applicants, the competition for a position continues to increase as well, making it one of the most competitive specialties.[1] With these trends, the importance of maintaining an informative and accessible website continues to grow. The importance of web-based information has been evaluated for multiple orthopedic fellowships[2-4] as well as various other surgical residencies.[5-7] Rozental et al. performed a similar study for orthopedic residencies in 2001.[8] Their study revealed at that time many academic orthopedic departments underutilized the Internet with subpar websites or lack of an Internet presence. Although the Internet has been established as a useful communication tool for quite some time, utilization has significantly increased since 2001.[9] Increased utilization brings more up-to-date and accurate information, however not all academic departments take advantage of this useful communication tool.[2-7]

Medical students frequently rely on online databases to identify available residency programs. Three commonly

* This article is reprinted with permission from the Iowa Orthopaedic Journal and the University of Iowa Hospitals and Clinics. Davidson AR, Loftis DM, Throckmorton TW, Kelly DM: Accessibility and availability of online information for orthopedic surgery residence programs, Iowa Orthop J. 2016; 36:31-36.

used databases are maintained by the Accreditation Council of Graduate Medical Education (ACGME),[10] American Medical Association (Fellowship and Residency Electronic Interactive Database-FREIDA),[11] and the open-source website Orthogate (http://www.orthogate.org).[12] The purpose of this study was to determine the availability and accessibility of information on orthopedic residency programs obtainable through the three databases. We analyzed the information available on various program websites through the links provided by the three databases and from the results provided by a Google search. In addition, previous research by Rozental et al. allowed a comparison to gauge the improvement in several key categories over the past decade. We hypothesized that the ease of accessing individual program websites from databases and discovering relevant program information contained within independent residency websites does not fully meet the needs of current orthopedic surgery applicants.

METHODS

Identification of orthopedic residency programs in the United States was accomplished with the use of the ACGME database, the AMA's FREIDA online database, and Orthogate's online database.[10-12] The database search only included allopathic orthopedic residencies, as there is not currently a combined process for osteopathic and allopathic residencies. The three databases were queried between December 21 and 23, 2014. Each database was assessed for availability and functionality of website links to each program by placing them in one of five categories: no link provided, a non-functional link, a link to the sponsoring institution requiring multiple clicks to navigate to the residency website, a link to the orthopedic department requiring multiple clicks to navigate to the residency website, and a link which led directly to the residency website. The databases were also evaluated for congruency of information, including programs listed, program director, and contact information.

A Google search (Mountain View, CA, USA)[13] was also performed to evaluate website accessibility for each program as an alternative to searching the three online databases. Google was selected because it is the most popular search engine worldwide.[14] A search was performed for each program using the phrase "program name + orthopedic surgery residency." Each search evaluated the first page of results (first 10 listings) for direct links to the residency program website.

Each orthopedic residency program's website was then evaluated for content using previously described areas of interest[2-4] with examination of resident education details, resident recruitment details, and contact information. In addition to criteria described in similar papers, a study by Deloney et al, which performed a survey of radiology interviewees at a single institution, was used to compile a list of relevant details. The Deloney et al study characterized details as necessary, desirable, or superfluous.[15] Resident education details included rotation schedule, didactic schedule, conference descriptions, research curriculum, and call schedules. Resident recruitment details included program description or director's letter, application requirements, faculty education, current residents, resident education information, career placement, and salary. Results were then analyzed as a proportion of programs containing the information compared to previous studies.

RESULTS

Database Information

The three databases revealed a varying number of total programs – 156 programs were listed in the ACGME database, 157 programs were listed in the FREIDA database, and 153 programs were listed in the Orthogate database. The databases provided either no link or a link that was non-functioning in 12% (FREIDA), 21% (ACGME), and 33% (Orthogate) of the program listings. A majority of programs provided a functioning link that, at a minimum, directed the user to an institutional website. A direct link to the unique residency website was provided by a small percentage of programs: ACGME listed 24 (15%), FREIDA listed 34 (22%), and Orthogate listed 26 (16%) **(Table I)**.

Database	Programs	No Link	Non-functioning	Institution	Department	Residency
ACGME	156	4 (3%)	28 (18%)	41 (26%)	60 (38%)	24 (15%)
FREIDA	157	9 (6%)	9 (6%)	43 (27%)	62 (39%)	34 (22%)
Orthogate	153	13 (9%)	37 (24%)	28 (18%)	49 (32%)	26 (17%)

Table I: Evaluation of Links Provided by Databases

Combining the search results of the three databases, 157 unique orthopedic residency programs were identified, including 149 civilian programs and 8 military programs. This combined list served as the basis for evaluation of institutional websites. All programs were found using a Google search that included "program name + orthopedic surgery residency."

Most of the contact information, including phone number, email, name of the program director, was congruent across the ACGME and FREIDA databases. Orthogate did not provide any contact information. However, 64 (41%) programs had different email addresses and 36 (23%) programs had different phone numbers listed in comparing the ACGME and FREIDA databases.

Resident Education

With respect to resident education, most programs included the evaluated criteria. A rotation schedule was provided by 118 (75%) programs. The majority of programs included information detailing their didactic schedules, research requirements, and meetings or courses attended by the residents. However, only a small number of programs presented information describing the resident call schedule **(Table II)**.

Education (n = 157)	No. (%)
Didactic Schedule	106 (67%)
Rotation Schedule	118 (75%)
Research Curriculum	93 (59%)
Conference Descriptions	94 (60%)
Call Schedules	19 (12%)

Table II: Number (%) of websites with information pertaining to resident education

Resident Recruitment

In regards to resident recruitment, the majority of programs covered the evaluated criteria. Nearly all programs provided a description of the program. A list of current residents could be found on the websites of 129 (82%) programs while only 109 (69%) provided detailed educational background for those residents. Career placement was supplied by half of the programs **(Table III)**.

Contact Information

Although contact information was listed for all 157 programs, the type of this information varied among programs. Eighty-one of the programs (52%) provided a telephone number and/or email for both the program director and residency coordinator, 70 (45%) listed information for only the coordinator, and 6 (3%) had only the director's information available.

Recruitment (n = 157)	No. (%)
Program Description	153 (97%)
Application Requirements	129 (82%)
Current Residents	129 (82%)
Resident Education Information	109 (69%)
Alumni Career Placement	79 (50%)
Faculty Education Information	109 (69%)
Salary	55 (35%)

Table III: Number (%) of programs with information pertaining to recruitment

DISCUSSION

When researching residency programs, medical students typically begin with a search of available programs using one of the publicly available databases and then progressing to evaluation of individual programs. Multiple studies have examined the quality of information available for various surgical sub-specialties and orthopedic fellowships.[2-7] In a comprehensive review of orthopedic programs in 2001[8], Rozental et al. found that most orthopedic programs underutilize the Internet as a tool for dissemination of information.

Our current research reveals improvement in utilization, both in accessibility and content, although room for improvement continues to exist. It appears academic departments are realizing the importance of an Internet presence in reaching potential applicants. Having multiple steps needed to access the website and out of date information reflects poorly on the individual program. Orthopedic residency websites compare favorably to websites for orthopedic fellowships; the shared criteria reveal similar proportions of inclusion.[2-4] This does not serve as surprise as many of the same individuals are responsible for both residency and fellowship websites. Expanding the comparison to other surgical specialties shows similar proportions as well.[6-7]

In 2014, seventy students applying to a radiology residency returned a survey prepared by Deloney et al.[15] More than half agreed with a long list of elements necessary for a residency website (many of the same elements evaluated by this project), with another 30% to 40% responding that those elements were desirable. They

suggested that websites are an important recruiting tool, maintaining them with current information is important to the recruitment process, and site navigation needs to be intuitive and efficient. A survey of orthopedic residency applicants would serve as an important future research avenue to more effectively determine what matters most to students pursuing a position in orthopedics.

Evaluation of the three available databases highlighted programs that did not provide a direct link to the residency homepage - 12% (FREIDA), 21% (ACGME), and 33% (Orthogate) of programs. . Although the lack of functioning links is not necessarily reflective of the program, as the databases are maintained by the AMA, ACGME, or are open-sourced, it does reflect a shortcoming in providing ease of access for applicants. Additionally, the FREIDA database included one extra program not listed by ACGME; the reason for this remains unclear. Concerning database congruency, most programs had the same information provided. Although many of the numbers and addresses appear to be similar (e.g. likely would reach someone within the orthopedic department), the discrepancy makes contacting the program involve unnecessary additional steps.

Since Rozental et al.[8] published their findings, the importance of having a useful web presence has increased significantly. As expected, each of the shared criteria between our studies shows an increased percentage of programs publishing the desired information. The improvement is likely tied to both an increased awareness of shortcomings as well as more individuals with a clearer understanding of the Internet's importance with today's students. Importantly, in 2001, only 73% of orthopedic programs maintained websites while in 2014, all orthopedic programs were noted to have a website. The elements demonstrating the largest increases between the 2001 study and ours are contact information listed, 43% to 100%; rotation schedules, 21% to 75%; current resident listing, 45% to 82%; and career placement of alumni, 12% to 50%. These numbers reflect critical improvement in providing a clear description of what the program has to offer.

Many of the orthopedic programs provided information in the areas evaluated in this study. In only two areas did fewer than half of the programs report the desired information – call schedule (12%) and salary details (35%). Also of note, 79 (50%) programs included information concerning career placement of their alumni. This information provides an opportunity for the program to showcase the success of previous graduates and allows the applicant insight into post-residency opportunities based on these trends. Another criterion to note was the medical school attended by current residents; 69% of programs reported this information. This information could potentially be important to prospective applicants, as the educational background highlights connections between prospective applicants and current residents. Previous studies have not included this criterion, however this information serves as an important tool in networking.

This study has several limitations. Although multiple publications have arrived at a consensus concerning important criteria in the application process, individual investigators determine these elements. A survey of residents, applicants, and interested medical students would be beneficial in directing future studies as to which criteria are truly important. In addition, the determination of whether the information was included in the website was a binary decision – there was no consideration as to the varying degrees of quality of information. Also, some programs maintain more than one website as they are affiliated with multiple entities. We only evaluated the top result on Google and did not continue to search for additional websites. Another important understanding is that many programs do not have direct control in updating their pages; as most academic centers have a central website, changes must go through other departments prior to publication. Most importantly, we realize that the Internet is a dynamic entity. These websites were evaluated in December 2014, and programs could have added or subtracted information, which may change the reported results.

In conclusion, orthopedic residency programs can evaluate their improvement in disseminating information based off two studies separated by thirteen years. The overall trend shows improved utilization of the Internet; however, there are still areas in which individual programs can increase their appeal to applicants. Ensuring that information is up to date on the centralized data-bases is one avenue. More directly under the program control is the information contained on their unique website. Most programs contain varying degrees of desired information, however, not all programs maintain up to date websites consistently including the same evaluated criteria. As this information is lacking, it is difficult for the applicant to perform head to head comparisons. Residency programs would benefit from routine analysis

of their website to ensure the information is up to date and serving as a positive representation of what they have to offer to potential applicants. The Internet already has established itself as the primary source for information, and program websites serve as the initial impression for many prospective applicants.

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A Quantitative Analysis of the Effect of Glenoid Bone Volume on Baseplate Failure in Reverse Total Shoulder Arthroplasty

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ABSTRACT

INTRODUCTION: Glenoid bone loss is a common and significant deformity in patients undergoing reverse total shoulder arthroplasty (RTSA). Glenoid bone loss can lead to insufficient bone stock that makes successful implantation of glenoid baseplates difficult secondary to inadequate bony fixation. While advances in implant technology and fixation techniques have minimized routine cases of baseplate failure, patients with tenuous glenoid bone stock can still be at risk for this complication. The purpose of our study was to compare the glenoid vault volumes of patients undergoing RTSA who developed baseplate failure to those of a comparison group of RTSA patients without baseplate failure to determine if a volume threshold exists where baseplate fixation is at risk for failure.

METHODS: Four subjects (two males, two females) who underwent primary RTSA and sustained a glenoid baseplate failure were identified and comprised our failure cohort. Over the same time period, we identified ten shoulders in nine subjects (two males, seven females) who had undergone primary RTSA for the surgical indication of inflammatory arthritis an/or erosive arthritis with advanced glenoid bone loss who had not sustained a glenoid baseplate failure to comprise our non-failure cohort. We used this comparison cohort of due to the presence of erosive glenoid wear and periarticular osteopenia as compared to other potential RTSA candidates thus making a "worse case" comparison group. Nine of the thirteen subjects, including all failures, required glenoid bone grafting (humeral head autograft; 3 males and 6 females). Pre-operative shoulder computed tomography (CT) scans were imported into Mimics (Materialise, Leuven, Belgium) to measure pre-operative glenoid vault volumes. Glenoid vault volumes (cm^3) were then compared between failures and non-failures. Gender-based subgroup comparison of failure and non-failure vault volumes was also performed to assess male and female specific differences. A two-sided t-test was then performed to compare each group. Differences with $p< 0.05$ were considered statistically significant.

RESULTS: The average glenoid vault volumes were not significantly different when comparing all failures to all non-failures: average failure volume 7.64 cm^3 (range 2.06 - 13.2 cm^3, SD 5.05 cm^3), average non-failure volume 11.51 cm^3 (range 5.68 - 19.81 cm^3, SD 5.13 cm^3), p=0.226. When subjects were separated by gender, the average glenoid vault volumes were significantly different between failures and non-failures: average female failure volume 3.52 cm^3 (range 2.06 - 4.98 cm^3, SD 2.06 cm^3), average female non-failure volume 8.59 cm^3 (range 5.68 - 11.90 cm^3, SD 2.39 cm^3), p=0.031; average male failure volume 11.78 cm^3 (range 10.35 - 13.20 cm^3, SD 2.02 cm^3), average male non-failure volume 18.31 cm^3 (range 17.14 - 19.81 cm^3, SD 1.37 cm^3), p=0.021.

DISCUSSION: This study demonstrated that when performing RTSA in the presence of advanced erosive glenoid wear, a threshold of glenoid bone volume exists above which baseplates were likely to survive, and below which they were likely to fail. Specifically, failures occurred in male patients with glenoid vault volumes at or below 13.5 cm^3 and

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female patients with glenoid vault volumes at or below 5 cm^3. This suggests there may be a horizon of glenoid bone volume necessary to achieve stable fixation for RTSA baseplates in these patients. Further studies are needed to determine whether pre-operative measurement of glenoid vault volumes or the use of patient-specific components would be helpful to optimize baseplate survival in these patients.

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The Role of Computed Tomography and Magnetic Resonance Imaging in the Diagnosis of Pediatric Thoracolumbar Compression Fractures*

Background: Because of concerns about radiation exposure, some centers consider magnetic resonance imaging (MRIs) the preferred imaging modality for pediatric thoracic and/or lumbar compression fractures. The purpose of this study was to evaluate the sensitivity of computed tomography (CT) and MRI in diagnosing thoracolumbar compression fractures and the utility of MRI in their management. Methods: Retrospective review identified 52 patients aged 0 to 18 years with 191 thoracic and/or lumbar compression fractures who had both CT and MRI during the initial trauma evaluation. The decision to perform CT and/or MRI was made by the attending pediatric spine surgeon. In all cases the CT scan was performed before the MRI. All imaging studies were reviewed by a board- certified pediatric radiologist and attending pediatric spine surgeon.

Results: Only 10 patients (19%) had a single-level injury. Of 42 with multiple compression fractures, 34 (81%) had fractures in contiguous levels, and 8 had noncontiguous injuries. Comparing CT and MRI, there was complete agreement in the number and distribution of fractures in 23 patients (44%). MRI identified additional levels of fracture in 15 patients (29%); 14 (27%) had fewer levels fractured on MRI than CT. Only one patient (2%) had fractures seen on MRI after a normal CT scan. Complete correlation between CT and MRI was seen in 59% (17/29) of patients aged 11 to 18 years, compared with 26% (6/23) of patients younger than 11.

Conclusions: In pediatric patients with mild thoracic or lumbar compression fracture(s), CT scan demonstrates a high sensitivity in determining the presence or absence of a fracture compared with MRI. Although some variability exists between the 2 modalities in the exact number of spinal levels involved, the definitive treatment and outcome were not changed by the addition of MRI. The in- formation that may be obtained from an MRI must be weighed against the increased time and expense of the study, as well as the risks associated with sedation when necessary.

Level of Evidence: Level II—diagnostic study.

Key Words: thoracolumbar compression fractures, children, di- agnosis, computed tomography, magnetic resonance imaging

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Five-Year Minimum Clinical And Radiographic Outcomes Of Total Shoulder Arthroplasty Using A Hybrid Glenoid Component With A Central Porous Titanium Post*

Hypothesis/Background: To determine the effectiveness of hybrid glenoid components in reducing the frequency of glenoid component loosening, we evaluated clinical and radiographic outcomes at minimum 5-year follow-up in 45 shoulders that underwent total shoulder arthroplasty (TSA) using a system with a central porous titanium post to augment the cemented peripheral pegs.

Methods: Function and pain were evaluated with the American Shoulder and Elbow Society (ASES) score, visual analog scale (VAS), active shoulder range of motion, and strength. Postoperative radiographs were analyzed for radiolucent lines, progressive loosening, and at-risk signs.

Results: The mean ASES score improved from 40.4 to 83.7 ($p<0.0001$), the mean VAS from 5.9 to 0.8 ($p<0.0001$). Forward elevation improved from 113 to 151 degrees ($p<0.001$), internal rotation from 49 to 60 degrees ($p=0.035$), and mean external rotation from 36 to 50 degrees ($p=0.0006$). Radiographs showed glenoid component radiolucency in 29 shoulders. Radiolucencies were confined to the area under the glenoid faceplate in 6 and radiolucencies only around the central post in 13. Nine TSAs (20%) demonstrated 2 or more columns of involvement but were not judged to be at-risk. One implant (2.2%) had glenoid component failure and was revised to a hemiarthroplasty.

Conclusion: Anatomic TSA using a hybrid glenoid component with a central porous titanium post demonstrated a low rate of mechanical failure and a rate of radiolucent lines comparable to reports of all polyethylene implants. Further evaluations are needed to demonstrate the long-term durability of these implants and to determine the significance and fate of the radiolucent lines, particularly relative to the central post.

Level of evidence: IV, Case Series, Treatment Study

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Concurrent Ipsilateral Tibial Shaft and Distal Tibial Fractures in Pediatric Patients: Risk Factors, Frequency, and the Risk of Missed Diagnosis

ABSTRACT

Background: The purpose of this study was to determine the frequency of concurrent ipsilateral distal tibial fractures with tibial shaft fractures in the pediatric population; to identify patient and fracture characteristics that increase the likelihood of a concurrent fracture; and determine if any of these concurrent distal tibial fractures were missed on initial radiographic examination.

Methods: Retrospective chart review was done to identify patients 5 to 17 years old treated for a tibial shaft fracture at a large, Level 1 free-standing children's hospital and an outpatient orthopaedic practice between 2008 and 2016. Patient and fracture characteristics were recorded.

Results: Of 517 fractures (515 patients), 22 (4.3%) had concurrent ipsilateral distal tibial fractures: 11 triplane, 5 medial malleolar, 3 bimalleolar, and 2 Tillaux (Salter-Harris III) ankle fractures, and 1 Salter-Harris II distal tibial fracture. Age was the only patient characteristic significantly associated with a second, more distal fracture: patients with both fractures were older (12.7 years) than those with an isolated tibial shaft fracture (11 years). There was no difference in the rate of distal tibial fractures between high-energy and low-energy mechanisms of injury and no differences in the rate of open injuries or the presence of a fibular fracture. Patients with a tibial shaft fracture at the junction of the middle and distal thirds were significantly more likely to have a concurrent distal tibial fracture; oblique and spiral fracture patterns were more frequent in the group with concurrent distal tibial fractures than in the isolated tibial shaft fracture group.

Conclusions: In our series, 36% of the concurrent distal tibial fractures were not diagnosed until chart review, suggesting the need for ankle-specific imaging in certain patients. We recommend ankle-specific imaging when an oblique or spiral tibial shaft fracture exists at the junction of the middle and distal thirds of the tibia or in patients in whom a distal tibial fracture is suspected because of pain, swelling, or bruising.

Level of Evidence: Level III, retrospective comparative study

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Posterior Approach Total Hip Arthroplasty Can Be Performed in Ambulatory Surgery Centers

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INTRODUCTION

Total hip arthroplasty (THA) performed in ambulatory surgery centers has increased steadily in the past 10 years after reports of successful outcomes[1-9]. Studies estimate elective primary total hip arthroplasties to grow by 174% between 2005 to 2030 with an estimated 572,000 performed in the year 2030[10]. In contrast, predicted growth of inpatient based total arthroplasty procedures is a mere 3%. This represents a change from 15% outpatient, 85% inpatient in 2016 to a predicted 51% outpatient, 49% inpatient in 2026[11]. Factors contributing to this trend include perceived patient benefits, reduced length of stay, reduced costs for patients and insurers, and overall improved efficiency to the healthcare system[12-14]. The posterior approach to THA has a proven track record in the inpatient setting. Currently, patients undergoing THA expect a short inpatient hospital stay for post-operative pain control and therapy. Appropriate patient selection, multimodal pain management protocols, improved anesthesia, and streamlined therapy have contributed to quicker post-operative recovery rates allowing these procedures to be performed in the outpatient setting[15-19]. Additionally, routine use of tranexamic acid has reduced blood loss and rates of transfusions for acute blood loss anemia in arthroplasty procedures[20-22]. Multiple studies have proven success of total hip arthroplasty, both anterior and posterior approaches, at their respective institutions[3, 5, 12]. Multiple factors contribute to the success of outpatient arthroplasty procedures. This study aims to confirm the posterior approach THA can be safely and reliably performed in the outpatient setting.

MATERIALS AND METHODS

After approval by our institutional review board, patient data was retrospectively reviewed of 77 posterior total hip arthroplasties performed by six orthopedic surgeons between November 2015 and January 2019. To be considered "outpatient," patients must have been discharged home within 24 hours of surgery (same-day). Charts were reviewed to gather patient demographic data including age, BMI, ASA score, anesthesia type, preoperative (90-day) complications, and modified HOOS score (when available).

PATIENT SELECTION

Patients who failed conservative management were considered for outpatient total hip arthroplasty. During the preoperative visit, medical history was reviewed by each surgeon to evaluate suitability for the outpatient setting. A BMI (body mass index) < 40 was used as a cutoff for both inpatient and outpatient total joints. Patients with anemia <30 on preoperative blood work were not scheduled until further workup or hematology referral was completed. Those with cardiopulmonary disease were excluded from outpa-

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tient surgery unless stable and without stent placement or coronary bypass within the last 6 months. Patients with history of thromboembolic event, including deep venous thrombosis or pulmonary embolism (DVT or PE, respectively) were excluded as candidates for outpatient arthoplasty. If deemed a candidate for total arthroplasty in the outpatient setting, patients were then additionally assessed by a member of the anesthesia staff. Patients requiring further risk stratification were evaluated and obtained medical clearance. Patients were also scheduled for a "prehab" visit with a physical therapist trained in outpatient total hip arthroplasty. Prehab visits also included patient education as to what to expect during the early post-operative period.

SURGICAL PROCEDURE

Operations were performed by one of six Campbell Clinic orthopaedic surgeons in the ambulatory surgery center through a standard posterior approach (Kocher-Langenbeck) in the lateral position. Appropriately sized uncemented femoral and acetabular components were placed. Variations in repair of the capsule and short external rotators were based on surgeon preference. Water-resistant antimicrobial dressings were applied and remained in place until the first follow-up appointment (approximately 2 weeks).

PERIOPERATIVE PROTOCOLS

Spinal anesthesia was utilized in 65 patients (84%) while 12 patients (16%) required general anesthesia due to prior spinal surgery, pre-existing neuropathy, or intraoperative conversion due to unsuccessful spinal anesthesia. A multimodal medication regimen was used pre-operatively including celecoxib, Gabapentin, Oxycontin, and acetaminophen. Postoperatively patients were prescribed celecoxib or meloxicam, gabapentin, tramadol, acetaminophen, and oxycodone. During the procedure, localized injections of either Exparel or a combination of ropivicaine w/ epinephrine, morphine, and Toradol were given based on surgeon preference. Tranexamic acid was administered intraoperatively at time of incision and at time of wound closure to minimize blood loss.

POST-OPERATIVE PROTOCOL

All patients were transferred to the recovery room where they received the oral multimodal regimen. Intravenous narcotic medication was used judiciously. Once the effects of spinal anesthesia subsided, patients were mobilized in the recovery room. Patient-specific functional goals, including stair navigation, were only addressed if required for home access. Patients were not discharged until additional criteria were met including adequate pain control on oral pain medications, stable vital signs, tolerating oral diet, ability to ambulate 100ft without orthostatic hypotension, and controlled voiding. Surgeon-specific discharge instructions were given to each patient and explained by recovery room staff. During the preoperative visit, outpatient therapy was scheduled to begin within two days of discharge from the ambulatory surgery center. Follow-up phone calls were made to all patients on post-operative day 1.

RESULTS

A total of 77 total hip arthroplasties were performed in 68 patients of which 39 were male and 29 were female. Unilateral total hip arthroplasty was performed in 59 patients while 9 patients had bilateral hip replacements in separate surgical episodes. Average age at the time of surgery was 54 years (33-64). The average BMI was 28.9 (21.3-35.8). Average ASA score was 1.89. There were no reported intraoperative complications. Four patients experienced a post-operative complication within 90 days of their procedure (5%). One patient sustained an anterior hip dislocation on post-operative day two requiring closed reduction with no subsequent episodes of instability. Another experienced a transient sciatic nerve palsy that resolved completely by three months. A periprosthetic medial calcar fracture was noted in one patient without antecedent trauma which was successfully treated conservatively and healed without incident. One patient experienced a small area of cellulitis around a stitch abscess that was cleared with oral antibiotics. Modified HOOS scores (Hip disability and osteoarthritis outcome score) were obtained in 60 patients averaging 84.9 (45-100).

DISCUSSION

As outpatient total hip arthroplasty becomes more popular among patients and surgeons alike, it is important to note that the posterior approach can be performed safely in the outpatient setting in select patients with minimal complication rates. New multimodal pain management protocols allow for limited post-operative narcotic regimens compared with more traditional narcotic regimens used among THA patients undergoing a

two- to three-day stay in an inpatient setting. Streamlined therapy protocols facilitate early and safe mobilization. The use of tranexamic acid has reduced rates of post-operative transfusions requiring inpatient readmission.

Complications noted in this series are comparable to those noted in other studies after standard inpatient total hip arthroplasty[12, 23, 24]. One patient was readmitted due to dislocation and discharged in less than 24 hours. The other complications reported did not require inpatient readmission. No post-operative emergency room visits were identified in this study, and we attribute this to patient education ("pre-hab" courses) which explained the expectations during the early post-operative course. This included proper dosing of medications, anticipated swelling, and maintenance of post-operative dressings. Additionally, a 24-hour physician hotline was available to all patients which may have also limited hospital visits for routine concerns answered over the phone.

Appropriate patient selection is essential for total arthroplasty to be safely performed in the outpatient setting. Screening by the treating physician, with additional screening by anesthesia staff, is necessary. Patient and surgeon preference ultimately decide the setting and the approach, but our findings in this paper support that the posterior approach can be safely and reliably used in the outpatient setting.

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Preoperative Narcotic Use and Inferior Outcomes After Anatomic Total Shoulder Arthroplasty: A Clinical and Radiographic Analysis*

ABSTRACT

Introduction: Our purpose was to determine if chronic use of preoperative narcotics adversely affected clinical and/or radiographic outcomes.

Methods: 73 patients (79 shoulders) with primary total shoulder arthroplasty (TSA) for osteoarthritis were evaluated clinically and radiographically at preoperative visits and postoperatively at a minimum of 2 years: 26 patients (28 shoulders) taking chronic narcotic pain medication for at least 3 months before surgery and 47 patients (51 shoulders) who were not taking narcotics preoperatively.

Results: Postoperatively, there were significant differences between the narcotic and non-narcotic groups regarding American Shoulder Elbow Society (ASES) scores and Visual Analog Scores (VAS) scores, as well as forward elevation (FE), external rotation (ER), and all strength measurements ($p<0.01$). The non-narcotic group had significantly higher ASES scores, better overall range of motion and strength, and significantly lower VAS scores than the narcotic group.

Discussion: Chronic pre-operative narcotic use appears to be a significant indicator of poor outcomes of anatomic TSA glenohumeral osteoarthritis. Additionally, we found that patients using chronic narcotics did not improve to the same degree as patients who were not chronic narcotic user regarding functional outcomes and had a higher complication rate with the surgery.

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Tobacco Use Results in Inferior Outcomes After Total Shoulder Arthroplasty*

ABSTRACT

Background: This study examined the effect of tobacco use on outcomes of primary anatomic total shoulder arthroplasty (TSA).

Methods: A retrospective search identified 59 nonsmokers, 29 former smokers, and 14 current smokers with primary anatomic TSA and at least 2 years of follow-up. At mean follow-up of 3 years, patients were assessed with a Visual Analog Scale (VAS), American Shoulder and Elbow Surgeons (ASES), and Single Assessment Numeric Evaluation (SANE) scores and range-of-motion testing.

Results: Smokers were significantly younger than nonsmokers or former smokers; there were no other statistically significant differences. VAS scores were significantly higher in current smokers and ASES scores were significantly lower. Complication rates were 36% in current smokers, 15% in nonsmokers, and 7% in former smokers (p=0.05).

Conclusions: Current smokers had significantly worse pain and functional scores and more complications. Former smokers had results similar to nonsmokers, suggesting improved outcomes are possible in patients who quit smoking preoperatively.

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Jordan D. Walters, MD, L. Watson George II, MD, Jim Y. Wan, PhD, Tyler J. Brolin, MD, Frederick M. Azar, MD, and Thomas W. Throckmorton, MD. Tobacco Use Results in Inferior Outcomes After Anatomic Total Shoulder Arthroplasty. Curr Orthop Practice. January/February 2019; 30(1):33-37.

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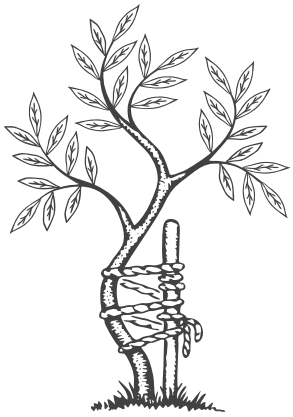

CAMPBELL CLINIC STAFF RESEARCH

Macrophage-Induced Corrosion in Stainless Steel

ABSTRACT

INTRODUCTION: Metal implants have become a common therapeutic intervention in cardiovascular, dental, and orthopaedic surgery. As such the assurance of safety and longevity of the orthopaedic device is important to the sustained health and wellbeing of the patient. Currently, between 3% and 80% of patients receiving an orthopaedic or dental implant experience short-term implant failure. The structural integrity and subsequent degradation of implant alloys in situ is particularly dependent on the type, composition, electrochemical, and mechanical properties of the alloy2. However, the human body is unique in that it can mount natural immune responses against foreign invaders. Previous studies have focused on osteoclasts in their investigation of orthopaedic implant failure but have failed to fully dissect the cause of damage. Direct cellular corrosion of orthopaedic implants is a controversial topic among studies of device failure. Previous research has demonstrated that macrophages may ingest small particulates released from metal implants, but the potential for a mounted attack directly on metal prostheses has yet to be completely explored or identified. The goal of this experiment was to understand whether macrophage attack of a metal alloy passivation layer in orthopaedic implants of Stainless Steel (SS) composition can occur. As an initial foray into determining this hypothesis we investigated the viability of IC-21 macrophages at 30 days in culture and their subsequent corrosive action against SS.

METHODS: IC-21 ATCC peritoneal macrophages from mus musculus were cultured in a 75cm3 flask to a concentration of 600 x 103 cells/mL. Cells were cultured with growth medium of RPMI 1640 with 10%FBS, L-glutamine, and gentamicin. Stainless steel discs were cut from rod stock by lathe turning. The average roughness ± Stdev (center path) is 0.90 ±0.28μRa. The surface was cleaned by sanitation in warm alkaline detergent, rinsed in deionized water and passivated in 30% nitric acid. The discs were then rinsed in DI water, rinsed in sterile (ultra pure) water, and sterilized under a UV lamp in the culture hood. 150ul of cells were added into a 96-well plate containing SS discs. Discs were placed in a 96-well culture plate. Cells were allowed to adhere to the surface of the discs for 24 hours. Interferon Gamma (IFNy) and Lipopolysaccharide (LPS) were used to induce activation of macrophages. Six experimental groups were used: Discs + (1) Medium, (2) 20 x 103 cells/150ul (20K), (3) 20 x 103 cells/150ul + 20ng/mL LPS + 20ng/mL IFNy (IFNy/LPS 20K), (4) 40 x 103 cells/150ul (40K), (5) 40 x 103 cells/150ul + 20ng/mL LPS + 20ng/mL IFNy (IFNy/LPS 40K), (6) 40 x 103 cells/150ul + 20ng/mL LPS (LPS 40K). The experiment was replicated on a control plate (TCP) without discs in order to monitor the integrity and growth of the cells under light microscopy. Culture medium was changed every 48 hours for the first 4 days and every 24 hours thereafter. Supernatant was collected every 2 days and frozen for later cytokine analysis. At Day 4, three wells from Group 3 (40 x 103 cells/150ul + 20ng/mL LPS + 20ng/mL IFNy) were selected from both the disc and control plate to ensure accurate cell count and growth. Cell viability and number was measured with CellTiter 96® Aqueous One

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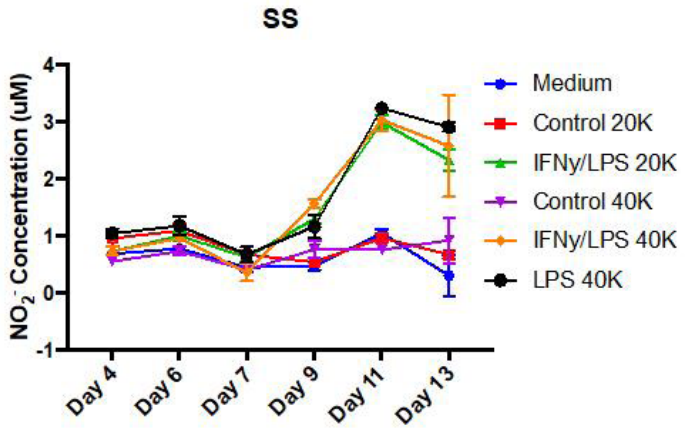

Figure 1: Nitric Oxide concentrations over the first two weeks of cell culture in each group studied.

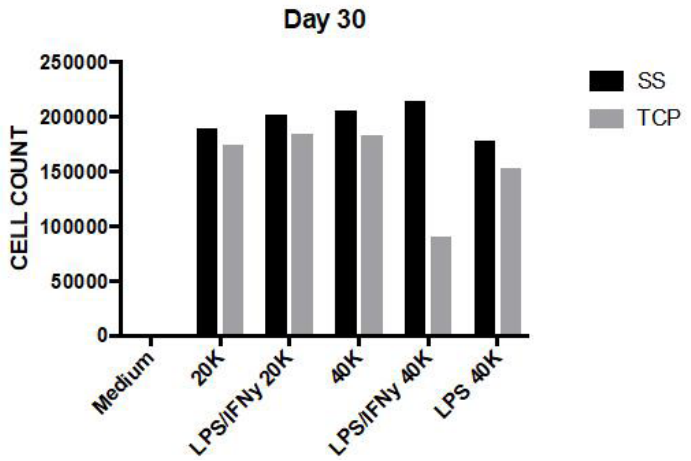

Figure 2: Cell counts in each group at the end of the culture period.

Solution Assay (Promega) using manufacturer protocol. The Griess Reagent Assay (ThermoFisher) was used to indirectly measure NO production from supernatant. After 30 days, supernatant was collected and cell viability and number was measured with CellTiter 96® Aqueous One Solution Assay (Promega) using manufacturer protocol. Discs were carefully removed from the 96 well plate and cleaned for SEM analysis. Removal of macrophages from the disc surface was accomplished via sequential cleaning. Discs were first soaked in a bath of water and detergent at a ratio of 10:1 for two consecutive 20 minute increments. Discs were ultrasonicated for two 30 minute periods in a water bath with diluted detergent. Scanning electron microscopy (SEM) (Zeiss, Oberkochen, Germany) at 20 kV was used to examine areas of possible interaction between the metal and cells. Energy dispersive X-ray spectrometry (EDS) (Oxford, High Wycombe, UK) was used to analyze the elemental compositions at various points using points in non-damaged areas as a baseline for comparison. Griffin- Did we get roughness measurements on these discs? (We have a Profilometer (DektakXT, Bruker,Tucson, AZ) in our lab if needed. BRM) That is the reason we got the pocket-surf back from Brian. (I returned the Pocket Surf. BRM)

RESULTS: Griess Assay data from the Stainless Steel discs were compiled across the various time points and plotted as a function of NO2 concentration. A 2-way ANOVA for simple effects within days and Dunnett's multiple comparisons test are shown in **Figure 1**. The stainless steel disc groups with LPS, IFNy+LPS 20K, and IFNy+LPS 40K produced significantly more NO compared to medium on days 9, 11, and 13. Additionally, control cells with 40K cells/well started producing significantly more NO on day 14. Cell viability and count assays showed no significant difference between experimental groups **(Figure 2)**. EDS results showed no differences between the control points and points indicative of cellular interaction. Initial SEM of selected discs showed an indentation of approximately 5um from IFNy/LPS 20K **(Figure 3)**.

CONCLUSION: IC-21 cells activated via LPS and IFNy at high concentrations produced significantly more NO compared to their control counterparts. Macrophages without additional activating factors started producing more NO after 14 days, showing a propensity toward activation after 2 weeks. This may indicate macrophages reacting to the stainless steel without inciting factors. Further analysis of the last half of the experimental phase will demonstrate if the macrophages can sustain increased activation for up to 30 days. Final cell viability and cell count assays showed an increase in cell count throughout the 30 days of culture and no significant differences in cell counts across the experimental groups. The demon-

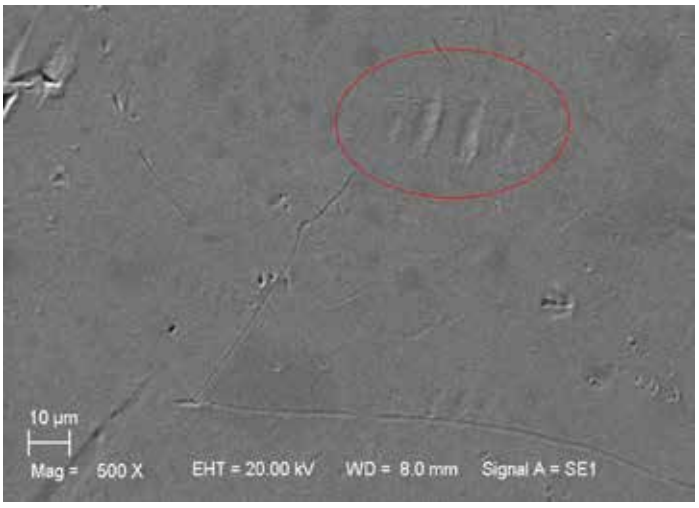

Figure 3: SEM of one metal disc with possible evidence of cell induced longitudinal pits. The dimensions are appropriate for possible macrophage interaction.

strated viability of the cells after 30 days therefore established a sustainable protocol for future studies investigating macrophage corrosion of metal implants. Additionally, SEM analysis of select discs demonstrated macrophage-sized corrosive pits. These results highlight the potential for macrophages to create corrosive pits on metal within 30 days. Further analysis should be conducted analyzing all metal discs with increased SEM area. Furthermore, collected supernatant should be analyzed for metal content to evaluate whether macrophages are causing metal particle release from the stainless steel discs. Though much effort is needed to demonstrate the direct role of macrophages in metal implant corrosion, the evidence thus far shows a compelling argument that macrophages are indeed capable of metal destruction.

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Evidence of Inflammatory Cell-Induced Corrosion (ICIC) of Total Knee Implants: Comparison to Electrocautery Induced Implant Damage

ABSTRACT

INTRODUCTION: Corrosion of orthopaedic implants is a clinical concern. Retrieval studies have found evidence of what appears to be direct pitting of metallic alloy implants. The mechanism of how these pits form is controversial, and two hypotheses have been suggested in the literature. First, it is believed by some that corrosion may be due to the use of an electrocautery device during the procedure.[1] In this scenario, the arc from the electrocautery device would have to make contact with the implant. A second hypothesis is that the hosts own inflammatory cells mount a response to the implant and create pits in the surface oxide later of the metal alloy.[2] The goal of this study is to determine if the source of corrosion is from an electrocautery device during surgery or from inflammatory cells. To accomplish this, we observed the profile of an implant that had been damaged by an electrocautery device and compared it with retrieved implants. The retrieved implants were from a donor program colleccted at the time of necropsy.

METHODS: Twelve cadaveric primary total knee arthroplasty specimens were collected, following institution review board approval. Light microscopy was utilized to identify areas of interest indicative of ICIC-like damage scares. Using a scanning electron microscope, 20 kV backscatter detection (BSD), and energy dispersive X-ray spectrometry (EDS) corroded regions were analyzed. A Cobalt Chromium knee implant was intentionally damaged by electrocautery from both Bovie and Aquamantys sources by a three second hover method. Bovie electrocautery damage was done at 30W, 45W, and 60W. Aquamantys electrocautery damage was done at 140W, 180W, and 220W. The implant was then cleaned in order to remove any debris from the corrosive process. The implant was first soaked in a bath of water and detergent at a ratio of 10:1 for two consecutive 30 minute rounds. Next, it

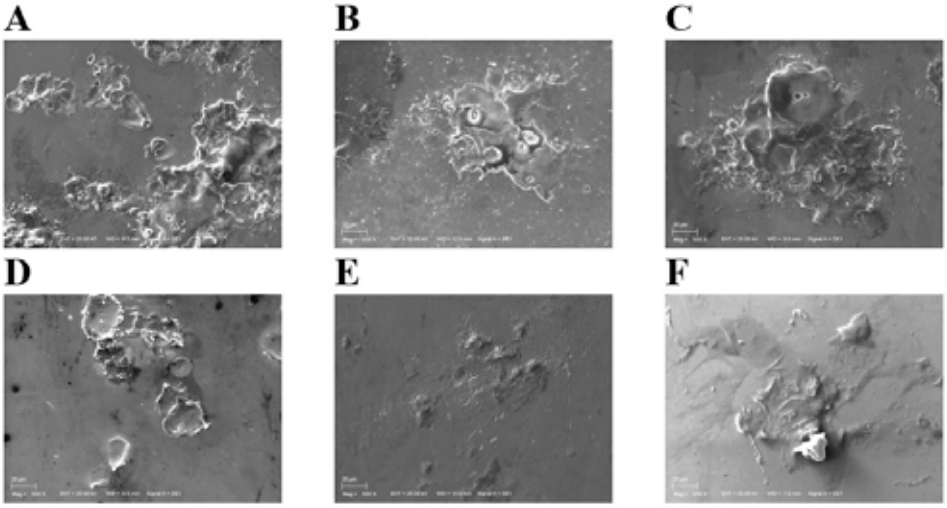

Figure 1: Shows damage done to the surface of CoCr knee implant at 500x.
A) Bovie 30W **B)** Bovie 45W **C)** Bovie 60W **D)** Aquamantys 140W
E) Aquamantys 180W **F)** Aquamantys 220W

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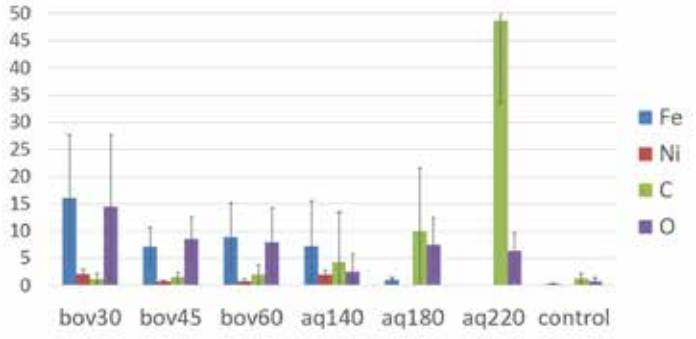

Figure 2: Percent weight of each element detected by EDS at the base of pits of ICIC damage areas. Error bars indicate +/- one standard deviation.

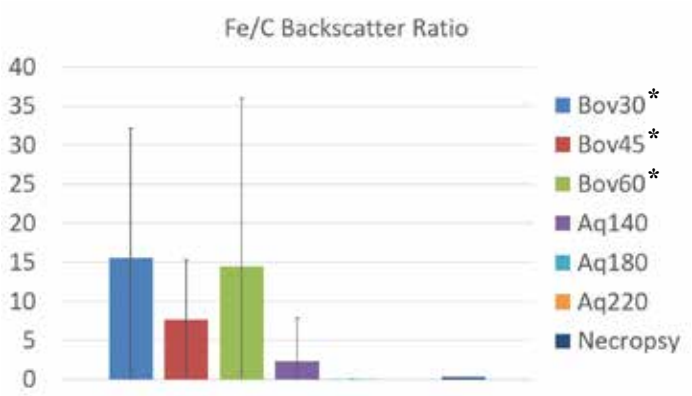

Figure 3: Ratio of the percent weight of iron to the percent weight amount of carbon found at the base of pits of ICIC damage areas. Error bars indicate +/- one standard deviation.
* indicates statistical significance

was ultrasonicated in a water bath with a few drops of detergent. Standard error of mean (SEM) data was collected using an identical method to that of the retrieved implants. The data generated was compared to the backscatter analysis of five knee implants retrieved from necropsy donors. The five retrieved implants were believed to have ICIC changes on their surfaces.

RESULTS: Necropsy retrievals showed signs of ICIC in five out of twelve (42%) of implants examined. Circular regions can be observed consisting of small pits and crater-like features. In some cases, there was evidence of a potential migration path of the cell as it was corroding the surface. EDS revealed high concentrations of carbon and salts in these areas, as well as varying iron concentrations in specific regions. Images of each type of electrocautery at each energy level where made at 500x, which showed pitting similar to that seen previously on knee implants that has been described as ICIC **(Figure 1)**. Iron, Nickel, Carbon, and Oxygen content were taken from the data collected to serve as surrogate markers of corrosion **(Figure 2)**. Elevated levels of iron, nickel, and oxygen were seen in all energy levels of Bovie cautery damage, while Aquamantys cautery damage results did not show a trend. The Iron/Carbon ratio of the Bovie electrocautery damaged knee implant compared to the necropsy retrieved knee implants was determined to be statistically significant using a non-paired t-test looking at different pitting regions **(Figure 3)**. Bovie 30W n=27, Bovie 45W n=15, Bovie 60W n=18, Aquamantys 140W n=17, Aquamantys 180W n= 22, Aquamantys 220W n= 8.

DISCUSSION: Our findings suggest that the pits seen in necropsy retrieved knee implants appear to be generated by a different mechanism than Bovie electrocautery damage. While the pits seen in both cases look similar, the contents of the pits are unique. These results aid in resolving the debate over the origin of the pits seen on the surface of retrieved knee implants. They are not only due to damage during surgery and may be caused by an immune reaction from the patient. More research is necessary to prove that inflammatory cells are capable of causing surface oxide damage of total joint replacement implants.

SIGNIFICANCE/CLINICAL RELEVANCE: Shedding light on the ongoing debate as to what is the source of the corrosion seen on retrieved knee implant will allow for future work to be done with hopes to mitigate the effects of ICIC of total knee implants.

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Laxity Differences in Cruciate-Retaining and Posterior-Stabilized Total Knee Arthroplasty: A Cadaver Study

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ABSTRACT

INTRODUCTION: Many total knee arthroplasty (TKA) design variations exist to address patient-specific needs. The two most common variations surgeons utilize are cruciate-retaining (CR) or a posterior-stabilized (PS) designs, depending on the desired level of constraint. TKA with both CR and PS implants have high success rates and survivorship, but it is uncertain how resulting stability in the coronal and transverse planes are affected when the PCL is sacrificed. We set out to determine if laxity differences exist between CR and PS TKA specimens obtained at time of necropsy to answer this question.

METHODS: Following IRB approval, 47 cadaveric specimens with primary TKAs were procured from the Medical Education and Research Institute (Memphis, TN) and Restore Life USA (Johnson City, TN). All skin, subcutaneous tissue, and muscle were removed while the stabilizing structures and ligaments of the knee were preserved. The femur and tibia were cut transversely 180 mm superior and inferior to the knee joint line. Once prepared, the specimens were mounted in a custom knee testing machine **(Figure 1)**. The laxity patterns were measured in a custom knee-testing machine at full extension and at 30, 60, and 90 degrees of flexion. Laxity was assessed at 1.5 Nm of internal/external torque in the transverse plane and at 10 Nm of varus/valgus torque in the coronal plane. An unpaired Student's t-test was performed to determine statistical differences between CR and PS laxity. A p-value of less than 0.05 was considered significant.

Figure 1

RESULTS: Of the 47 specimens included in this cohort, 21 specimens were PS designs while 26 specimens were CR designs. **Table 1** includes the p-values for the comparison of varus, valgus, and combined coronal laxities as well as internal rotation, external rotation, and combined internal/external rotational laxities between the two cohorts across each of the flexion angles. Coronal laxity, or combined varus and valgus laxity, increased as the flexion angle increased in both cohorts. While statistical significance was not detected between the difference of coronal laxity in the PS and CR TKAs, the PS implants had increased coronal laxity at 60 degrees (PS=15.19 ± 10.39 degrees vs. CR=13.48 ± 10.39 degrees; p=0.087) and 90 degrees of flexion (PS=20.73 ± 10.39 degrees vs. CR=14.90 ± 10.39 degrees; p=0.086). The only statistical significance was at 90 degrees of flexion

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	Varus Laxity	Valgus Laxity	Combined Coronal Laxity	Internal Rotational Laxity	External Rotational Laxity	Combined Internal/ External Rotational Laxity
0 degrees	0.377	0.403	0.310	0.098	0.005	0.007
30 degrees	0.124	0.674	0.444	0.526	0.201	0.068
60 degrees	0.446	0.700	0.087	0.474	0.966	0.596
90 degrees	0.019	0.534	0.086	0.622	0.229	0.341

Table 1: P-values for the comparison between varus, valgus, combined coronal (varus/valgus), internal rotation, external rotation, and combined internal/external rotation laxities of the PS and CR cohorts across each flexion angle

where the PS implants had increased varus laxity when compared to the CR implants (PS=12.30 ± 6.74 degrees vs. CR=7.87 ± 5.45 degrees; p=0.019). Transverse plane rotational laxity, or combined internal and external rotational laxity, increased as the flexion angle increased in both cohorts, except for the CR implants at 60 degrees of flexion. The transverse plane rotational laxity of the PS cohort was significantly greater than that of the CR cohort at full extension (p=0.007). While not statistically significant, the PS cohort had a transverse plane rotational laxity of 34.45 ± 8.94 degrees compared to rotational laxity of 30.21 ± 6.59 degrees for the CR cohort (p=0.068) at 30 degrees of flexion.

DISCUSSION: While PS and CR TKA both have high success rates with excellent long-term survivorship, it is unclear if the laxity profiles of these two implant designs differ due to the secondary stabilizing effect of the PCL in the transverse and coronal planes. This study sought to answer the question as to whether PS implants can compensate for the increase in flexion space or the loss of coronal stability after PCL resection[1]. The results of this study demonstrated significant laxity differences between PS and CR TKA designs in the transverse plane at full extension as well as in varus laxity at 90 degrees of flexion validating the proposed hypothesis. The more medial anatomical location of the PCL should affect valgus laxity more once the PCL is released but the findings of this study found that PS TKAs had less support with a valgus torque applied to the knee in flexion. The PCL also functionally supports external rotation more than internal and the results support this finding with more external rotational laxity under the applied torque in the knee simulator. This study was limited by certain factors. The study cohort included a wide-range of varying implant designs, a variable that could not be controlled. Due to the in vitro nature, this study model lacked active secondary muscle stabilizing forces. Additionally, it was unknown whether any of the specimens had significant deformities requiring extensive soft-tissue balancing at the time of the index procedure and the surgical technique (matched resection versus gap balancing) utilized is not known as well. While research indicates that retention or substitution of the PCL in the absence of clear clinical indications for its resection or substitution does not impact clinical survivorship, our findings suggest that the PCL not only stabilizes the knee in sagittal plane, but also affords coronal and rotational stability. Our results may seem to advocate a gap balancing approach for PS TKA to better handle the mismatch in extension and flexion gaps. While the cruciate ligaments are known to function as stabilizers against rotational torque, few published studies have reported on the differences in internal-external rotational laxity between PS and CR TKA devices. This study may supplement the paucity of research on the implications PS and CR TKA on rotational laxity. Our findings suggest that further patient reported outcome measures and clinical research concerning the impact of PCL resection and implant design may be warranted.

SIGNIFICANCE/CLINICAL RELEVANCE: These findings suggest that the PCL not only stabilizes the knee in sagittal plane, but also affords coronal stability in flexion and rotational stability in extension.

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Post-Operative Use of the Wheeled Knee Walker After Foot and Ankle Surgery

ABSTRACT

Introduction/Purpose: Countless foot/ankle injuries occur each year, many of which require that the patient be non-weight-bearing or maintain limited weight-bearing during healing. A variety of walking aids are used to meet weight-bearing restrictions while remaining active. The knee-walker is a relatively newer walking aid that strives to combine safety, efficacy, ease of use, and mobility. Despite their widespread use, data are limited regarding the safety profile of these devices. The purpose of this study was to explore their risk/benefit profile. Primary endpoints were the number of falls, frequency of falls, and additional injuries that may have occurred as a result of falls. Secondary endpoints were characteristics of the knee walkers used, duration of use, education for use, patient demographics and comorbidities, and overall satisfaction with the aid. These characteristics were further reviewed to determine their role in or associations with falls/injuries.

Methods: A prospective, observational, and descriptive study examined the use of knee-walkers after foot or ankle surgery or injury. Inclusion criteria were unilateral foot or ankle surgery, physician-instructed non-weight bearing status, and use of a knee-walker. With institutional review board approval, paper surveys were given to patients in the clinic during follow-up visits. Survey data were collected from December, 2016, through May, 2018. From the survey data, we gathered information regarding the characteristics of the knee walker used, duration of use, payment for the knee-walker, occurrence and frequency of falls, and adverse events other than falls. Patient satisfaction and recommendations to their acquaintances for or against the use of knee-walkers also were collected. 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 T-test for continuous variables.

Results: 271 surveys were gathered and analyzed. The average patient age was 51, and the average BMI was 32. Approximately 19% (51 of 271) of participants had 3 or more systemic comorbidities. Most of the participants in the study used a four-wheeled (87%, 237 of 271) and steerable (98.5%, 267 of 271) model. Participants used the knee walkers for an average of 6.4 weeks, 6.6 hrs./day. Seventy percent (190 of 271) of participants did not receive education on how to use a knee walker.

Approximately 90% (242 of 271) reported that they were at least moderately satisfied, 5% (14 of 271) were neutral, and 6% (15 of 271) were dissatisfied. A substantial proportion (42%, 114 of 271) of knee-walker users fell while using the knee walker, and half of those (57 of 114) fell multiple times. Injuries were reported by only 25% of those who had fallen (28 of 114), most of which required no treatment. There was no statistically significant association between falls and gender, age, BMI, specific comorbidities studied (including diabetes, neurological disorders, and anxiety/depression), or knee walker characteristics. There was a statistically significant association between falls and patient dissatisfaction (p=0.001).

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Conclusion: A previous retrospective study and this follow-up study represent some of the only studies related to wheeled knee-walker use in a clinical population. A substantial proportion (42%) of knee-walker users fell while using the knee walker, and half of those fell multiple times. Despite these falls, there was a high level of satisfaction (89%) among patients who used the knee walker. Plans for future studies include a comparison study of fall rates between knee walkers and other walking aids, as well as a study to determine if in-clinic education helps decrease fall rates.

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Corticosteroid Injections for Trigger Finger in 110 Digits: Time to Patient Response

ABSTRACT

INTRODUCTION: The purpose of this study was to evaluate patient-reported outcomes in the first 30 days after corticosteroid injection for trigger finger to determine the time to pain relief, resolution of triggering, and restoration of hand function and to identify factors affecting outcomes.

METHODS: Pre-injection baseline questionnaires (Brief Michigan Hand Outcomes Questionnaire (bMHQ) and Pain Catastrophizing Score (PCS) were completed by 126 adult patients. After injection of 1mL of 40 mg/mL methylprednisolone acetate and 1 mL of 1.0% plain lidocaine, patients were instructed to complete a one-month home diary recording daily visual analog scale (VAS) pain scores and assessment of hand function and triggering symptoms; 99 patients (110 digits) completed the diary.

RESULTS: Most patients had improvement in pain scores within the first day and reached their lowest pain scores 12 days post-injection. Only initial VAS score were significantly associated with the number of days until lowest post-injection pain score ($p<0.05$). A flare reaction (temporary increase in pain score by 2 or more) was experienced by 10% of patients following injection. Hand function and triggering improved, on average, 3 to 4 days after injection. Complete resolution of triggering and return of normal finger function occurred in only half of patients and took on average 3 to 4 weeks for these patients. Co-morbidities such as diabetes mellitus, age, Green classification, and duration of symptoms did not affect the overall outcome after injection.

CONCLUSIONS: Patients can expect significant pain relief following corticosteroid injection for trigger finger, with only 10% of patients experiencing a flare reaction. Most patients see improvement in triggering within 1 week after injection, but only roughly half of patients have complete resolution of triggering at 1 month. Triggering appears to resolve in a delayed fashion compared to pain resolution after injection; no co-variables were associated with short-term outcomes.

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Infection Rate After Open Fractures in Pediatric Patients: A Study of Data From 11 Years

ABSTRACT

Purpose: Open fractures are rare in pediatric patients, accounting for only 2% to 9% of all fractures. Despite extensive literature on open fracture management in adults, it is unclear if these findings translate to pediatric patients. Our goal was to identify factors in managing pediatric open fractures that may influence the rate of infection.

Method: After IRB approval, retrospective review of all open fractures treated at a large, level 1 children's hospital from 2006-2016 identified 302 patients aged 1 to 17 years. Demographic information, mechanism of injury, fracture location, Gustilo grade, time to antibiotics and debridement, and other surgical information were documented. Continuous measures were compared with Mann-Whitney U tests and categorical variables with chi-square tests and Fisher's exact tests as appropriate. Odds ratios (OR) and 95% confidence intervals (95% CI) were determined.

Results: Of the 302 patients, 24 (7.9%) developed post-traumatic infections. There was no association between the development of an infection and the mechanism of injury (p=0.22), time to surgical debridement (p=0.87), or administration of ancef vs other antibiotics (p=0.65). There was an association between the number of surgeries and the development of infection [mean: 2.7 vs. 7.3 (no infection vs infection) p<0.01]. There also was an association between infection and antibiotic administration within 1 hr (OR: 2.6; 95% CI: 1.1, 6.5, p=0.04) and 3 hours of injury (OR: 4.7; 95% CI: 1.1, 20.6, p=0.04), likely because fractures with gross contamination or higher ISS were treated faster.

Conclusion: The rate of infection after open fractures in 302 pediatric patients was 7.9%. Antibiotic administration within 1 hour of the injury did not decrease the infection rate, possibly because of expedient transfer of patients with more severe injuries to a level 1 facility. Decreased time to surgical debridement did not decrease the infection rate.

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Can Pediatric Orthopaedic Surgery Be Done Safely In a Freestanding Ambulatory Surgery Center? Review of 3,780 Cases.

ABSTRACT

Background: The purpose of this study was to determine the intraoperative and 30-day postoperative complication rates in a large consecutive cohort of pediatric patients who had orthopaedic surgery at a freestanding ASC. We also wanted to identify the rates of same-day, urgent hospital transfers, and 30-day hospital admissions. We hypothesized that pediatric orthopaedic procedures at a freestanding ASC can be done safely with a low rate of complications.

Methods: Retrospective review identified patients 17 years old or younger who had surgery at a freestanding ASC over a 9-year period. Adverse outcomes were divided into intra-operative complications, post-operative complications, need for secondary procedure, unexpected hospital admission on the same day of procedure, and unexpected hospital admission within 30 days of the index procedure. Complications were graded as grade 1, the complication could be treated without additional surgery or hospitalization; grade 2, the complication resulted in an unplanned return to the operating room (OR) or hospital admission; or grade 3, the complication resulted in an unplanned return to the OR or hospitalization with a change in the overall treatment plan.

Results: Adequate follow-up was available for 3,780 (86.1%) surgical procedures. Overall, there were 9 (0.24%) intraoperative complications, 2 (0.08%) urgent hospital transfers, 114 (3%) complications, and 16 (0.42%) re-admissions. Seven of the 9 intraoperative complications resolved before leaving the OR, and 2 required return to the OR.

Neither complications nor hospitalizations correlated with age, race, gender, or length or type of surgery. There was no correlation between the presence of medical comorbidities, body mass index, or ASA score and complication or hospitalization.

Conclusions: Pediatric orthopaedic surgical procedures can be performed safely in an ASC because of multiple factors that include dedicated surgical teams, single-purpose ORs, and strict preoperative screening criteria. The rates of emergency hospital transfer, surgical complications, and 30-day readmission, even by stringent criteria, are lower than those reported for outpatient procedures performed in the hospital setting.

Level of Evidence: Level IV, Case Series

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Preventing Early Postoperative Constipation After Posterior Spinal Fusion in Adolescents: A Double-Blind, Randomized, Controlled Medication Study

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INTRODUCTION

Pediatric and adolescent patients undergoing posterior spinal fusion (PSF) surgery are at risk for post-operative constipation because of the combination of anesthesia, opioids, and decreased mobility.[1,2] Post-operative ileus occurs frequently as a result of this procedure and can last up to 72 hours post-operatively depending on the procedure type and medications given. PSF is an extensive procedure involving 5-6 hours of anesthesia followed by 3-5 days of opioid analgesics during patient hospitalization. Post-operative constipation can increase pain and discomfort, decrease patient mobility, and interfere with adequate nutritional intake. All of these factors can lead to an increased length of stay, potential acute complications, and a dissatisfied patient and family.[1,3]

Limited literature is available on the treatment and prevention of early post-operative constipation in pediatric orthopedic patients. Polyethylene glycol 3350 (PEG) and mineral oil (MO) use in pediatrics has been extensively documented in the literature.[4-8] PEG and MO are recognized as standard of treatment for constipation in pediatric patients by the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition.[1,9-11] Despite both medications being used to treat constipation, they have different mechanisms of action. PEG works as an osmotic laxative that increases the amount of water in the stool[12] while MO works as a lubricant to the intestines and prevents absorption of water.[13]

The objective of this prospective, double-blind, randomized study was to determine which oral medication, PEG or MO, is more effective in preventing early postoperative constipation in adolescent patients who have had PSF.

MATERIALS AND METHODS

This prospective, parallel, double-blind, randomized study was undertaken to compare the effectiveness of PEG with that of MO in preventing post-operative constipation. Institutional review board approval was obtained prior to patient enrollment, and informed consent was obtained.

Patients between the ages of 12 to 21 years with adolescent idiopathic scoliosis (AIS) who underwent a PSF were included in this study. Patients were not enrolled if they were lactose intolerant or if they had irritable bowel syndrome, a swallowing disorder, developmental delay, a texture disorder, or an allergy to milk or chocolate. Non-English-speaking patients also were not enrolled. The patients in this study were not a consecutive series because patients who had any of the above criteria or whose families refused study participation were not enrolled. The study was con-

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ducted at a large, urban, academic hospital with 255 inpatient beds.

The dose of MO was 30 ml mixed with 1 oz (28.35 g) of chocolate pudding and 3 oz (85 g) of chocolate ice cream. The dose of PEG was 17 g mixed with the same combination of chocolate pudding and ice cream as the MO. The medications were labeled "Power Pudding." Patients received their assigned dose once daily until a bowel movement was achieved or the patient was discharged from the hospital. A bowel movement was not a requirement for discharge. A similar post-operative pathway was followed for each patient group, including scheduled docusate, with enemas and suppositories administered if indicated for abdominal distention and pain.

Using a random number generator, a study pharmacist (the only unblinded investigator) assigned patients to receive either PEG or MO. A control group of untreated patients was not studied because this is not a standard of practice for post-operative patients. The pharmacist then dispensed the prepared mixture to a medication freezer on the nursing unit for administration. The nursing staff, patients, and the other investigators were blinded to the type of medication received.

The surgical time in minutes from skin incision to skin closure, type and amount of pain medication received, time to mobilization, diet progression, time to bowel movement, amount of ondansetron received, the use of rescue cathartics or enemas, and total length of hospitalization were collected from the electronic medical records. Demographic variables also collected included: age, height, weight, body mass index (BMI), gender, and race. No patient identifiers were collected. Data collected were stored using the Research Electronic Capture (REDCap) management system.[14]

Statistical methods

The Fisher's exact test was used to compare bowel movement prior to discharge, the use of rescue cathartics and/or enemas, and refusal of doses between the PEG and MO groups. The Wilcoxon rank sum test was used in comparing surgical time, amount of pain medication received, time to mobilization, diet progression, time to bowel movement, and the length of hospitalization between the two groups. All statistical analyses were performed using SAS Software, version 9.3 (SAS Institute Inc., Cary, NC).

RESULTS

Fifty nine patients were recruited between May 25, 2012 through March 11, 2014. Thirty-one of 59 (52.5%) received PEG and 28 of 59 (47.5%) received MO. Approximately 82% of the patients were female, 46% were Caucasian, and 46% were African American. Race was not evenly distributed, with the PEG group having more Caucasians and the MO group having more African Americans. The mean ± standard deviation (sd) for age in the PEG group was 15.5 ± 2.3 years and 14.6 ± 1.8 years in the MO group **(Table 1)**. Overall, there were no statistically significant differences between the PEG and MO groups. There were no losses or exclusions of patients after randomization. The intervention was not discontinued in any patient. There were no adverse or unintended events noted in the study.

When the two groups were compared, there were no differences in the number of patients who had a bowel movement prior to discharge (p = 0.776). Information regarding time to bowel movement after discharge was not collected. Of the nine patients in the PEG group and the seven patients in the MO group who had a bowel movement prior to discharge (27%), the time from surgery to bowel movement was not statistically significant

Variable	PEG Group (n= 31)	MO Group (n= 28)
Gender, n (%)		
Male	6 (19)	5 (18)
Female	25 (81)	23 (82)
Race, n (%)		
Caucasian	17 (55)	10 (36)
African American	12 (39)	15 (54)
Other	2 (6)	3 (10)
Age (years)		
mean ± sd	15.5 ± 2.3	14.6 ± 1.8
Height (cm)		
mean ± sd	161.3 ± 11.8	161.6 ± 8.0
Weight (kg)		
mean ± sd	55.3 ± 15.8	61.2 ± 18.5
BMI		
mean ± sd	21.2 ± 4.7	23.2 ± 6.0
BMI, body mass index; **MO**, mineral oil; **PEG**, polyethylene glycol 3350; **sd**, standard deviation		

Table 1: Demographic Characteristics

(p = 0.670) between groups. Only one patient in each treatment group required a rescue enema. In the PEG group, eight patients (26%) required a rescue cathartic and three patients (11%) in the MO group (p = 0.187). Nine patients refused one dose in the PEG group compared to seven patients in the MO group (p = 0.776).

Based on the results of the Wilcoxon Rank Sum test, there was no statistically significant difference between the two groups in the total amount of oral pain medications given (p = 0.343), total amount of intravenous (IV) pain medication given (p = 0.891), and the overall amount of ondansetron received (p = 0.964)**(Table 2)**. Pain medication received was converted to morphine equivalents in mg/kg and then analyzed accordingly. Length of stay (p = 0.808), surgical time (p = 0.727), progression to a regular diet (p = 0.777), and time to ambulation post-operatively (p = 0.124) also were not significantly different. Both groups received an average of just over two doses of the study drug (PEG = 2.5 ± 1.2; MO = 2.3 ± 1.2 doses). Each group was given docusate for an average of 4 days (PEG= 4.8 ± 0.9 days; MO = 4.5 ± 1.2 days) as this is also local standard of care for patients after posterior spinal fusion for idiopathic scoliosis.

Variable	PEG Group (n=31)Median (range)	MO Group (n=28) Median (range)	p-value
Length of stay (hours)	127 (91 to 178)	127 (81 to 732)	0.8078
Time to mobilization (days)	2 (2 to 3)	2 (2 to 3)	0.1238
POD diet resumed	3 (2 to 4)	3 (2 to 5)	0.7769
# of bowel regimen received	3 (0 to 4)	3 (0 to 4)	0.513
Ondansetron mg/kg received	0.5 (1 to 1.7)	0.5 (0.2 to 0.9)	0.9637
MO, mineral oil; **PEG**, polyethylene glycol; **POD**, postoperative day			

Table 2: Variable Descriptions

DISCUSSION

Constipation is a common pediatric complaint, especially during the post-operative period when patients have reduced mobility, decreased intake, and receive medications with constipation being a side effect. The literature states various ways to treat functional constipation; however, evidence is lacking regarding post-operative constipation in pediatric patients. A Cochrane review of 18 randomized controlled trials that included 1643 patients and compared nine different constipation-treating medications found MO and PEG to be safe and effective treatments for pediatric constipation.[1,15]

In this study, only 16 patients had a bowel movement prior to discharge, and of these 13 required a rescue cathartic or enema. In pediatrics oral therapy is first line to assist in preventing and treating constipation; however, if unsuccessful suppositories and enemas can be administered although not preferred. Assessment of the patients during the study revealed that decreased appetite may have affected the amount of "Power Pudding" consumed, thereby reducing the total number of doses received. Decreased appetite is commonly seen post-operatively because of narcotic pain medication, decreased mobility, and increased nausea.

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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 computed tomography (CT) and T2-weighted magnetic resonance imaging (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.

Conclusions: 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.

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Liposomal Bupivacaine Mixture Has Similar Pain Relief and Significantly Fewer Complications at Less Cost Compared to Indwelling Interscalene Catheter in Total Elbow Arthroplasty*

Background: Postoperative pain control, short-term and long-term narcotic consumption, complication rates, and costs of indwelling interscalene catheter (ISC) were compared with a liposomal bupivacaine (LBC) mixture in patients undergoing primary Total Elbow Arthroplasty (TEA).

Methods: Forty-four consecutive patients were identified, the first 28 with an ISC and the later 16 with an intraoperative LBC injection that also included ketorolac and 0.5% bupivacaine. Medical records were reviewed for visual analog scores (VAS), oral morphine equivalent (OME) usage, complications, and facility charges.

Results: Average VAS scores at 24 hours, 2 weeks, 6 weeks, and 12 weeks were not significantly different. Mean OME usage was significantly greater in the LBC group at 24 hours but less at 12 weeks, although this difference was not statistically significant. Twelve anesthetic-related complications occurred in the ISC group (1 major and 11 minor); 10 (36%) patients had at least one complication. The major complication was respiratory failure requiring emergent tracheostomy. Minor complications included leaking pump/catheters, catheters inadvertently pulled out early, global hand paresthesias, forearm paresthesias, and pain at the catheter site. There were no anesthetic-related complications in the LBC group. The average charge for the LBC mixture was $327.10; charges for ISC, including equipment and anesthesia fees, were $1472.42.

Conclusion: An LBC mixture provides similar pain relief with fewer complications at a lower cost than indwelling ISC following TEA. Although the OME use in the LBC group was almost double that of the ISC group at 24 hours, there was no difference at later time points.

Level of Evidence: Level III, Retrospective Comparative Study

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Body Mass Index Significantly Affects Characterization of Glenohumeral Wear Patterns in Shoulder Arthroplasty: Axillary Lateral Radiography Versus Computed Tomography

ABSTRACT

Background: Preoperative imaging is critical in shoulder arthroplasty for understanding pathoanatomy and to prepare for glenoid component placement. Both axillary lateral radiographs and computed tomography (CT) have been advocated to guide preoperative planning. The purpose of this study was to evaluate and compare preoperative axillary lateral radiographs and axial CT slices for classification and measurement of glenoid wear, glenoid version, and glenohumeral subluxation as well as to determine the influence of body mass index (BMI) on characterization of glenoid wear patterns.

Methods: Axillary lateral radiographs and CT imaging of 88 consecutive patients who underwent shoulder arthroplasty for the diagnosis of glenohumeral osteoarthritis were reviewed. Patient demographics were also obtained. Seven blinded observers reviewed the images to classify glenoid wear (Walch and Mayo classifications) and glenohumeral subluxation (Mayo classification). Glenoid version measurements were made using Friedman's technique. After a minimum two-week period, the same observers repeated the process to obtain intra and interobserver reliability.

Statistical analysis was performed to obtain Cohen's kappa, Fleiss' kappa, intraclass correlation coefficients, and t-test and F-test probabilities. Kappa values greater than 0.8 were considered to indicate substantial agreement, values between 0.6-0.8 good agreement, values between 0.4-0.6 fair agreement and values less than 0.4 were considered to indicate poor agreement. Differences with $p<0.05$ were considered statistically significant.

Results: Of the 88 shoulders reviewed, 58 (66%) radiographs and 84 (95%) CT scans were of sufficient quality to perform each classification by all evaluators ($p<0.0001$). The average BMI of patients whose x-rays could not be entirely classified by each observer was 37 (vs. 31, $p=0.0003$). Similarly, for measurement of glenoid version, 63 (72%) radiographs and all 88 CT scans were sufficient for evaluation by all observers ($p<0.0001$). The average BMI of patients whose glenoid version could not be measured on x-ray was 38 (vs. 31, $p<0.0001$).

Kappa values for intraobserver reliability for the Walch, Mayo glenoid wear, and Mayo subluxation classification all indicated moderate agreement for x-ray and CT. Kappa values for interobserver reliability mostly indicated fair agreement.

The intraobserver reliability for measurement of glenoid version using x-ray was 0.77 (good agreement) and 0.91 (substantial agreement) for CT scan. The interobserver reliability for measurement of glenoid version using x-ray was 0.65 and 0.73 (both good agreement) for CT scan.

Conclusions: When readable, axillary lateral radiographs and axial CT imaging demonstrated similar intra- and interobserver agreement for all classifications of glenoid wear and glenohumeral subluxation in this study. However, CT imaging was significantly more likely

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to provide sufficient characterization of glenohumeral wear patterns by multiple observers; as over 1/3 of axillary lateral films were inadequate for classification and 28% were inadequate for version measurements. For axillary lateral and CT images that were unable to be fully evaluated, increased BMI factored significantly in the observers' ability to judge classifications, likely due to projection of the axillary soft tissue. Precise characterization of glenoid wear by measurement of glenoid version was more reliable with CT imaging.

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Patients Receiving Nonsurgical Management for Sacroilitis Diagnosed with Intra-articular Injection Report Positive Outcomes at Long-Term Follow-up

ABSTRACT

Background: Sacroilitis is a common cause of chronic low back pain. Diagnosis is difficult due to the lack of specific symptoms or radiographic findings and is usually accomplished through various clinical maneuvers. Utilization of a diagnostic injection into the SI joint has been adopted as a practice in order to further solidify the diagnosis of sacroilitis; however, to date it is undetermined whether or not these injections predict positive responses to future directed therapy. Our study, a retrospective review with telephone survey, provides evidence that relief with intra-articular injection more definitively confirms a diagnosis of sacroilitis and predicts positive outcomes with non-surgical management.

Methods: This is a retrospective review with telephone follow-up of 256 patients. Type of treatment, satisfaction with treatment, complications of treatment, current VAS, current pain level (better, worse, same), willingness to have treatment again if necessary, underlying inflammatory conditions, number of births, and surgical history of lumbar fusion or hip replacement were determined from the phone survey. Patients were grouped according to how they felt after initial diagnostic injection (Improved , Not Improved [NI], or No Injection [NO]). Grouping was based on a 5-point Likert scale.

Results: When patients were grouped (I, NI, NO) significantly more (p= 0.001) patients in group I, 94/128 (73%), also described themselves as better at final follow-up compared to only 19/70 patients (27%) in group NI describing themselves as better at final follow-up. 41/58 patients (71%) in the NO group described themselves as better at final follow up. Mean VAS score at final follow-up was significantly higher in the NI group (6.0 ± 3.0) compared to the I group (3.9 ± 2.8) and the NO group (3.1 ± 3.1). Significantly more patients in the I group said they would go through their treatments again (75%) compared to the NI group (29%). There were no significant differences between the groups in terms of other demographic data, inflammatory conditions, or past surgical history. Only 3 patients in the study were treated with SI joint fusion, 2 in the I group and 1 in the NI group.

Conclusion: Sacroilitis patients who respond positively to intra-articular injection of the SI joint are likely to benefit from nonsurgical management. Sacroiliac joint fusion should be postponed until conservative management fails due to risks associated with surgery.

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Tobacco Use Predicts Increased Narcotic Consumption After Elective Anterior Cervical Discectomy and Fusion

ABSTRACT

BACKGROUND: Anterior discectomy and fusion (ACDF) has been shown to provide predictable pain relief and post-operative outcomes. However, studies investigating patient-specific risk factors, including tobacco use, that may predict early post-operative outcomes, including narcotic use, are lacking. This is especially relevant during a time when opioid dependence has reached epidemic levels. At this same time, early post-operative outcomes are of particular interest given the evolution of reimbursements tied to global episodes-of-care. We proposed to evaluate post-operative pain, narcotic use, and complications in patients following elective one and two level anterior cervical discectomy and fusion who are either current tobacco users or non-users.

METHODS: After IRB approval, a database search of elective one and two level anterior cervical discectomy and fusions performed in patients with a diagnosis of cervical radiculopathy at our institution was conducted. Patients were identified as current tobacco users or non-tobacco users by health history on intake forms and clinical interview. Visual analog pain scores (VAS) were recorded at the pre-operative visit and at 2, 6, and 12 week visits after surgery. Narcotic use was recorded based on discharge medications and prescriptions given at 2, 6, and 12 week visits. This was complimented by query of a statewide narcotic prescriptions database. Readmissions, reoperations, emergency department visits, and complications data were also recorded. Statistical analyses for pre-operative and post-operative measurements were performed using student's t-tests and Fisher's exact tests with $p<0.05$ considered statistically significant.

RESULTS: Following database search, 100 elective one and two level anterior cervical discectomy and fusions were identified. There were 34 patients in the current tobacco use group and 66 patients in the no tobacco use group. There were no statistically significant differences between groups regarding gender, age, operative indication, comorbidities, or body mass index (BMI).

At 12 weeks after ACDF, VAS scores decreased from 6.9 to 3.5 ($p<0.0001$) in the tobacco use group and 6.5 to 2.2 ($p<0.0001$) in the no tobacco use group. While both groups experienced significant decreases in average VAS scores, the average VAS score at 12 weeks was significantly higher in the current tobacco group (3.5 vs. 2.2, $p=0.018$), and the improvement in VAS was significantly less in the current tobacco cohort as well (3.4 vs. 4.3, $p=0.045$). At 6 weeks after ACDF, 50% of tobacco users were still requiring narcotic pain medicine versus 29% in the no tobacco use group ($p=.048$). No statistically significant differences were found between the current tobacco use group and the no tobacco use cohort regarding complication rates (53% vs. 39% $p=0.21$), emergency department visit rates (5.9% vs. 7.6%, $p=1$), or hospital readmission rates (2.9% vs. 1.5%, $p=1$). There were no re-operations in the 90 day postoperative time period for either group.

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CONCLUSIONS: Current tobacco use is a significant predictor of increased post-operative pain and narcotic use in the global period following elective one and two level anterior cervical discectomy and fusion. Though emergency department visits, complication rates, hospital readmissions, and re-operation rates were not significantly different, tobacco users required significantly more narcotics and in general had a more difficult post-operative course than non-users. As risk stratification models evolve for bundled payment plans, current tobacco use should be identified as a predictor of a more difficult post-operative course.

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Heterotopic Ossification in Kocher-Langenbeck Approach: Risk of Reoperation Based on Gender and Race

ABSTRACT

Purpose: To determine the predictors of heterotopic ossification (HO) formation in patients who underwent fixation of acetabular fractures through a Kocher-Langenbeck approach. HO formation has been cited in up to 47% of cohort research populations and previously cited risk factors for HO including male sex, concurrent craniocerebral or thoracoabdominal trauma, T-shaped acetabular fracture, sciatic nerve injury, femoral head injury, intra-articular debris, ipsilateral femur fracture, and delay to surgery. There is a push for recognition of risk factors in HO formation with acetabular fractures in the trauma setting due to the debilitating nature of high grade HO. The goal of our study is to identify modern predictors of HO formation in patients undergoing fixation of acetabular fractures through a Kocher-Langenbeck approach. We hypothesize that male gender and African-American race will increase the risk for HO after a Kocher-Langenbeck in the treatment of acetabular fractures.

Design and Methods: Retrospective chart review of 99 patients with acetabulum fractures undergoing fixation via Kocher-Langenbeck approach at a single institution from January 1, 2006 to December 31, 2016. Clinical demographics included age, gender, race, weight, sex, BMI, ISS, time to definitive treatment, method of definitive treatment, length of hospital stay, fracture complications (superficial or deep infection; nonunion; etc.). Primary outcome was HO and defined as any radiographic evidence of HO formation within a 1-year period. Secondary outcomes include reoperation for HO excision, surgical complications, and comorbidities.

Results: 99 patients (37 female, and 62 male) underwent Kocher-Langenbeck approaches for acetabular surgery in the above time. Male patients (27%) were found to have a greater incidence of HO within one year in comparison to female patients (14%), although this was not found to be statistically significant (p=0.7). African-American patients had 22% incidence of HO in comparison to white patients (20%)(p=0.8). There were 8 (29%) females who underwent re-operations for HO resection in comparison to 0 males (p=0.002). African-American patients had 4% reoperation for HO resection in comparison to 3% white patients (p=1).

Conclusion: After a Kocher-Langenbeck approach for acetabular fracture, female patients were more likely to undergo reoperation for HO than male counterparts, which is contrary to previous literature reports. Race was not found to be a contributing risk factor for reoperation or incidence of HO in our population.

Level of Evidence: Level III Retrospective Review

Key words: Heterotopic Ossification

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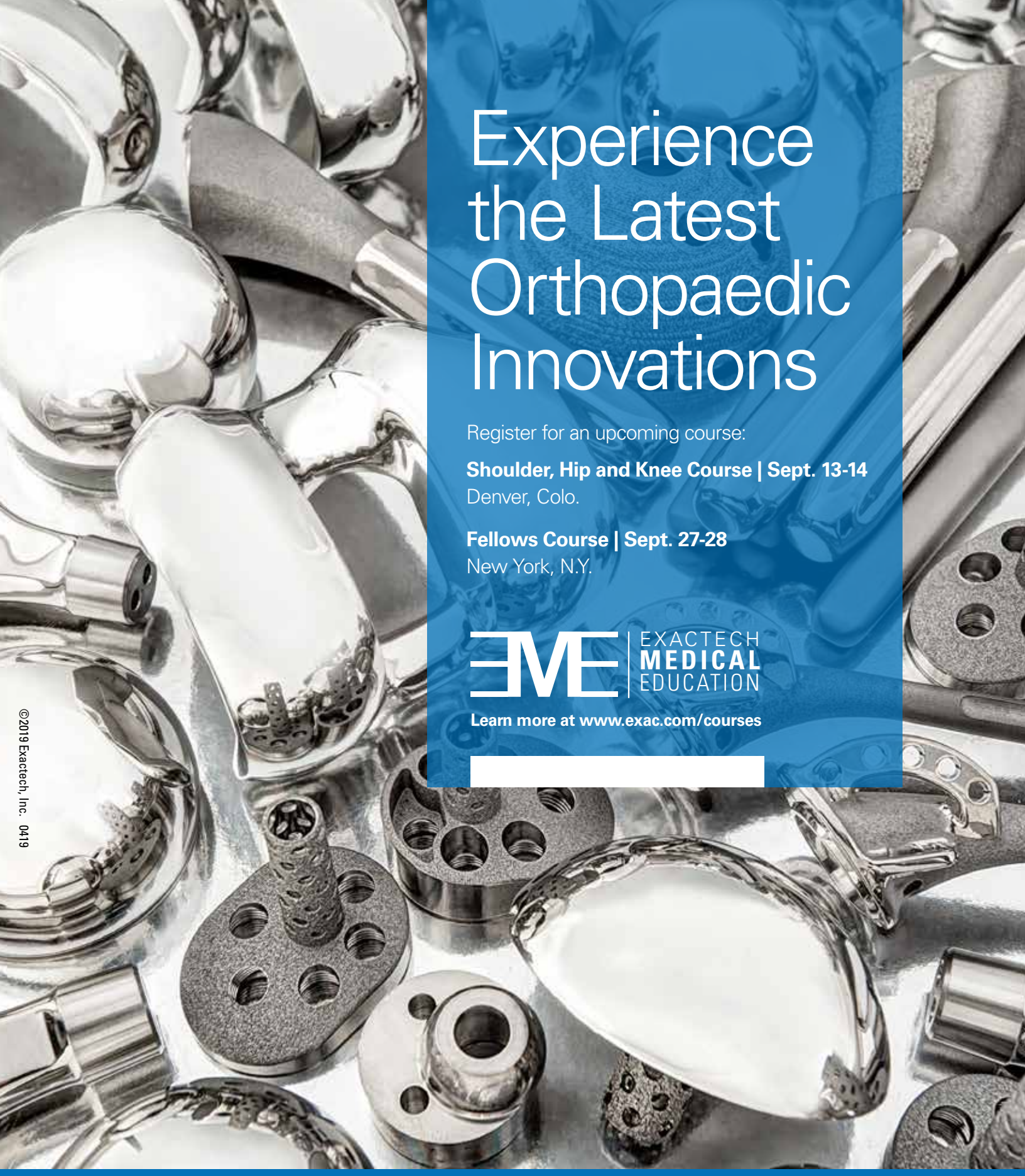

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Campbell Clinic Orthopaedics is my team's **MVP.**

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I remain intrigued and impressed by the discoveries – large and small – that emerge from clinical research. Following the lead established by the hand-selected partners of Dr. Willis Campbell, the physicians of Campbell Clinic remain dedicated to thorough study and review of their work – the results achieved by their patients following orthopaedic treatment.

Abuse of opioids is a constant newsmaker, and the physicians of Campbell Clinic are actively measuring and monitoring alternative ways to manage patients' pain – especially post-operative pain. While the projects reported on in these pages do not fully describe the breadth of work underway in this area, as the Chairman of the Board for the Campbell Foundation – the charitable trust for the physicians of Campbell Clinic, and the entity tasked with managing this clinical research effort - I have the advantage of hearing about the work now underway. And, I've watched as the group uses principles from the business world – specifically, that you can only manage what you measure – to relentlessly track projects, publications, presentations, and other ways to share our discoveries with the world. This has served to ensure that there is steady progress – these surgeons begin with the end in mind – and ask, "Where might this be useful?" "At what scientific conference, or in what peer-reviewed publication might we be able to spread this information best?"

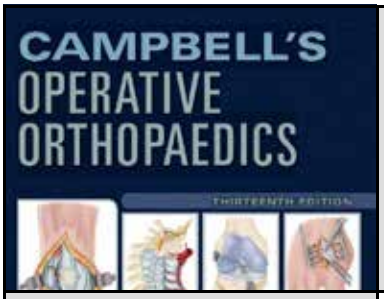
Not every physician spends time "hands-on" conducting research, but the group at Campbell Clinic is dedicated to gathering information and constantly reviewing their results. Perhaps it is related to the fact that Campbell Clinic is an academic practice, and that they are teaching others. Perhaps, some of these surgeons have an innate curiosity about a clinical observation or problem, combined with the determination to find answers. Why is this patient reacting differently to this treatment? If the result is better, how can we ensure that everyone achieves this kind of outcome? These very questions launch the research pursuit and the discoveries follow. Often, the hypothesis that is presented seems almost radical - is it possible that we could expect this kind of result if we make this kind of change?

This is why the Campbell Foundation is dedicated to supporting research. Not only has it been a part of our heritage since our founding in 1946, but it continues to deliver discoveries and innovation that transform people's lives. Reflecting on the past year, we reviewed our first year in our center for the treatment of children with cerebral palsy - a multidisciplinary center that places the patient and his family at the center of the clinical team and brings together all of the various surgeons and therapists and nursing staff to allow the child to grow to his greatest potential. Since these children are often medically fragile, we are tracking their clinical data, and have begun to "mine" the database for trends and insights into their care. We even have begun to share some of our early findings with members of the American Academy for Cerebral Palsy and Developmental Medicine, at their annual conference later this year.

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

Thank you, Campbell Alumni



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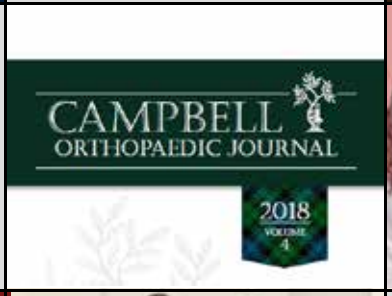

40 Residents Trained

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The Campbell Foundation wishes to thank the Alumni who supported our mission in 2018.

Thank you for making an impact!

Report from Alumni

Randy Davidson, M.D.

Campbell Club President

May, 2019

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 make the research activity that fills this issue of *Campbell Orthopaedic Journal* a reality.

During the Academy meeting in March, I enjoyed reconnecting with fellow alums and had the opportunity to meet some of the current residents and fellows – including those in class with my son, Austin – the Class of 2019. What an impressive group of young physicians. We can all be proud of them.

During the meeting, we learned that, once again, Campbell Clinic fully matched, and this new class – the Class of 2024 – represents the beginning of our second century of orthopaedic residency training – since the founding of the program in 1924. The legacy of Willis C. Campbell continues to grow. 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.

Next year, 2020, will be the 30th anniversary of my own Campbell residency graduation. I'm amazed at how much has changed since then, in terms of technology and the practice of orthopaedics. But, as I talk with my son and his fellow residents, I'm struck by how much remains the same. How the shared experience of this training program builds and shapes us not only as physicians and surgeons, but helps make us who we are – connected by a shared desire to help our patients – doing what is best for them, each and every time – while supporting and helping each other. Pursuing excellence, but with compassion for the individual at the heart of every clinical decision.

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 essential for their orthopaedic training. Thank you for your continued support.

Sincerely,
Randy Davidson '99
Campbell Club President

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AUSTIN R. DAVIDSON, M.D.
Hometown: Columbia, Tennessee

Undergraduate Institution: Lipscomb University, Nashville, Tennessee

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

Dr. Davidson, second of six children, had a wonderful childhood. He and his wife Molly, a Speech Pathologist, met through mutual friends in Memphis. They have been married since 2012, and are the proud parents of their daughter, Nola, who is two.

Dr. Davidson chose to pursue a career in medicine because he has always enjoyed helping others and fixing things; medicine appeal to his love of science and he appreciated the logic in solving problems.

His first exposure to orthopaedics came from his father, and he always considered following his wonderful example. (Dr. Randy Davidson, '90, currently serves as President of Willis C. Campbell Club Alumni Association.) Dr. Davidson shared, "I like the gratification of putting things back together and attempting to get people back to their normal activities.

Plans After Campbell: Dr. Davidson will complete a Foot & Ankle Fellowship at Harvard in Boston, Massachusetts, and then will join Knoxville Orthopaedic Clinic in Knoxville, Tennessee.

Dr. Davidson adds, *"Thanks to all the staff for allowing me to assist in taking care of your patients and taking the time to teach. Thanks to the Class of 2019 for making it an enjoyable 5 years. Thanks to Memphis for being a wonderful home for the past 9 years. And most importantly, thanks to Molly and Nola for bringing joy and support."*

STEVEN M. DELBELLO, M.D.
Hometown: Fort Wayne, Indiana

Undergraduate Institution: Rhodes College, Memphis, Tennessee

Medical School: University of Texas Medical School at Houston, Houston, Texas

Dr. DelBello, the oldest of four children, grew up in a family of physicians, including his mother and father, grandfather, and two uncles – but he will be the first orthopaedic surgeon. He met his fiancée, Jennifer, an Educational Administrator, on a blind date, in Houston. They will be married this June.

Dr. DelBello wanted to "go into the family business" as a physician, and he chose orthopaedics because it allows him to help others remain physically active to pursue their lifelong goals.

Plans After Campbell: Dr. DelBello will complete a Sports Medicine Fellowship at Mississippi Sports Medicine and Orthopaedic Center in Jackson, Mississippi.

Dr. DelBello commented, *"A huge thanks to my fellow residents for being the best group of friends to work with day in and day out, and a big thanks to the faculty for guiding me on the path to a successful orthopaedic career."*

DONALD B. FRANKLIN, M.D.
Hometown: Signal Mountain, Tennessee

Undergraduate Institution: Samford University, Birmingham, Alabama

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

Dr. Franklin is the oldest of three children. He is following his father, a nephrologist, in medicine. Dr. Franklin is not yet married, but hopes to find a spouse with a trust fund, who will fall in love with his fur baby, Cooper, a 9-year old yellow Labrador retriever.

Dr. Franklin chose a career in medicine through a process of elimination, in his words because, *"my eyesight wasn't good enough to be a fighter pilot and I'm too weak for professional body building."*

His love of power tools led him to orthopaedics.

Plans After Campbell: In jest, he wants to disappear somewhere on a boat, but he will first complete a fellowship in Sports Medicine in Taos, New Mexico.

Dr. Franklin left these remarks: *"Many thanks to all of my mentors and peers for their patience with me over the past 5 years. It was a true blessing getting to know each of you. Roll Tide!"*

CLAY G. NELSON, M.D.
Hometown: Rocky Mount, North Carolina

Undergraduate Institution: University of North Carolina, Chapel Hill, North Carolina

Medical School: Eastern Virginia Medical School, Norfolk, Virginia

Dr. Nelson is the third of four children in the Nelson family, and the third physician, and following in his father's footsteps into orthopaedics. He and his wife Julia, a Teacher, met while in college at UNC. They have been married since 2012, and are the proud parents of Mason, 2.5, and Jackson, born earlier this year.

Dr. Nelson's interest in medicine began at a young age spending his weekends rounding in the hospital with his father and working with him in a free sports medicine clinic for high school athletes. He knew early on that he wanted a career in medicine from these early experiences.

He chose orthopaedics for the way it allows him to help his patients get back to their desired level of function. Helping his patients achieve their goals through both surgical and non-operative measures is a very gratifying profession.

Plans After Campbell: Dr. Nelson will complete a Sports Medicine Fellowship in Jackson, Mississippi.

Dr. Nelson wishes to thank many, offering, *"Thank you to all of the faculty, residents, and staff at the Campbell Clinic. Each of you have had an impact on my training, and I am forever grateful for the time I have spent with each of you."*

MIMS G. OCHSNER, III, M.D.
Hometown: Savannah, Georgia

Undergraduate Institution: University of Georgia, Athens, Georgia

Medical School: Mercer University School of Medicine, Savannah Georgia

Dr. Ochsner is the middle child of three in a medical family. His great grandfather, his grandfather, his father and his brother are all physicians. He met his wife, Piper, a Tech Recruiter, through mutual friends in Savannah. They have been married since 2016, and are the proud parents of their daughter, Eleanor Rawls, who is nearly two.

Dr. Ochsner chose to pursue a career in medicine because it provides him the opportunity to altruistically pursue his passions for anatomy and physiology.

Dr. Ochsner chose orthopaedics because he enjoys the eclectic catalog of surgical interventions, the tools used in the O.R., and the pathology of acute injuries and chronic ailments. He also enjoys being part of a multi-faceted team including radiology technicians, physical and occupational therapists, ortho Pas/NPs and other orthopaedic surgeons.

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

Dr. Ochsner said, *"I want thank the faculty at Campbell Clinic for the lasting mark they have made on me. I would also like to thank Tonya Priggel, Kay Daugherty, and Keidra Willis for their assistance and support."*

COLIN W. SWIGLER, M.D.
Hometown: Panama City, Florida

Undergraduate Institution: University of Florida, Gainesville, Florida

Medical School: Florida State University College of Medicine, Tallahassee, Florida

Dr. Swigler looks up to his older sister, and is the first in his family to choose medicine.

Dr. Swigler states that when he was young, he found himself frequently visiting the E.R. for asthma attacks, minor injuries, and sutures, etc. He watched as the physicians treated others and was inspired by their ability to help people during times of need.

He noted that he had always enjoyed finding a way to fix things that were broken. When he scrubbed into his first orthopaedic case as a third year medical student, he *"immediately realized that this was exactly where I wanted to be. The ability to significantly improve the outcome of a disease process or injury for a person is very gratifying, and the patient's appreciation after a successful case makes every hour of training worthwhile."*

Plans After Campbell: Dr. Swigler will complete a Fellowship in Hand Surgery at the University of Florida in Gainseville, Florida.

Dr. Swigler *"wishes to thank the faculty and staff for their endless commitment to our education, for their patience during the process, and for the personal sacrifices made by each while contributing to our future as orthopaedic surgeons"*

KIRK M. THOMPSON, M.D.
Hometown: Harrisburg, Illinois

Undergraduate Institution: Rose-Hulman Institute of Technology, Terre Haute, Indiana

Medical School: Southern Illinois University School of Medicine, Springfield, Illinois

Dr. Thompson is older by one-minute to his twin sister. He is the first in his family to pursue a career in medicine. He says he grew up admiring the physicians in his small hometown and has always respected those who help others. The medical field provides an opportunity to make a real difference in others' lives.

He chose orthopaedic surgery because of orthopaedic surgeons' ability to fix problems. He said orthopaedic surgeons are *"able to see the almost immediate impact of their interventions on patient problems and that is very rare in other specialties. The power tools are pretty fun to use, too."*

Plans After Campbell: Dr. Thompson will complete a Fellowship in Spine Surgery at OrthoCarolina in Charlotte, North Carolina, and then will join the Campbell Clinic.

Dr. Thompson states, *"Thanks to all the faculty and staff for the sacrifices and countless hours of instruction you provide to all residents. I am grateful for the opportunity to have trained at The Campbell Clinic"*

JORDAN D. WALTERS, M.D.
Hometown: Augusta, Georgia

Undergraduate Institution: Furman University, Greenville, South Carolina

Medical School: Wake Forest University, Winston-Salem, North Carolina

Dr. Walters has one older sister, and follows others in his family to pursue a career in medicine, including his father and grandfather. He met his wife, Mary Grace Walters, a Marketing Manager at Flow Automotive Group, through mutual friends in college at Furman University. They have been married since 2011, and are the proud parents to Joshua (age 4) and Luke (age 2).

He was greatly influenced by a medical missions trip to Honduras in college. He enjoys the work of bringing healing and restoration to God's creations as a reflection of the gospel. He chose orthopaedic surgery because he felt that the culture was the best fit for him. He added, *"I enjoy working with my hands, and I am fascinated by the musculoskeletal system."*

Plans After Campbell: Dr. Walters will complete a Fellowship in Sports Medicine at the University of Virginia in Charlottesville, and then will join a group in Tallahassee, Florida.

Dr. Walters says, *"I would like to thank the sports medicine doctors who have guided me through my journey. I would also like to thank the trauma doctors who more than anyone taught me how to operate and care for patients skillfully. I would also like to thank the residents who have been there for us to help bear the load of training."*

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

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TAYLOR R. BEAHRS, M.D. • Foot & Ankle Fellow
Hometown: North Oaks, Minnesota

Undergraduate Institution: Gustavus Adolphus College, St. Peter, Minnesota

Medical School: University of Illinois College of Medicine, Chicago, Illinois

Orthopaedic Residency: Mayo Clinic, Rochester, Minnesota

Dr. Beahrs is the youngest of two children, and both his father (urology) and mother (cardiology) are physicians. In 2007, he married his high school sweetheart, Ruthie, who is a homemaker and they are the proud parents of Oliver (7), Earl (5) and Harry (3).

Dr. Beahrs grew up liking science and anatomy, and he likes helping people. His parents were a great example to him as he saw what a rewarding career medicine could be.

Dr. Beahrs was drawn to orthopaedic surgery because it provides an ability to solve structural problems and he has an interest in musculoskeletal anatomy. He stated that he likes helping people get back to the activities they love.

Plans After Campbell: After Fellowship, Dr. Beahrs plans to move back home and begin working for the Mayo Clinic Health System.

Dr. Beahrs adds, *"I really appreciate getting to know the residents at Campbell Clinic. They are a very impressive group. Thanks to Drs. Murphy, Bettin, Richardson, and Grear for the hours spent training. Thanks to my co-fellow, Dr. Reagan."*

DANIEL W. BROWN, M.D. • Pediatrics Fellow
Hometown: Torrance, California

Undergraduate Institution: Brigham Young University, Provo, Utah

Medical School: Duke University, Durham, North Carolina

Orthopaedic Residency: University of California San Francisco, Fresno, California

Dr. Brown grew up in a household with three older sisters. His father and brother-in-law are both radiologists. He met his wife, Ani, while working on a farm and ranch in Idaho. They were married in 2009 and are the parents of Camilla (8), Naomi, (6), McKay (3) and Eliza (1).

Dr. Brown jests that medicine was his backup plan after nothing else worked out.

He chose orthopaedics because he enjoys working with his hands, fixing broken things, studying and understanding anatomy and mechanical relationships, and using power tools. His interest in pediatric orthopaedics is from his interest in helping kids.

Plans After Campbell: Dr. Brown will join a private practice in Anchorage, Alaska following graduation.

Dr. Brown states, *"Thank you to all the pediatric staff; it has been a great year and wonderful learning experience. Thank you to the entire Campbell Clinic for making it possible."*

JACOB T. DAVIS, M.D. • Orthopaedic Trauma Fellow
Hometown: Fort Worth, Texas

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

Medical School: University of Texas McGovern School of Medicine, Houston, Texas

Orthopaedic Residency: JPS Health Network, Fort Worth, Texas

Dr. Davis is the youngest of three brothers. His father, Jerry T. Davis, DO, is a family physician. He met his wife, Mindy, in the operating room during a scoliosis case; she was the X-ray tech and it was love at first sight. They have been married since 2017, and are the proud parents of son Jameson, who is one.

Dr. Davis chose to pursue a career in medicine because it is an amazing opportunity that allows him to serve, help, and connect with people during their time of greatest need. He chose orthopaedics because it allows him to definitively fix problems, restoring a patient's mobility and function.

Plans After Campbell: Dr. Davis will enjoy an orthopaedic trauma practice at Baylor, Scott & White Hillcrest Hospital in Waco, Texas.

Dr. Davis wishes to thank his mentors at Campbell, stating, *"Thanks to the trauma faculty for all they have done for me and taught me. Thank you to Dr. Rudloff for teaching me how to hit home runs with reductions and how to spot a classy beard cover. To Dr. Weinlein for teaching me about real pizza, millennials, and Bon Jovi songs. To Dr. Beebe for teaching me about billing and every that he has 'published a study on.' And to Dr. Perez for all of the 'what am I thinking?' questions and advice on life and careers. Thank you to all of the residents for all of the help and hard work. I have learned more from them than I could ever teach."*

JAMES T. REAGAN, M.D. • Foot & Ankle Fellow
Hometown: Chattanooga, Tennessee

Undergraduate Institution: East Tennessee State University, Johnson City, Tennessee

Medical School: Quillen College of Medicine, East Tennessee State University, Johnson City, Tennessee

Orthopaedic Residency: Marshall University Orthopaedics, Huntington, West Virginia

Dr. Reagan is the second of four children in the Reagan family, and the first to choose a career in medicine. He married Carolyn, a Dental Assistant, in 2013, and they are the proud parents of Russell (3) and twins Charlotte (1) and Collins (1).

Dr. Reagan chose to pursue a career in medicine because he wanted to join a respected profession and make a difference in people's lives.

Dr. Reagan chose orthopaedics because he likes working with his hands and has always enjoyed mechanical work and putting things together. The actual work of orthopaedics in the O.R. is both enjoyable and satisfying.

Plans After Campbell: Dr. Reagan will start a practice in Knoxville with Tennessee Orthopaedic Clinic.

Dr. Reagan states, *"I appreciate being welcomed into the Campbell Clinic family for a year. I am very happy with my decision to pursue the Foot & Ankle Fellowship here, and I am sincerely thankful to the fellowship staff for helping to further my education."*

PATRICK J. SMITH, M.D. • Sports Medicine Fellow
Hometown: Saint Petersburg, Florida

Undergraduate Institution: Yale University, New Haven, Connecticut

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

Orthopaedic Residency: University of South Alabama Medical Center, Mobile, Alabama

Dr. Smith, is the youngest of three children of alumnus Michael J. Smith, who graduated from Campbell Clinic in 1978. His uncle is also an orthopaedic surgeon.

Dr. Smith chose to pursue a career in medicine because no other career lets you directly influence other people's attitudes and physical well-being like medicine can. He selected orthopaedics because, as he states, *"no career in medicine is better equipped to take care of athletes….. and power tools!"*

Plans After Campbell: Dr. Smith will work in private practice in Saint Petersburg, Florida.

To the Campbell team, Dr. Smith notes, *"We have the best faculty; they are such gentlemen and I would be proud and happy to send any family member to come see them. They are patient with the learner, and have fantastic techniques to teach."*

JOHN C. WU, M.D. • Hand Fellow
Hometown: London, Ontario CANADA

Undergraduate Institution: Queens University, Kingston, Ontario CANADA

Medical School: State University of New York Upstate Medical University, Syracuse, New York

Orthopaedic Residency: Beaumont Health Systems, Royal Oak, Michigan

Dr. Wu has one older sister, Hannah, who is a pathologist. He met his wife McKenna Knych, an E.R. physician, while in school, and they've been married since 2014. They are the proud parents of Quinn (3) and Maeve (1).

Dr. Wu chose to pursue a career in medicine because, in addition to being to help others, he was intrigued by the challenges that medicine offered.

He chose orthopaedics because it is a great specialty that makes a difference on people's daily lives. Dr. Wu adds, *"Orthopaedics and its surgeries are fun. Having the chance to help other while enjoying what I do is all I can ask for in a career."*

Plans After Campbell: Dr. Wu will complete a Shoulder & Elbow Fellowship followed by private practice.

Dr. Wu wishes to thank many, saying, *"Thanks to all of Campbell Clinic (faculty, residents, office staff and assistants, OR staff, X-ray and the Foundation) for a great year. I appreciate your welcoming attitudes and all of your kindness (and patience) during my hand fellowship. Thanks for lunch."*

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Current Orthopaedic Residents

INTERNS

Seth R. Cope, M.D.
Undergraduate: Brigham Young University
Medical School: University of Texas School of Medicine at San Antonio

Austin Hardaway, M.D.
Undergraduate: The University of Alabama
Medical School: University of Tennessee Health Science Center College of Medicine

Hayden S. Holbrook, M.D.
Undergraduate: Wake Forest University
Medical School: Wake Forest School of Medicine

Caleb A. Jones, M.D.
Undergraduate: Tyler Junior College
Medical School: University of Texas School of Medicine at San Antonio

Anthony J. Marois, M.D.
Undergraduate: Wake Forest University
Medical School: Wake Forest School of Medicine

Zachary A. Mosher, M.D.
Undergraduate: Auburn University
Medical School: University of Alabama School of Medicine – Huntsville

Daniel J. Smigielski, M.D.
Undergraduate: University of Alabama
Medical School: University of Tennessee Health Science Center College of Medicine

Eric D. Villereal, M.D.
Undergraduate: University of Mississippi
Medical School: University of Tennessee Health Science Center College of Medicine

CLINICAL YEAR 2

Nathaniel B. Alexander, M.D.
Undergraduate: University of Arkansas
Medical School: University of Arkansas for Medical Sciences College of Medicine

Stephanie N. Chen, M.D.
Undergraduate: Case Western Reserve University
Medical School: University of Toledo College of Medicine

Travis B. Eason, M.D.
Undergraduate: North Carolina State University
Medical School: Brody School of Medicine at East Carolina University

Richard A. Hillesheim, M.D.
Undergraduate: Washington University in St. Louis
Medical School: Sidney Kimmel Medical College at Thomas Jefferson University

Austin B. Murphy, M.D.
Undergraduate: Samford University
Medical School: University of Alabama School of Medicine

David L. Parker, M.D.
Undergraduate: Brigham Young University
Medical School: University of North Dakota School of Medicine and Health Sciences

Naveen Pattisapu, M.D.
Undergraduate: University of Texas at Austin
Medical School: Baylor College of Medicine

Devon Tobey, M.D.
Undergraduate: University of Georgia
Medical School: Mercer University School of Medicine

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Current Orthopaedic Residents

CLINICAL YEAR 3

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

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

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

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

Matt 'Jejo' Matthew, M.D.
Undergraduate: University of Kansas
Medical School: University of Kansas School of Medicine

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

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

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

CLINICAL YEAR 4

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

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

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

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

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

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

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

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

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