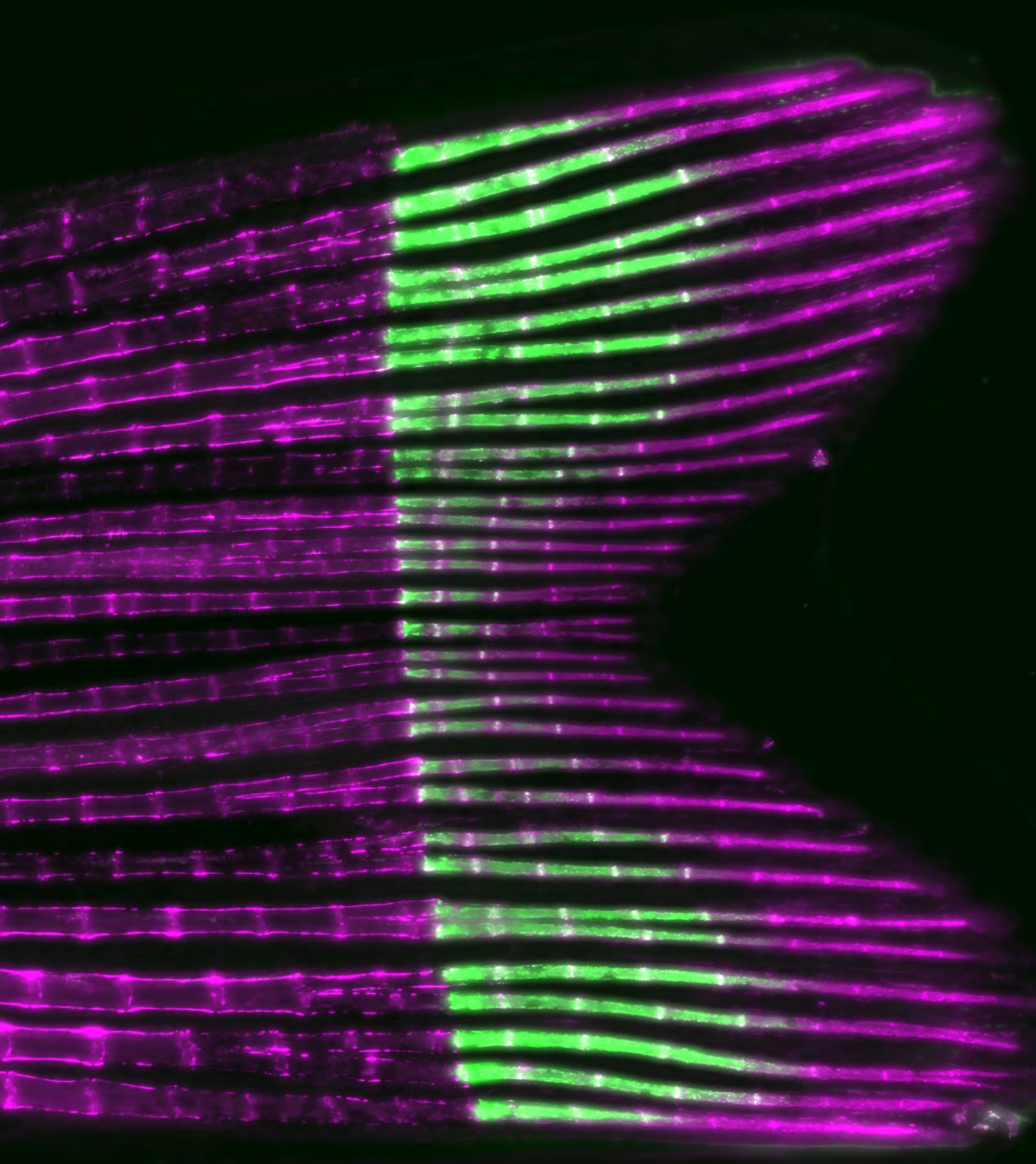
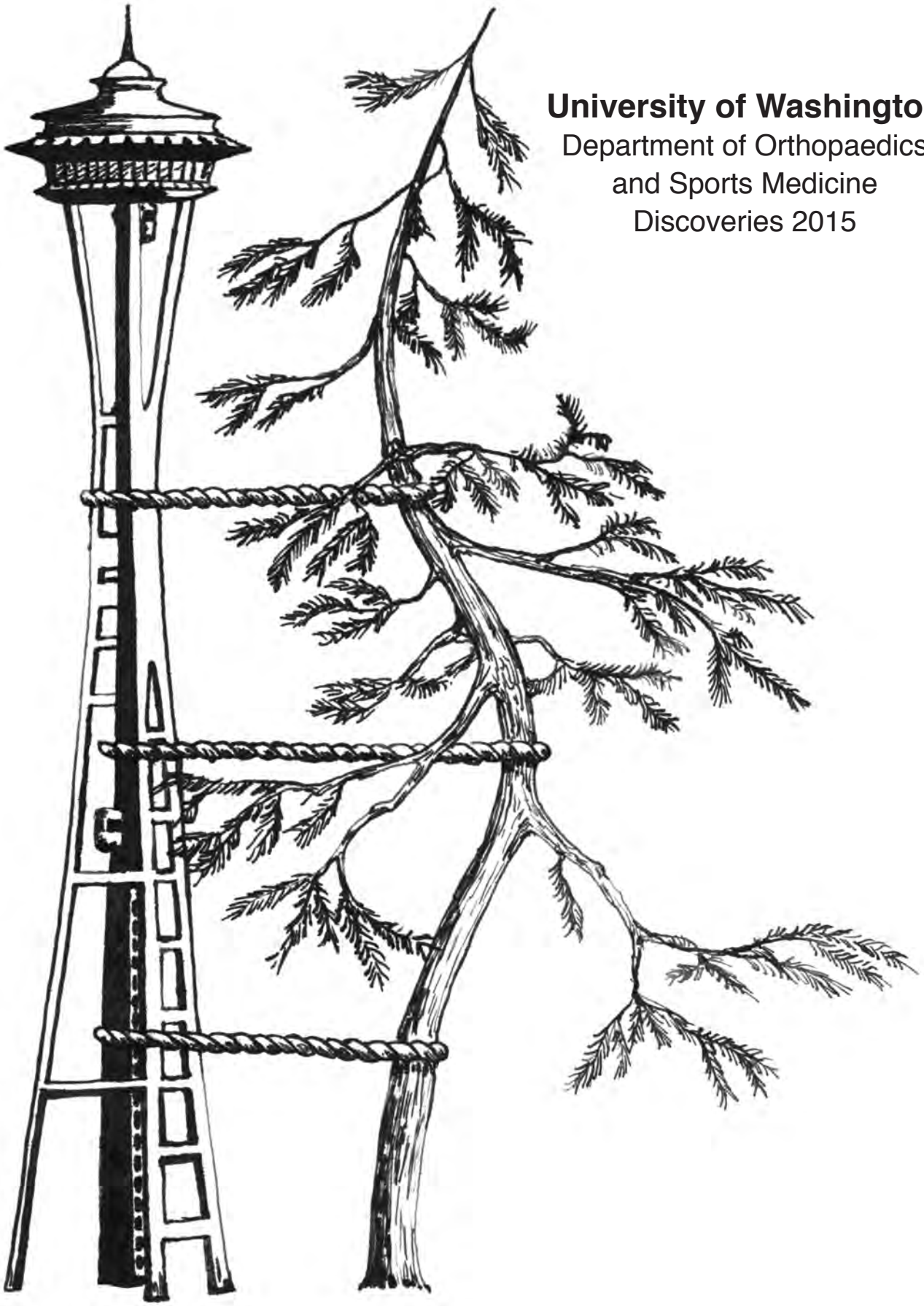


DISCOVERIES 2015

University of Washington Orthopaedics & Sports Medicine



University of Washington

Department of Orthopaedics
and Sports Medicine
Discoveries 2015

UW Medicine
SCHOOL OF MEDICINE

Department of Orthopaedics and Sports Medicine
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Front Cover Illustration: Ray-finned fishes such as zebrafish possess a remarkable ability to regenerate their bony fin rays following amputation. The image depicts the bony rays of a zebrafish subjected to partial fin amputation, and labeled with calcium-binding dyes at two different time points (green: 7 days post amputation, purple: 14 days post amputation) to label newly mineralized bone tissue. The transparency of the fin enables newly regenerated bone to be visualized within a living fish. The image was taken at the Kwon lab using high-resolution fluorescence microscopy.

A pdf of this publication is available at our website:
www.orthop.washington.edu. Or, connect using the QR code below:

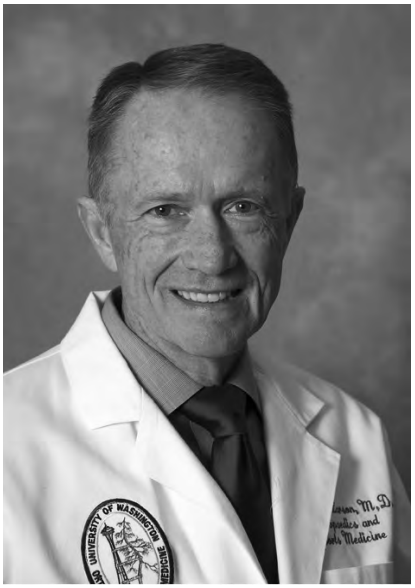
Contents

Foreword

This year has been one of growth and further practice maturation for the Department of Orthopaedics and Sports Medicine. We have had several transitions this year, most notably several new recruitments and the upcoming retirement of Roger V. Larson, MD.

Dr. Larson attended the University of Utah for both medical school and his orthopaedic residency. After a fellowship in sports medicine at the Cincinnati Sports Medicine & Orthopedic Center he joined the faculty of the University of Washington in 1982. As a member of our Department, Roger made seminal contributions to the science of the placement of anterior cruciate ligament grafts as well as to the reconstruction of patella tendon injuries. Roger also served as Chief of the Sports Medicine Clinic. In his capacity as a surgeon, Roger's clinical expertise in knee surgery is legendary and thus it is no surprise that he operated on the knees of many Husky athletes and UW faculty of the years. Roger was himself an athlete and he participated in many marathons, including the prestigious Boston Marathon. In addition he was a much beloved Residency Director who each year would introduce the residents at the graduation banquet with grace and diplomacy. On a personal note, Roger was very welcoming when I moved to Seattle in 1992 and like others in the Department and University, I have greatly valued his friendship over the years.

The department's scientific and clinical future is secure as we continue to recruit stellar young faculty. This year we were fortunate to recruit three new faculty members directly out of their fellowships. Jason Hsu, MD joined us at the University of Washington Medical Center, Adam Sassoon, MD at Northwest Hospital

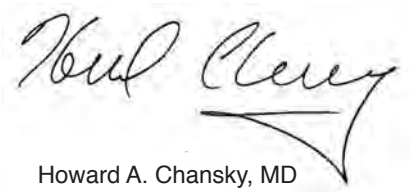


Roger V. Larson, MD

and Maryse Bouchard, MD at Seattle Children's Hospital. Dr. Sassoon's expertise is in total joint surgery as well as hip preservations surgery. Dr. Bouchard's expertise is in limb lengthening and deformity correction as well in pediatric foot and ankle surgery. Dr. Hsu specializes in shoulder and elbow surgery. We expect each of these surgeons to respect the great traditions of our department while also challenging conventional wisdom. Suzanne Yandow, MD is also a new recruit though she came to us from her mature practice and role as Chief of Pediatric Orthopaedics at the University of Utah. Dr. Yandow is assuming the position of Chief of Pediatric Orthopaedics previously held by Ernest "Chappie" Conrad, MD. After many years or remarkable service to the Department and Seattle Children's Hospital, Dr. Conrad desired to focus on his clinical practice. Under Chappie's leadership we saw dramatic growth in pediatric orthopaedics, joint appointments of non-surgeons to care for and help triage the many children that do not require surgery as well as the formation of robust ties to the local school athletic programs. We are most grateful for Chappie's years of leadership of pediatric orthopaedics.

We are fortunate to have a remarkably talented and loyal group of alumni. They have been very generous in their support of the Department and the residency. We have several firsts this year that are directs results of our loyal alumni. The Washington State Orthopaedic Association has agreed to invite all UW Medicine orthopaedic faculty to the alumni reception at the annual AAOS meeting. This year we had a great turnout at the reception held at the Paris Hotel in Las Vegas. This summer we will have our first combined alumnus and faculty barbecue. Mark Freeborn, an alumnus of our residency and spine fellowship, and his wife Jayme have kindly offered to host this event. More details to come on what we hope will become an annual event.

Finally, much gratitude to Fred Westerberg, Program Operations Specialist at the UW and a jack of all trades. Fred's "herding", organizational and editing skills are what makes this publication possible. Please enjoy our 2015 edition of Discoveries and feel free to contact Fred or myself with comments or suggestions for future issues.



Howard A. Chansky, MD
Professor and Acting Chair

In Memorium: John M. Clark, Jr., MD, PhD

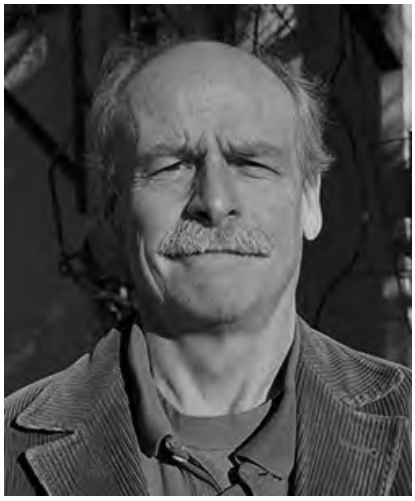
March 16, 1948 - April 13, 2015

After a long illness, Dr. John M. Clark passed away on the morning of April 13th, 2015. For many years, John was a dear friend and mentor of mine, and of many other orthopaedic colleagues around the country and the world.

Dr. Clark completed his undergraduate studies at the University of Kansas and he received his PhD in anatomy as well as his medical degree at the University of Chicago. After his orthopaedic residency at the University of Washington, John pursued a total joint fellowship in London with MAR Freeman in 1981. Eventually returning to our Department, he was a dedicated clinical and research mentor to many residents, medical students and faculty, many of whom remained in contact with him long after they completed their training.

Well before it was mainstream, John was a powerful advocate for diversity in surgery and this was reflected in his support of his wife Pat Gorai's own career as an orthopaedic surgeon. John would often bring up the issue of under-representation of women and minorities in orthopaedic surgery and as with many other issues related to inclusiveness and social justice, he was always passionate in his beliefs. Many of us, myself included, viewed ourselves as members of John's and Pat's extended family.

John also treated his patients as family and I continue to care for many of his former patients who remained fiercely loyal to him. These patients consistently refer to Dr. Clark's honesty and compassion. Testifying to his surgical expertise, these patients continue to do remarkably well many years after their joint replacement or fracture surgery. His knowledge of anatomy and the history of many aspects of orthopaedic surgery were unparalleled and no doubt contributed to his skills. John's deep insight into orthopaedic issues led to him being a respected reviewer of scientific manuscripts. He was a consistant reviewer for several journals inclding the Journal of Bone and Joint Surgery John's enthusiasm extended to the realm of orthopaedic research. Some of his important scientific contributions enhanced our understanding of rotator cuff anatomy as well as the response of articular cartilage to injury and mechanical load.

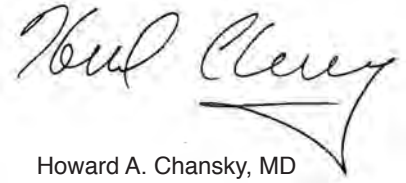


(Above) John Clark and (middle) with Peter Hall, PA, and (below) with his wife Pat.

Those that knew him would surely agree that John was a raconteur who could discuss almost any topic with insight and humor, and often for hours on end. I enjoyed every moment of these conversations that I was fortunate enough to have on many occasions over the years. I am sure other colleagues will agree that we will be the worse for no longer being able to debate and learn from John.

As John often liked to say in response to a question, "there are three things" about him that I want to mention in closing. He had a huge heart and when you were a friend of John's, you were a friend for life. He was a dedicated father to his son Andrew and a devoted husband to his wife Pat. Finally, he was a kind, generous and decent man who thought deeply about how to positively influence the world around him.

Sincerely,



Howard A. Chansky, MD
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New Faculty

Maryse Bouchard, MD

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Maryse Bouchard, MD joined our faculty as an Acting Assistant Professor at Seattle Children's on March 1, 2015. Dr. Bouchard is from Montreal, Quebec where she attended Dawson College and obtained her medical degree at McGill University. She completed her orthopaedics residency at the University of Toronto in Ontario. While there, she also obtained a Masters' of Science. She investigated the access to orthopaedic care and medical devices in low-income countries. Her research enabled her to work in Uganda and Rwanda in 2010. Maryse's fellowship training began with a year of adult foot and ankle surgery. She completed a clinical and research fellowship under Dr. Tim Daniels at the University of Toronto, and trained with Dr. Thibault Leemrijse's team in Brussels, Belgium. Preferring to care for children, she then elected to pursue a second fellowship at the Seattle Children's Hospital in general pediatric orthopaedic surgery. Prior to joining on staff at Seattle Children's and the University of Washington, she completed a fellowship in adult and children lower limb reconstruction at the Royal Children's Hospital in Melbourne, Australia with Mr. Leo Donnan. Maryse's main interests are in treating foot and ankle deformities and injuries, such as clubfoot and fractures, lower limb deformities including leg length differences, and children with genetic bone and soft tissue disorders. Her research focuses on management of the above diagnoses, but also access to health care both at home and in low-income countries, corruption in health care, and socioeconomic impacts of disability after injury. She also enjoys traveling and keeping active, especially with weightlifting and kettlebell training.

Jason E. Hsu, MD

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Dr. Jason Hsu is the newest member of our shoulder and elbow team. He joined our department in September 2014. Jason attended medical school at Northwestern University and then completed his residency at the University of Pennsylvania. During his residency, he spent a dedicated year working at the McKay Orthopaedic Research Laboratory. Prior to joining the University of Washington, he completed a shoulder and elbow fellowship at Washington University in Saint Louis.

Dr. Hsu has extensive experience in laboratory research. He spent significant time during his undergraduate and medical school years working in the biomechanics laboratory of Dr. Li-Qun Zhang and more recently worked with Dr. Lou Soslowsky at the McKay Orthopaedic Research Laboratory. There, he focused on utilizing the rat rotator cuff model to investigate joint damage after rotator cuff injury and recovery after rotator cuff repair.

He has been published in multiple peer reviewed periodicals including the Journal of Orthopaedic Research, Journal of Biomechanics, Journal of Shoulder and Elbow Surgery, the Journal of Bone and Joint Surgery, Clinical Orthopaedics and Related Research, and Arthroscopy. His current research interests focus on outcomes after shoulder arthroplasty and the diagnosis, prevention, and treatment of Propionibacterium infections after shoulder arthroplasty.

New Faculty

Adam A. Sassoon, MD

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Dr. Adam Sassoon is a dual-fellowship trained orthopedic surgeon with expertise in joint preservation, joint replacement, and orthopedic trauma. Dr. Sassoon currently focuses his clinical efforts on revision and primary total joint replacement of the hip and knee, partial joint replacement, hip resurfacing, hip arthroscopy, hip preservation procedures (periacetabular osteotomies and surgical dislocations), and post-traumatic reconstruction.

Dr. Sassoon completed his orthopedic surgery residency at the Mayo Clinic in Rochester, MN. While in residency, he also completed a Master's Degree in Biomedical Science based on work focusing on tissue engineering using adult derived stem cells. He was given the H.A. Peterson Award for scholarly writing, and was a finalist for the Patrick J. Kelly Research Award for works completed during this time. Additionally, he was the first individual to be awarded three separate Mayo International Health Program Grants for orthopedic outreach in Central America performed while in residency.

Following residency, Dr. Sassoon completed an orthopedic traumatology fellowship at Orlando Regional Medical Center and a subsequent fellowship in hip and knee preservation, resurfacing, and replacement at Washington University in St. Louis. During these two years, Dr. Sassoon performed and assisted in over 1500 surgeries.

Dr. Sassoon has also devoted himself to advancing the field of orthopedic surgery. He has contributed over 20 original, peer-reviewed, scientific articles to the medical literature, and authored multiple book chapters in orthopedic surgical texts. His research has also been showcased in regional and national orthopedic scientific meetings on over 40 occasions.

New Faculty

Suzanne M. Yandow, MD

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Suzanne Yandow, MD joined our faculty as Professor and Chief of Pediatric Orthopaedics on January 1, 2015. Most recently she was the Chief of Staff of Shriners Hospital in Salt Lake City and Chief of Pediatric Orthopedics at the University of Utah. Dr. Yandow received her medical degree at the University of South Florida. She completed her internship in general surgery and residency in Orthopaedic Surgery at the University of Utah serving as Chief Resident in her final year of residency. Dr. Yandow finished a one-year orthopaedic oncology fellowship in at the University of Florida with Dr. William Enneking and Dr. Travis Heare. She was the Dorothy and Bryant Edwards Fellow at the Texas Scottish Rite Hospital for Crippled Children. Dr. Yandow was appointed to Assistant Professor with the Department of Orthopaedics at the University of Utah from September 1992 through 1999 with a promotion to Associate Professor in May 1999 and served as the Assistant Chief of Staff for Shriners Hospital for Children in Salt Lake City. From September 2000 through 2002 she was an Associate Professor of Surgery and Pediatrics at the John A. Burns School of Medicine at the University of Hawaii. Other responsibilities included the Director of Research for the University of Hawaii, Department of Orthopedics. She taught medical student anatomy and developed a course for Physical Diagnosis of the Spine and Extremities for all of the John A. Burns School of Medicine (JABSOM) medical students. Dr. Yandow was promoted to Professor of Surgery at the JABSOM, University of Hawaii in 2002 and served as the Assistant Chief of Staff at the Shriners Hospitals. She was appointed Clinical Professor of Orthopaedic Surgery at the University of Texas Medical Branch, Austin, Texas, in 2008 and served on the IRB for Dell Children's Hospital and pediatric musculoskeletal oncologic surgeon at Dell Children's Hospital. She was the founding Medical Director of the One Health Initiative that involved a multidisciplinary collaboration with The School of Veterinary Medicine at Texas A&M University, which is an approach to medical and veterinary student teaching and research in an attempt to benefit humans and animals as well as the ecosystem. She remains an Adjunct Professor of Veterinary Science at Texas A&M and the School of Medicine. Following her 7 years in Texas she returned to Salt Lake City as a Professor of Orthopedics and Chief of Staff of the Shriners Hospital for Children before accepting the position as Chief of Orthopedics and Sports Medicine at Seattle Children's Hospital. Her research has focused on pediatric benign bone tumors and bone cyst. She and her husband, Thomas Samuel Shomaker, MD, JD, have three grown children living in both Australia and Colorado.

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Claire Watson, PhD

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Visiting Lecturers

2015 LeCocq Lectureship

Thursday & Friday, January 29-30, 2015

We were happy to have Dr. Andrew R. Burgess visit us as the guest lecturer for the 2015 LeCocq Lectureship. On Thursday January 29th he spoke on "Damage Control Orthopaedics: Are We Overdoing It?" At the 51st Annual John F. LeCocq Dinner that evening, he lectured on "Crash Research: Effect on Orthopaedic Practice." The following day he gave his last talk on "Pelvic Fractures: An East Coast View."

Dr. Andrew R. Burgess is Professor and Vice-Chairman of the Department of Orthopaedic Surgery at The University of Texas Medical School at Houston, where he also serves as Chief of Orthopaedic Trauma. Dr. Burgess received his medical degree from Albany Medical College in New York, where he also completed his orthopaedic residency training. He completed a trauma fellowship at the Shock Trauma Center at the Maryland Institute for Emergency Medical Services System in Baltimore, Maryland, and a second AO Trauma Fellowship in Chur, Switzerland.

Dr. Burgess served as Professor and Chief of Orthopaedic Surgery at the University of Maryland Shock Trauma Unit from 1982 to 2002. He has been a Professor of Orthopaedic Surgery (part-time) at Johns Hopkins University School of Medicine since 1998. Immediately before joining The University of Texas Health Science Center at Houston, he was Academic Chairman and Director of Trauma at Orlando Regional Hospital from 2004 through 2010. Responsible for educating military orthopaedic residents from both Bethesda and Walter Reed at Maryland's Shock Trauma Unit, he held the rank of Adjunct Professor at the Uniformed Services School of Medicine from 2001 through 2004.

He has been active in crash injury research and motor vehicle design, and was a leader of University of Maryland's CIREN (Crash Injury Research and Engineering Network) center. He has been selected as a Landstuhl Scholar to educate staff and participate in the care of our wounded warriors at Landstuhl Regional Medical Center, Germany, 2007 and 2011.

Dr. Burgess is a founding member and past President of the Orthopaedic Trauma Association (OTA). He is a member of numerous medical societies and committees. His affiliations include the Motor Vehicle Safety Research Advisory Committee and The American College of Surgeons, where he also served on the Committee on Trauma. He was named in "Best Doctors in America", first elected in 1992. He has won "teacher of the year" awards at Johns Hopkins University, the University of Maryland and Orlando Regional Hospital.

Top Photo: (left to right) Adam Sassoon, MD, Howard Chansky, MD, and Andrew R. Burgess, MD. Bottom Photo: Dr. Burgess, Dr. Chansky, and many of the guests from the 51st Annual John F. LeCocq Lectureship.

Visiting Lecturers

2015 Resident Research Day

June 12, 2015

We were very happy to host Joseph D. Zuckerman, MD as the guest lecturer for our Resident Research Day on June 12, 2015.

Joseph D. Zuckerman, MD was born and raised in the suburbs of New York City. After attending Hicksville High School, he received his undergraduate degree from Cornell University in 1974. He attended the Medical College of Wisconsin receiving his MD degree in 1978. His Orthopaedic Surgery Residency training was completed at the University of Washington in 1983. He then completed a one year clinical and research fellowship in arthritis surgery at Brigham and Woman's Hospital in Boston. As a result of his interest in shoulder problems, he was a visiting clinician with Robert Cofield, MD at the Mayo Clinic following his fellowship. Dr. Zuckerman joined the academic faculty at the Hospital for Joint Diseases in 1984. He was appointed Chief of the Shoulder Service in 1986. In 1990, he became Director of the Orthopaedic Surgery Residency Program, as well as Vice Chairman of the Department. In 1994, he became Chairman of the Department of Orthopaedic Surgery and Surgeon-in-Chief of the Hospital for Joint Disease. In September 1997, Dr. Zuckerman was appointed Professor and Chairman of the New York University – Hospital for Joint Diseases Department of Orthopaedic Surgery and he is the holder of the Walter A. L. Thompson Professor of Orthopaedic Surgery chair.

Dr. Zuckerman was chosen as a North American Traveling Fellow in 1985 and an ABC Exchange Fellow in 1991. He has received the Otto Aufranc Award from the Hip Society in 1986. He has been the recipient of a Teacher of the Year Award from the residents at the Hospital for Joint Diseases on five separate occasions and he received the Resident Appreciation Award in 1994 and 1995. Dr. Zuckerman won the Orthopaedic Research and Education Foundation (OREF) Clinical Research Award in 2002. In 2004, he was recognized as "Alumnus of the Year" by the Medical College of Wisconsin. He was honored with the Lifetime Achievement Award from the New York Chapter of the Arthritis Foundation in 2005.

He is a member of the American Academy of Orthopaedic Surgeons and has served as a member of the Board of Directors in 1992 and 1993. He has served as Chairman of the Committee on Surgical Skills Education and the Instructional Course Lecture Committee. In 2009, Dr. Zuckerman was named the 77th President of the American Academy of Orthopaedic Surgeons. He served as President of the American Shoulder and Elbow Surgeons in 2003-2004.

Dr. Zuckerman's areas of clinical interest include shoulder disorders and hip and knee replacement. His research has focused on hip fractures in elderly patients, as well as basic science and clinical studies of shoulder problems. He has also maintained an interest in socioeconomic issues of orthopaedic surgery.

Dr. Zuckerman is married to Janet (above center), a clinical psychologist and psychoanalyst. He has two sons – Scott (above left) who is a neurosurgery resident at Vanderbilt University and Matthew (above right) who is an architect at Deborah Berke Partners in New York City.

Empathy

Michael J. Goldberg, MD

Presented at the Pediatric Orthopaedic Department Retreat
Seattle Children's Hospital
December 10, 2014

Good morning: I want to thank our department leadership, Suzanne Yandow and Timothy Cooper, for asking me to begin a conversation about "Who are we as a department" and "What are the core values that bind us together." I would suggest they are, (or at least should be), empathy and trust.

Empathy is the ability to understand and share the feelings of another. It is not sympathy, which is the feeling of pity and sorrow for someone else's misfortunes. Empathy is the ability to understand and share the feelings of another. It originates in the right side of the brain where creativity, music, art and compassion reside (as compared with the left side of the brain where computers, mathematics, physical equations, and electronic medical records reside).

This year was my 50th Medical School Reunion and my 10th year at Seattle Children's Hospital. I was a medical student before Roe v. Wade; when homosexuality was a disease treated by psychotherapy; (and for those resistant cases of being gay) by hormones and electroconvulsive therapy; and at a time when survival for acute leukemia was 3 months.

I was a medical student and resident when there were no such things as MAs or PAs, and when nurses were either LPNs or RNs and wore starched uniforms and caps.

I was an "iron resident"; as so many of the doctors of my generation bragged. But were we really iron? True it was a time before the resident work hour rules were in place. But while we were in the hospital for longer stretches of time, days and nights often running into each other; when we left, we were gone. We were not connected by endless e-mails; text messages; electronic posts; PACS, the EMR, and calls to a mobile phone that is always on.

We had time for respite care. I am often saddened to see this generation of residents and fellows and nurses and admins tethered by an information umbilical cord; never to be cut loose even for a moment to take stock of life and its meaning. You have sworn to treat diseases in real people, not in surgical simulators; and certainly not in the Electronic Medical Record as if the patient was an avatar in some medical computer game. All of us need time for a personal time out.

Iron resident? I think not. I had it easy. For so many of my patients, there was simply nothing that I could do, except sit with them and listen.

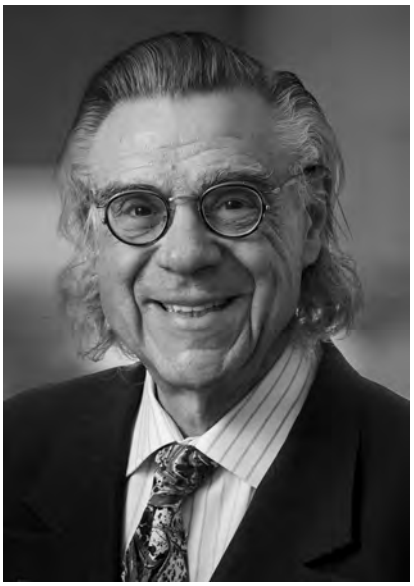
But during the next decades, much of that changed.

We have developed a remarkable array of therapies that can both prolong life and improve its quality. We have developed cardiac and orthopaedic techniques that permit the elderly to seek more active lives in spite of having indulged themselves in an epidemic of obesity, heart disease and diabetes. We have developed new antibiotics that are keeping us one step ahead of the ever increasing number of resistant bacteria. We have developed the skills to make spines straight, legs perfectly aligned, and limbs longer. We save people from motor vehicle accidents that previously were fatal. We have deciphered some fundamental flaws in DNA, flaws that produce variations in humankind and horrific diseases.

But these accomplishments have come with some unintended consequences. I suggest, it has been a loss of trust and empathy.

What does entrusted to heal really mean? What does it mean to you, to your patients, and to their families?

A fundamental tenant of healing is trust. When it comes to how we deliver care today, that trust has been damaged. Some would argue that it was



the result of managed care schemes that created the perception that care was being limited; or that trust was damaged because of public disclosures of complex financial relations between industry and doctors; or that trust was violated when medicine began to follow a business model and the quality of care was often based on the type of insurance one had; or that trust was shaken when patient access trumped patient safety.

Because we feel so vulnerable when we are ill, a loss of trust in those who care for us is devastating. It is equivalent to betrayal by a dear friend or a spouse. Indeed, it has been said that trust itself is healing. Trust enhances ones responsiveness to treatments, to medicine, and to surgery.

While research scientists, physicians, and surgeons have made great strides in curing disease, those who practice in our medical community have fallen behind in healing and comforting our patients. Doctors, nurses and hospitals are simply better at curing disease than they are at healing

the person who is afflicted. Empathy is being assaulted. Every malady comes with a human attached. For those whose health is failing, whose disease is incurable, I hear doctors talk of new research or new drug trials; of cutting edge technology; of soon to be innovative methods. I do not hear the simple words: "There is nothing more I can do for your disease. What can I do for you?"

We have shared leadership with both nurses and administrators and have made great strides in finding solutions to increase productivity; for efficiency; for standard work processes; for improving Takt time; and for billing. Have we made similar strides in preserving empathy?

Maybe what is needed are "acts of loving kindness".

There is an ever increasing need for our patients to be comforted and healed by us, by all of us in this auditorium. Both clinicians and researchers are on a path devoted to preventing diseases (with, for example, new vaccines) or to curing disease (with new minimally- and maximally-invasive procedures). Will a time come (or is it, I fear, already here?) when we are too busy curing, and preventing, and standardizing, and counting, and documenting and billing, to heal. Who could possibly take our places?

In every city and in every community, there are a number of walks and marches to "find the cure". A walk to find the cure for diabetes. A walk to find the cure for breast cancer. A walk to find the cure for multiple sclerosis. The monies raised go to research: which will find the cause of the disease: and then, once the cause is found, can the cure not follow quickly behind?

For the elderly, and for most of my pediatric patients with birth defects and syndromes, the cause of their disease is not known. And when the cause is found, it will be of only modest interest to them. For most of my patients, there is little hope for cure. In our health care system, life for them is a search for comfort and caring. It is a search for healing and sustaining hope. It is a search for empathy. It is an area where I have worked for more than 40 years and have loved every minute.

Will you be there for me when I need that healing and comforting? In an age of quick fixes, fast food, instant messaging, and immediate gratification; in an age where friendship are those itemized on a Facebook account; the need to care and comfort, and the need to reduce suffering and to sustain hope, is becoming increasingly difficult to fulfil. Must we do it? Must we, as orthopaedic physicians and surgeons, as RNs, MAs, and PA, as administrators, as members of this great department; perform acts of loving kindness? Why can't we focus only on the technical aspects of the surgery: the pedicle screw and the arthroscope? I would like you to believe that performing acts of loving kindness is our duty and responsibility. That it is our social contract with humanity. That it is the covenant we make with medicine and with each other. That when someone says "The Department of Orthopaedics at Seattle Children's Hospital" the word that comes to mind is "empathy": Empathy for each other and for our patients. Empathy: the ability to understand and share the feelings of another.

I am honored to be a member of this department.

Thank you.

References

1. Goldberg, MJ Duties and responsibilities; rights and privileges. J. Bone Joint Surg Am 2003; 85: 962-963

2. Goldberg, MJ Acts of loving kindness. J Child Orthop 2008; 2: 247-249

Muscle, Bone, and Nerve Differentially Interact to Achieve Trabecular and Cortical Bone Homeostasis

Steven D. Bain, PhD, Phillipe Huber, BS, Ronald Y. Kwon, PhD,
Laura E. Stoll, MD, and Ted S. Gross, PhD

Muscle and bone increase and decrease their size in tandem. This relation has been predominantly associated with the interplay between muscle and bone during functional activity that is responsible for mechanical loading of the musculo-skeletal system. In this study, we sought to explore whether neuromuscular function (outside of direct mechanical influences) plays a critical role in maintaining musculo-skeletal health.

Introduction

Muscle atrophy precipitates rapid and frequently profound bone loss. The reduction in skeletal loading concomitant with sarcopenia has been presumed to be a primary mediator of bone catabolism. However, it is unclear whether diminished muscle function may modulate bone homeostasis independent of skeletal loading as *in vivo* models of muscle atrophy are invariably coupled with decreased skeletal loading. To address this question, we implemented three *in vivo* models of neuromuscular dysfunction intended to demonstrate differential gait dysfunction and muscle atrophy.

Materials and Methods

We used gait kinetics and kinematics to quantify tibia mid-shaft normal strains and serial microCT imaging to quantify muscle, tibia trabecular and cortical bone atrophy in female C57 mice (16wk). Mice were randomly assigned to receive transient paralysis of the right calf (C) or quadriceps (Q) muscle groups (2U/100g Botulinum Toxin A, BTxA) or peripheral nerve injury (PNI) of the right sciatic nerve via a plastic sleeve (n=8/grp). Mice were assessed on d0, d5 and d12, with all measures normalized to d0 data.

Results

Gait-induced normal strains were more diminished by Q than C paralysis at d5 (-53.0 ± 4.9% vs -35.4 ± 3.1%; p=0.01), but were equivalently diminished by d12 (C: -37.0 ± 3.8%; Q: -40.6 ± 8.1%). PNI did not alter normal strains vs d0. By d12, calf muscle volume was diminished more by C (-32.2 ± 0.9%; p<0.01) than Q paralysis (-18.0 ± 2.4%), but not altered by PNI. C and Q paralysis significantly, but equivalently, degraded trabecular BV/TV at d5 (C: -21.4 ± 5.2%; Q: -33.8 ± 3.0%) and d12 (C: -69.1 ± 3.6%, Q: -72.0 ± 3.2%), while PNI induced less, but significant BV/TV loss at d12 (-26.5 ± 4.1%; Figure 1). C (8.4 ± 1.0%) and Q paralysis (11.7 ± 2.0%) induced significant (but equivalent) endocortical resorption at d12, while PNI did not. Diminished normal strains and decreased trabecular BV/TV were minimally correlated (r^2<0.19), but the relation between diminished normal strains and endocortical expansion was significant (r^2=0.62, p<0.01).

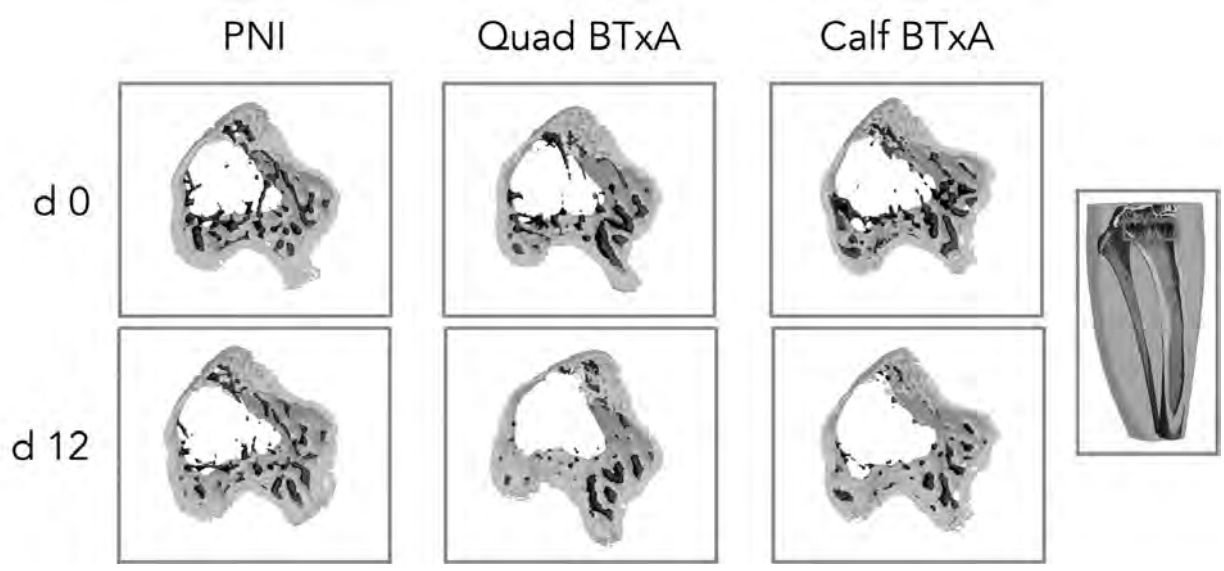


Figure 1: Micro-CT images of proximal tibia metaphyseal trabeculae for representative mice challenged by PNI, Quadriceps Paralysis, or Calf Paralysis. At 12 d post-intervention, significant loss of trabecular bone was observed in each group, although loss induced by PNI was less than 40% of the loss induced by BTxA induced paralysis.

Discussion

In sum, these data suggest that cortical and trabecular bone are differentially regulated by muscle, bone and nerve interactions. For cortical homeostasis, muscle function was a potent modulator via gait-induced mechanical stimuli. However, the significant trabecular loss following PNI and the poor correlation between decreased gait-induced strains and BV/TV, suggest that neuronal pathways serve an essential role in trabecular homeostasis.

References

1. Avin KG, Bloomfield SA, Gross TS, Warden SJ (2015). Biomechanical aspects of the muscle-bone interaction, Curr Osteoporos Rep.13(1):1-8.

2. Ausk BJ, Huber P, Srinivasan S, Bain SD, Kwon RY, McNamara EA, Poliachik SL, Sybrowsky CL, Gross TS (2013). Metaphyseal and diaphyseal bone loss in the tibia following transient muscle paralysis are spatiotemporally distinct resorption events. Bone. 57(2):413-22.

3. Mitchell WK, Williams J, Atherton P, Larvin M, Lund J, Narici M (2012). Sarcopenia, dynapenia, and the impact of advancing age on human skeletal muscle size and strength; a quantitative review. Front Physiol. 3: Article 260.

Acknowledgements

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Cross-Species Transcriptomic Analysis Reveals Homologous Transcriptional Stages and Conserved Gene Co-Expression Dynamics During Zebrafish and Rat Bone Regeneration

Ronald Y. Kwon, PhD, Amarjit Virdi, PhD, and Dale R. Sumner, PhD

The use of simple vertebrate models represents a powerful yet largely unexplored strategy to elucidate osteogenic gene networks in higher organisms. Our studies demonstrate that zebrafish fin regeneration shares common molecular signatures with mammalian bone regeneration and healing, putting forth the potential to map underlying gene networks in a highly tractable experimental system.

Introduction

By virtue of its unique experimental characteristics, the regenerating zebrafish tail fin holds unique potential as a rapid, genetically tractable, and optically transparent model of osteogenesis. While growing studies (including our own [1]) suggest the potential of the fin to recapitulate osteogenic deficits arising from known inhibitors of bone formation, the degree to which fin regeneration molecularly resembles post-natal osteogenesis in mammals is unclear. Toward overcoming this hurdle, our goal was to utilize cross-species transcriptomic analysis to test the thesis that zebrafish and rat osteogenesis exhibit homologous transcriptional dynamics during intramembranous bone regeneration.

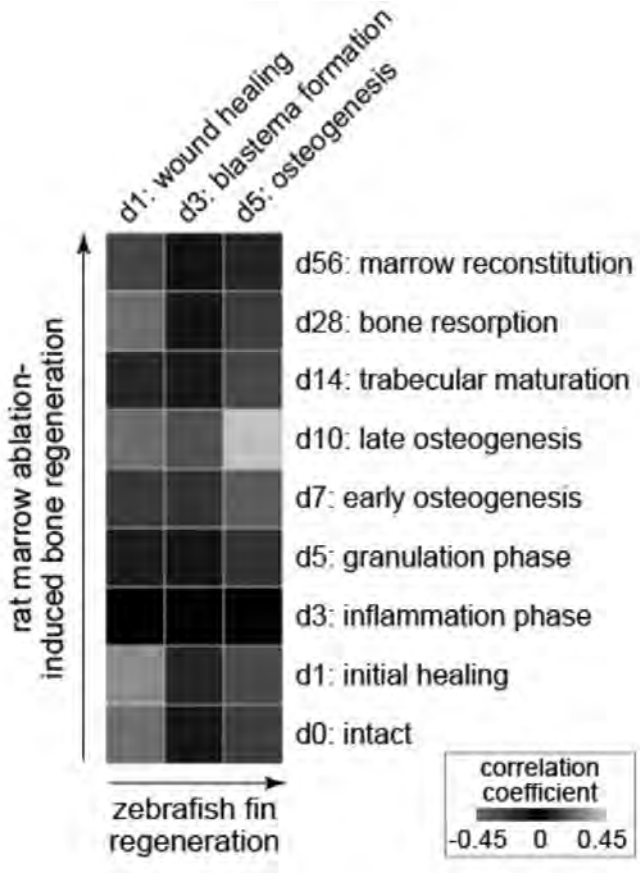

Figure 1: Correlation coefficients for genome-wide gene expression during zebrafish fin regeneration and rat marrow ablation-induced bone regeneration.

Materials and Methods

We developed custom meta-analysis software to compare genome-wide gene expression during zebrafish and rat bone regeneration. Briefly, we developed a microarray analysis pipeline that integrated data processing, gene ID referencing, and gene homology mapping to map zebrafish and rat protein sequence homology pairings to their respective genome microarray probe sets. Using this software, we cross-correlated microarray datasets obtained from two different conditions: zebrafish tail fin regeneration (d1, d3, and d5; GEO accession GSE3667), and rat marrow ablation-induced intramembranous bone formation (d0, d1, d3, d5, d7, d10, d14, d28, and d56; GSE22321; for details see our publication in [2]). For co-expression analysis, gene eigenvectors ("eigengenes") were constructed from the covariance matrix of the rat microarray data set using principal component analysis (PCA), and zebrafish data were projected onto the rat eigenspace to compute eigengene expression levels.

Results

Transcriptomic analysis revealed 1,778 and 14,845 significantly ($p<0.05$) altered genes during zebrafish and rat bone regeneration, respectively. Of these significant genes, 720 (40% of max possible) were identified as orthologous gene pairs. Genome-wide correlations during zebrafish and rat initial healing ($r=0.31$ for d1 in zebrafish & d1 in rat, $p<1e-16$) and early osteogenesis ($r=0.42$ for d5 in zebrafish

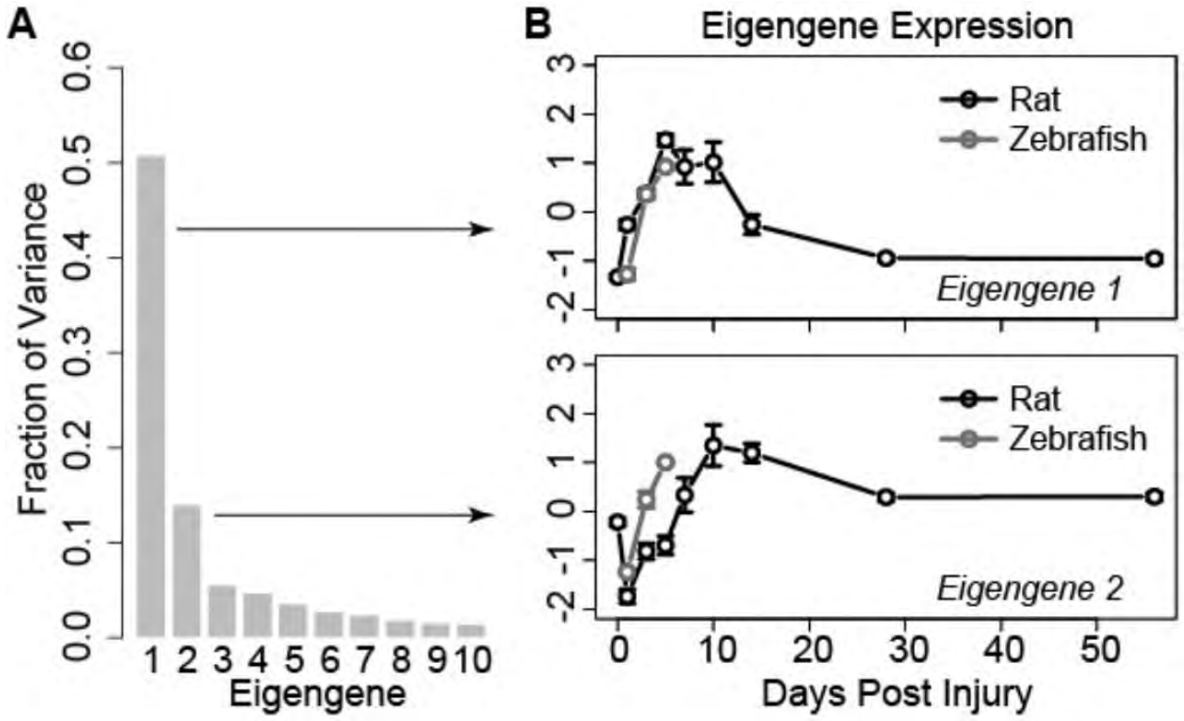

Figure 2: Genome-wide co-expression dynamics are conserved during zebrafish and rat bone regeneration. (A) Gene expression variation during rat bone regeneration is largely explained by eigengenes 1 and 2. (B) Time course analysis reveals homologous eigengene dynamics during rat and zebrafish bone regeneration.

& d10 in rat, p<1e-16) were highly significant (Figure 1), approaching the 95% confidence interval for inter-group (i.e., biological replicates) correlations within each species (r=0.36-0.87 in zebrafish and r=0.51-0.64 in rat). Lower correlations were observed during zebrafish blastema formation (r=-0.15 to 0.17 for d3 in zebrafish and d1-d10 in rat), suggesting that blastema formation is a transcriptionally distinct event that is not recapitulated following marrow ablation. PCA of the rat microarray dataset revealed that 65% of the gene expression variance following marrow ablation could be explained by eigengenes 1 and 2 (Figure 2A). Further analysis revealed that expression dynamics of rat eigengenes 1 and 2 during early rat bone regeneration were recapitulated during zebrafish fin regeneration (Figure 2B), indicating the potential of the fin to predict homologous gene co-expression dynamics.

Discussion

Our studies are the first to identify homologous transcriptomic stages between zebrafish and rat bone regeneration. In doing so, our data put forth the potential to synchronize osteogenic stages in the regenerating zebrafish fin to mammalian bone anabolic physiologies through cross-species transcriptomic analysis, overcoming challenges associated with the lack of phenotypic homology in bony fin rays. PCA analysis revealed that rat bone regeneration eigengene dynamics are recapitulated in the regenerating fin, suggesting that underlying gene regulatory networks are conserved in both systems. Analysis of ortholog gene pairs revealed a number of genes implicated in disorders of bone mineralization (phex, lemd3, fkbp10, crtap, mmp2, sost, col1a1, col1a2, sparc, periostin), craniofacial disorders (msx2, twist1), and skeletal dysplasias (col10a1, col11a1, col11a2, fgr3), suggesting the utility of the fin as a model of not only bone regeneration but also a broad range of bone pathologies. Collectively, these studies identify distinct stages of transcriptomic convergence during zebrafish and rat intramembranous bone regeneration, an essential step toward cross-species examinations of osteogenesis in the zebrafish and mammalian skeletons.

References

1. Recidoro AM, Roof AC , et al., Kwon RY, 2014. J Bone Min Res doi:10.1002/jbmr.2274

2. Wise JK, Sena K, Vranizan K, Pollock JF, Healy KE, Hughes WF, Sumner DR, Virdi AS, 2010. PLoS ONE 5(10): e12987

Development and Validation of a 3D Printed Chemical Screening System for Osteoactive Compound Discovery in the Regenerating Zebrafish Tail Fin

Adrian T. Monstad-Rios and Ronald Y. Kwon, PhD

While in vivo chemical screens have unique potential to accelerate bone therapeutic discovery, such screens are largely inaccessible in traditional animal models of bone anabolism. In this study, we developed and validated a novel 3D printed system for chemical screening in adult zebrafish, opening the door to in vivo osteoactive compound discovery in the zebrafish skeleton.

Introduction

Though in vivo chemical screens represent a powerful strategy for bone pathway discovery, such screens are largely inaccessible in traditional animal models of bone anabolism. In this project, we seek to utilize the regenerating zebrafish tail fin, a rapid, genetically tractable, and optically transparent model of intramembranous ossification, for osteoactive compound discovery. A central challenge to such efforts is the inability to apply established in vivo chemical screening strategies in zebrafish to post-embryonic physiologies. In particular, unlike embryonic zebrafish (whose skeletons are largely unossified), adult zebrafish require a relatively large water volume for housing. This makes adult zebrafish cost-prohibitive for large-scale screening efforts due to the large compound quantities necessary to achieve an active concentration in the water. To overcome this hurdle, the objective of this study was twofold: 1) to develop a 3D printed screening system that enabled rapid, efficient, and cost-effective chemical administration in adult zebrafish, and 2) validate its potential to detect a clinically-relevant osteoactive compound during fin regeneration.

Materials and Methods

For 3D printing, CAD designs were generated on Pro ENGINEER, converted to STL files, and printed in PLA using a MakerBot Replicator 2 Desktop 3D Printer. For fin regeneration studies, adult zebrafish were anesthetized in MS-222, and subjected to 50% tail fin amputation using a straight razor blade [1]. Following this procedure, fish were housed in screening inserts nested in 6L tanks in which fresh water (28°C) was continuously replenished using a recirculating system. For chemical administration, 9-well plates were filled with water (10mL/well), the compound stock solution was added to each well, and the inserts (with fish inside) were quickly transferred into the plates. Using this system, fish were treated daily for 1hr/day starting 1 day post amputation (dpa) and ending on 7dpa. At 8dpa, fish were immersed in buffered calcein (0.04% for 10min), rinsed in fresh water, and subjected to microscope imaging. Percent area of regrowth was calculated using established procedures [1].

Results

We fabricated a custom chemical screening platform using 3D printing that allowed for unrestricted fish movement during normal housing while minimizing compound usage during chemical dosing (Figure 1A). To achieve this, we designed a dual-compartment mesh-bottom insert for housing individual fish. The insert consists of a large volume upper compartment that tapers into a low volume lower compartment (Figure 1B). When not subjected to dosing, the inserts are nested in 6L tanks, enabling the fish to swim freely in the upper compartment. During

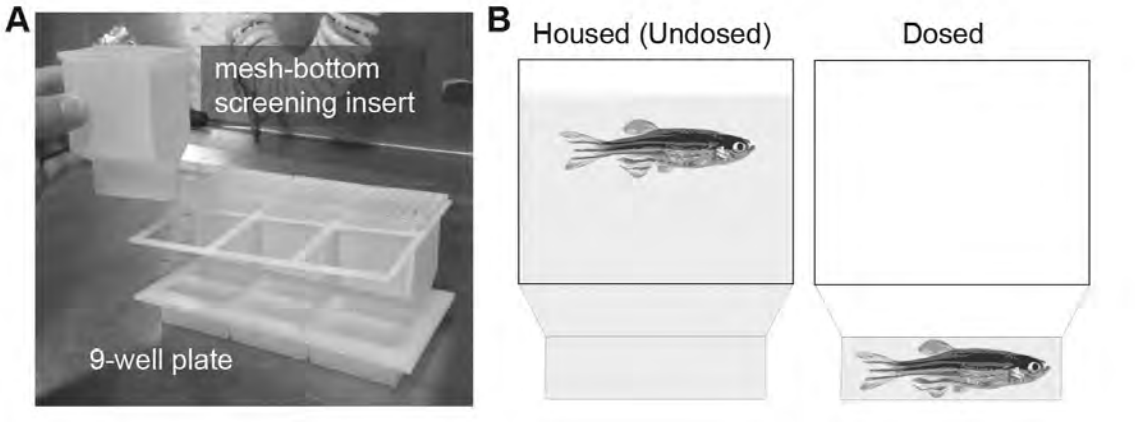

Figure 1: 3D printed system for chemical screening in adult zebrafish. A) Image showing the mesh-bottom dual-compartment inserts nested in the 9-well plate. B) Schematic demonstrating the design principle of the screening inserts. During normal housing (left), the inserts are nested in a 6L tank, enabling unconfined swimming in the upper compartment. During chemical administration, the fish are drained to the lower compartment, minimizing compound usage.

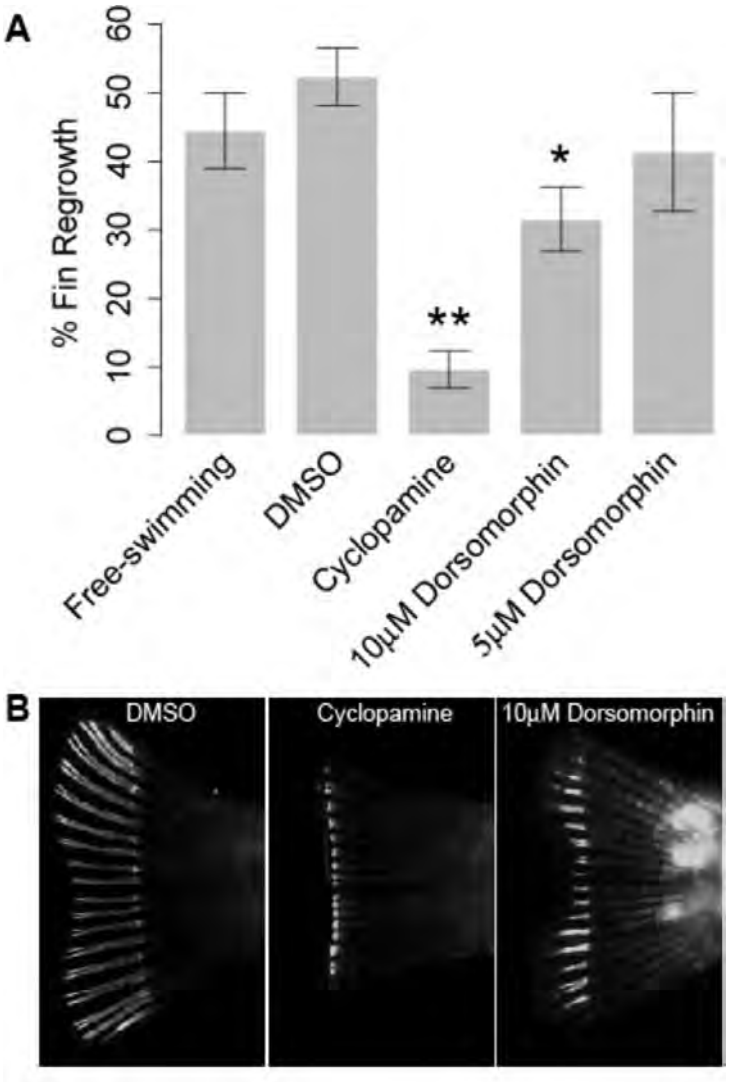

Figure 2: Cyclopamine and dorsomorphin inhibit fin regeneration in a "mock" chemical screen. (A) Percent regrowth 8dpa. *: $p<0.05$, **: $p<0.01$ vs. DMSO; n=2-3. (B) Proximalized calcein labeling in cyclopamine and dorsomorphin-treated fish.

dosing, the fish follow the draining water into the lower compartment, which inserts into a custom 9-well screening plate for chemical administration (via immersion). Using this system, we assessed the effects of the screening regimen on fin regrowth, its fidelity in detecting a known inhibitor of fin regeneration (cyclopamine), and its potential to detect a clinically-relevant inhibitor of osteogenesis (dorsomorphin) (Figure 2A). Fin regrowth in free-swimming fish was nearly identical to DMSO fish housed in the screening system, suggesting that neither housing fish in the inserts nor the dosing regimen itself had a detrimental effect on fin regeneration. Consistent with previous studies [2], fish administered cyclopamine exhibited a severe reduction in fin regrowth ($p<0.01$ relative to DMSO controls). For dorsomorphin, fish administered 10uM, but not 5uM, exhibited a significant reduction in regrowth ($p<0.05$). Calcein labeling revealed impaired mineralizing activity characterized by intense labeling at the amputation site in cyclopamine-treated fish, and proximalized labeling in fish subjected to dorsomorphin (Figure 2B).

Discussion

In this study, we developed a novel 3D printed screening system for in vivo small molecule screening in adult zebrafish. Chemical screens for post-embryonic physiologies (e.g., skeletogenesis) in zebrafish have been largely unexplored (only one published study to our knowledge [3]). This is primarily due to the large quantities of chemicals required to achieve an active concentration. By developing a dual compartment screening system, we were able to decrease the quantity of compounds required for screening by tenfold, opening the door to large-scale screening efforts in adult animals. As part of our studies, we demonstrated the potential to detect a clinically-relevant small molecular inhibitor of osteogenesis, dorsomorphin. Dorsomorphin is a potent inhibitor of AMP-activated protein kinase (AMPK) as well as bone morphogenetic protein (BMP) type 1 receptors, the specific roles of which are both unknown in the regenerating tail fin. Notably, dorsomorphin-like compounds are currently in drug development for the treatment of heterotopic ossification and other syndromes associated with excessive BMP signaling. Thus, these findings support both the potential utility of the regenerating fin as a basic genetic model for pathological modeling, as well its potential to identify compounds relevant for clinical use. In summary, we have developed a rapid and efficient 3D printed system for chemical screening in adult zebrafish, an essential step toward bone pathway and therapeutic discovery in the regenerating tail fin.

References

1. Recidoro AM, Roof AC, et al., Kwon RY, 2014 J Bone Min Res doi:10.1002/jbmr.2274

2. Quint E, Smith A, Avaron F, Laforest L, Miles J, Gaffield W, and Akimenko M-A, 2002 PNAS 99(13):8713-8718

3. Oppedal D, Goldsmith MI, 2010 Zebrafish 7(1):53-60.

Proper Maintenance of Trabecular Bone in Adult Animals Requires ESET Histone Methlytransferase

Liu Yang, PhD, Albert O. Gee, MD, and Howard A. Chansky, MD

Trabecular bone (also called cancellous or spongy bone), is one of the two types of calcium tissue that make up bones in the human body. Through tamoxifen-inducible deletion of a specific gene in adult mice and comparison of these knockout mice to wild type controls, here we show that adult animals depleted of the ESET histone methyltransferase exhibited a grossly deficient bone histology in distal femur and proximal tibia. Our results further confirm that trabecular bone metabolism in adult life is tightly regulated by histone modification enzymes.

Introduction

Compared to cortical bone, trabecular bone has a higher surface area to mass ratio because it is less dense. Trabecular bone is typically found at the ends of long bones, proximal to joints and within the interior of vertebrae. The greater surface area in comparison with cortical bone makes trabecular bone suitable for metabolic activity such as exchange of calcium ions.

The ERG-associated protein with a SET domain (ESET) is known to be expressed in cells of mesenchymal lineage that gives rise to chondrocytes and osteoblasts, and we have reported that ESET plays a critical role in endochondral ossification and articular chondrocytes [1-2]. Deletion of ESET from mesenchymal cells in mouse embryos has been found to inhibit bone formation in post-natal young animals [3]. However, it is not clear whether such bone defects are a direct result of ESET on bone cells, or whether they are secondary effects due to abnormal anatomy found in these knockout animals. To find the answer, we carried out rounds of genetic manipulations to obtain genetically marked mice which develop normally into adulthood and are indistinguishable from wild-type littermates. Upon injection with tamoxifen, the ESET gene in these genetically marked mice will be deleted from bone-forming cells and the mice can then be analyzed for changes in bone characteristics.

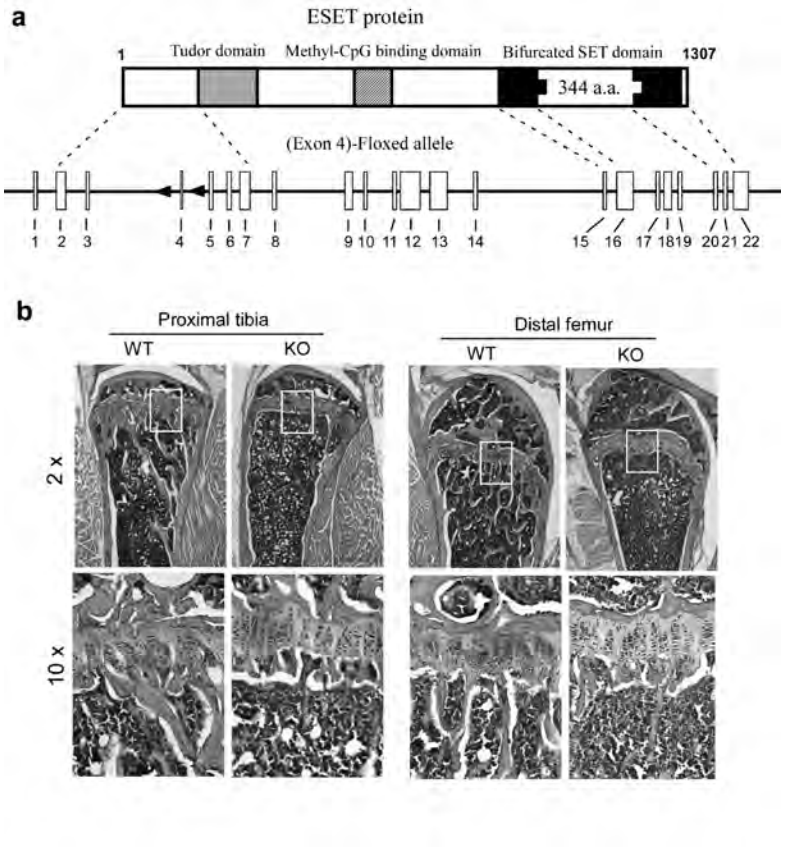

Figure 1: Effects of ESET knockout on trabecular bone in adult mice. a, ESET genomic and protein structure. Note that exon 4 is flanked by two loxP sites (dark triangles) for Cre-mdiated deletion of DNA sequence. b, H&E staining of long bone from 3 month-old wild-type (WT) and ESET knockout (KO). Selected areas near the growth plate (top panels) are also shown at higher magnifications (bottom panels).

Materials and Methods

All experiments were reviewed and approved by the Institutional Animal Care and Use Committee at the VA Puget Sound Health Care System. Breeding between ESET(exon 4)$^{Flox/Flox}$ and ESET(exon 4)$^{Flox/WT}$; CAG-Cre/Esr1 mice generated the desirable ESET(exon 4)$^{Flox/Flox}$; CAG-Cre/Esr1 mice that develop normally and indistinguishable from wild-type mice before tamoxifen injection. Once sexually mature (around one month-old), ESET(exon 4)$^{Flox/Flox}$; CAG-Cre/Esr1 mice twice received peritoneal injection of tamoxifen (0.75 mg/10 g body weight within 3 days) to ensure complete deletion of the ESET gene. Two months after tamoxifen injection, these 3 month-old animals were sacrificed, bone tissues were fixed with paraformaldehyde for micro CT analysis, and decalcified for histological analysis using H&E staining to evaluate trabecular bone proximal to the knee joint.

Results

Structures of exon 4-floxed ESET gene and the corresponding ESET

protein are shown in Figure 1a. Tamoxifen-induced and Cre-mediated deletion of exon 4 in one month-old mice results in a frame-shift mutation that eliminates the entire ESET protein from all cell types including osteoblasts. Two months after tamoxifen injection, the cortical bone does not appear to be affected by ESET knockout. In addition, we observed little difference in long bone length and diameter between age-matched wild-type and ESET knockout mice. When trabecular bone was analyzed by histological staining (Figure 1b), drastic difference was observed in wild-type mice vs mice with tamoxifen-induced ESET knockout. In wild-type mice, both proximal tibia and distal femur showed a staining pattern that is rich in trabecular bone. In ESET knockout animals, however, staining for trabecular bone is significantly less either at the proximal tibia or at the distal femur. Trabecular bone loss in ESET knockout mice was also confirmed by micro CT analysis that showed a significant decrease in bone mineral density at proximal tibia and distal femur.

Discussion

These findings demonstrate conclusively that ESET histone methyltransferase is critical to the proper maintenance of trabecular bone in adult animals. How does ESET plays such a role in trabecular bone turn over? Our osteogenesis study of cultured mesenchymal cells has shown that ESET promotes osteogenic differentiation from mesenchymal cells into osteoblasts [3]. We speculate that in adult mice lacking ESET, failure to generate sufficient osteoblasts to replenish trabecular bone results in an imbalance toward bone resorption and loss. As ESET protein level in mesenchymal cells could gradually decrease as we age, our findings may also have implications in human bone diseases such as osteoporosis frequently found in post-menopausal women.

References

1. Yang, L. et al. ESET histone methyltransferase is essential to hypertrophic differentiation of growth plate chondrocytes and formation of epiphyseal plates. Dev. Biol. 380, 99–110 (2013).

2. Lawson, K. A. et al. Mesenchyme-specific knockout of ESET histone methyltransferase causes ectopic hypertrophy and terminal differentiation of articular chondrocytes. J. Biol. Chem. 288, 32119–32125 (2013).

3. Lawson, K. A. et al. ESET histone methyltransferase regulates osteoblastic differentiation of mesenchymal stem cells during postnatal bone development. FEBS Lett. 587, 3961–3967 (2013).

Outcomes of Leiomyosarcoma: A Comparison with Other Primary Bone Tumors

Tara N. Garland, BS, Amy M. Cizik, MPH, Robin Jones, MD,
and Darin J. Davidson, MD, MHSc

Leiomyosarcoma is a rare soft tissue tumor that occurs uncommonly as a primary bone sarcoma. When compared to other primary bone tumors, survival outcomes of these unusual tumors are not well established due to low case numbers and variability in treatment. The primary goal of this study was to estimate the oncologic outcomes of primary leiomyosarcoma of bone compared to other primary bone sarcomas to contribute a better understanding of the prognosis of these rare tumors.

Introduction

Leiomyosarcoma (LMS) is a rare tumor accounting for 1 of every 10 soft tissue sarcomas [1]. Microscopically they have smooth muscle differentiation and most commonly affect the soft tissues. Primary leiomyosarcoma of bone occurs even more rarely and is believed to arise from intraosseous vascular tissue [2-5], most often affecting the long bones [3]. More commonly, leiomyosarcoma presents as a metastatic lesion.

Evans and Sanerkin first reported LMS of bone in 1965 [6], but since that time the literature has been limited to case reports and small case series [1-3,5,7-12]. There is little evidence to support treatment regimens and few prognostic indicators [7,13,14] though they are widely believed to be highly malignant [15]. To this point their management has been based on high-grade primary tumors of bone including osteosarcoma and Ewing's family of sarcomas. These more common tumors have better evidence to support prognostic indicators and treatment regimens [16,17], and are believed to have a lower rate of recurrence and better long-term outcomes than that of LMS of bone. Furthermore, LMS of bone remains difficult to diagnose [1].

Immunohistochemistry remains at the forefront of diagnosis, characterizing tumors via smooth muscle markers

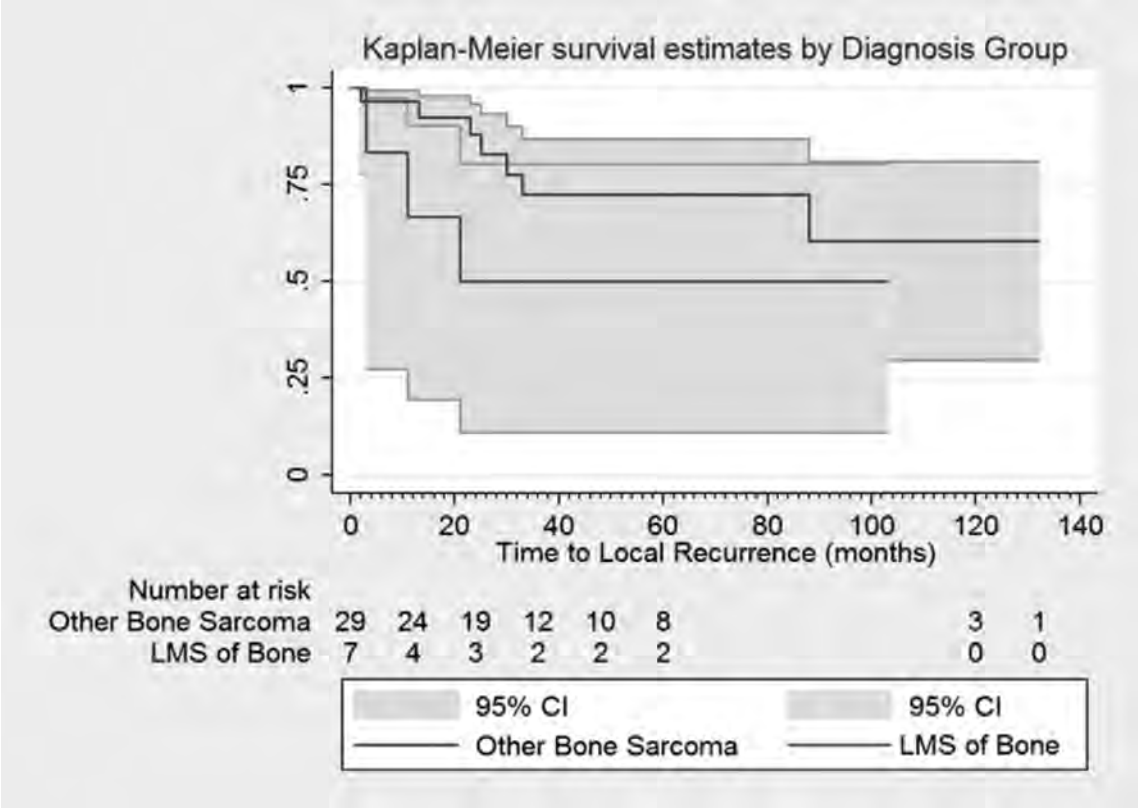

Figure 1: Kaplan Meier Survival Estimates by Diagnosis. Overall DFS for other bone sarcoma group was 60% (95% CI: 30% - 81%) compared to 50% for pLMS (95% CI: 11% - 80) at last follow-up (p=0.17 (log-rank) and p=0.07 (Wilcoxon)).

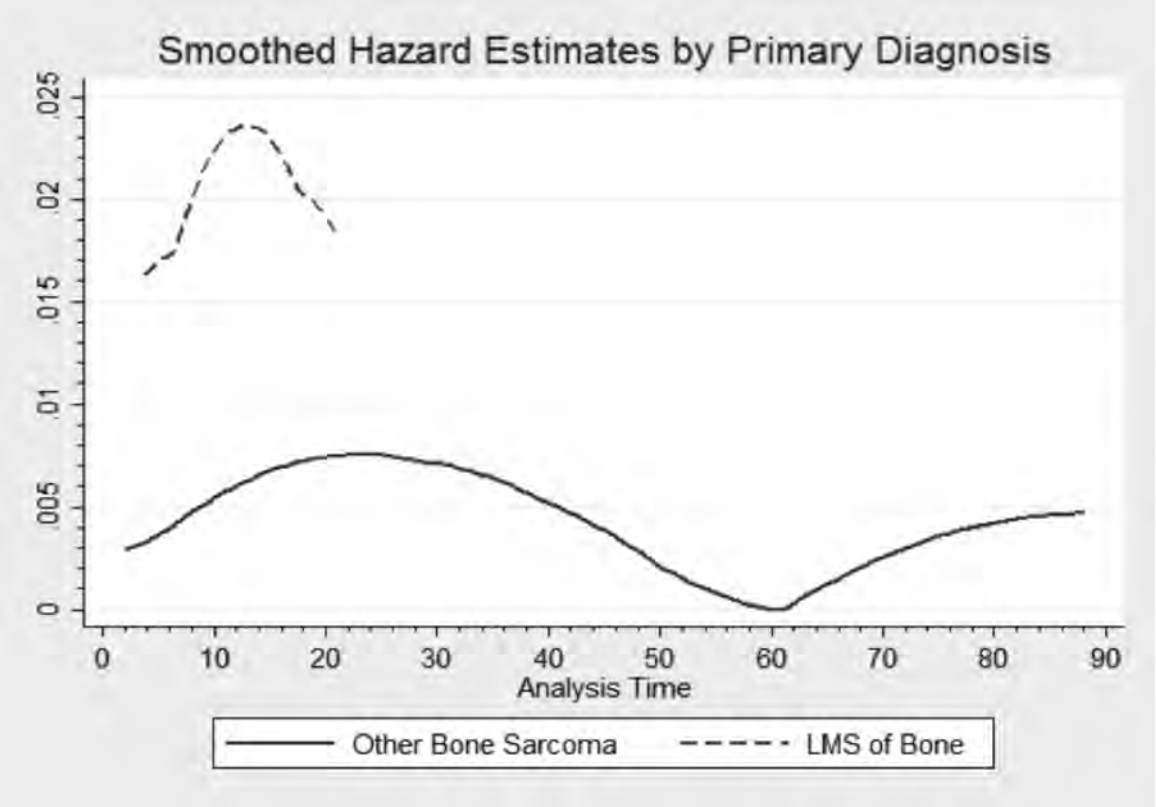

Figure 2: Hazard Estimates for Local Recurrence by Diagnosis. Smoothed hazard functions by primary diagnosis group for local recurrence. The HRs describe hazard of local recurrence for each monthly time interval.

including α-smooth muscle actin, vimentin, and desmin [3,7,18]. Though these markers are helpful, they are heterogeneously represented and are not completely unique to LMS of bone. H-caldesmon, smooth muscle myosin, cytokeratin and S100 protein have also been described but are not ubiquitously present in LMS of bone [7].

Treatment of LMS of bone has been loosely based on that of other high-grade bone tumors, the mainstay of which is chemotherapy and surgical excision with wide margins [14]. Some authors report LMS of bone to be resistant to radiation [1,3], and evidence supporting neo/adjuvant chemotherapy is variable due to limited case numbers and inconsistent treatment regimens [7]. As such, prognosis has been difficult to assess, as are recommendations for neo/adjuvant therapy. This study compares primary LMS of bone (pLMS) to other primary bone sarcomas (pBS) also treated with surgery and chemotherapy to estimate primary oncologic outcomes, specifically tumor recurrence and overall survival.

Methods

A retrospective review of 38 patients treated for a primary sarcoma of bone from 2000 to 2013 at the University of Washington and the Seattle Cancer Care Alliance was completed.

For inclusion, all patients had primary and localized disease at diagnosis, treatment with chemotherapy and surgery, and a biopsy-proven diagnosis of primary LMS of bone or other bone sarcoma treated with combination chemotherapy and surgery.

Patient demographics, details of tumor type and characteristics and disease specific outcomes including presence and timing of local and/or systemic recurrence and overall survival were recorded.

Analysis of data included descriptive statistics of the study sample and of disease specific outcomes using Kaplan Meier survival analysis (KMSA) of disease free survival (DFS) as well as hazard ratios to estimate local recurrence. The log-rank and Wilcoxon test was used to compare the statistically significant differences between the two diagnosis groups of pLMS and pBS with a two-tailed p-value less than 0.05 considered to be statistically significant. STATA 13 (College Station, TX: StataCorp LP) statistical software was used for analysis.

Results

Median follow up was 20.1 months for pLMS (range 0.30-103.3 months) while pBS had a median follow up of 35.4 months (0.16 to 137.9 months). Overall, pLMS had a higher percentage of local and systemic recurrences and a lower disease free survival (Figure 1).

All pLMS patients were alive and 50% were disease free at most recent follow up. Those with disease had both local and metastatic disease. Of pBS patients, 12/30 (40%) had metastatic disease, 7/30 (23.3%) had local recurrence and 2/30 (6.7%) had died of disease. The 5-year DFS for the pBS and pLMS group was 73% and 50%, respectively. This was not statistically significant when using log-rank (p=0.10), but when applying more weight to early failures using the Wilcoxon test, the difference was

statistically significant (p=0.04).

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There was a 2.50 increase in the risk of local recurrence after primary excision in pLMS diagnosis group, compared to the pBS diagnosis group (HR=2.50, 95% CI: 0.643-9.71, p=0.19). The risk of a local recurrence initially decreased in the first five years for those with pBS, but subsequently increased after 5 years. The risk of local recurrence in the pBS group remained less than the pLMS group overall (Figure 2). The peak HR for local recurrence occurred at approximately 1 year for pLMS patients compared to the peak for the pBS group, which occurred closer to 2 years post primary excision.

Conclusions

Patients with pLMS had a higher proportion of tumor recurrences in a shorter time period than did pBS. These results address a difficult but important question regarding the therapies and prognosis associated with primary LMS of bone.

The general belief that LMS of bone portends a more rapid progression of disease and therefore poorer prognosis and greater mortality is substantiated by our results.

This evidence supports early diagnosis and aggressive treatment of these rare bone sarcomas given the widespread and relatively short time to recurrence of these tumors.

References

[1] Rekhi B, Kaur A, Puri A, Desai S, Jambhekar NA. Primary leiomyosarcoma of bone--a clinicopathologic study of 8 uncommon cases with immunohistochemical analysis and clinical outcomes. Ann Diagn Pathol 2011;15:147–56.

[2] Sanerkin NG. Primary leiomyosarcoma of the bone and its comparison with fibrosarcoma. Cancer 1979;44:1375–87.

[3] Antonescu CR, Erlandson RA, Huvos AG. Primary leiomyosarcoma of bone: a clinicopathologic, immunohistochemical, and ultrastructural study of 33 patients and a literature review. Am J Surg Pathol 1997;21:1281–94.

[4] Wang TY, Erlandson RA, Marcove RC, Huvos AG. Primary leiomyosarcoma of bone. Arch Pathol Lab Med 1980;104:100–4.

[5] Templeton K. Leiomyosarcoma of bone. Am J Orthop 2005;34:249–51.

[6] Evans DM, Sanerkin NG. Primary leiomyosarcoma of bone. J Pathol Bacteriol 1965;90:348–50.

[7] Adelani MA, Schultenover SJ, Holt GE, Cates JMM. Primary leiomyosarcoma of extragnathic bone: clinicopathologic features and reevaluation of prognosis. Arch Pathol Lab Med 2009;133:1448–56.

[8] Angervall L, Berlin O, Kindblom LG, Stener B. Primary leiomyosarcoma of bone: a study of five cases. Cancer 1980;46:1270–9.

[9] Shen SH, Steinbach LS, Wang SF, Chen WY, Chen WM, Chang CY. Primary leiomyosarcoma of bone. Skeletal Radiol 2001;30:600–3.

[10] Narváez JA, De Lama E, Portabella F, Ortega R, Condom E. Subperiosteal leiomyosarcoma of the tibia. Skeletal Radiol 2005;34:42–6.

[11] Young CL, Wold LE, McLeod RA, Sim FH. Primary leiomyosarcoma of bone. Orthopedics 1988;11:615–8.

[12] Miura K, Hatori M, Hosaka M, Kokubun S, Watanabe M, Ehara S. Primary leiomyosarcoma with the invasion into the intertrabecular space of bone: a case report and the review of the literatures. Clinical Imaging 2001;25:209–14.

[13] Wirbel RJ, Verelst S, Hanselmann R, Remberger K, Kubale R, Mutschler WE. Primary leiomyosarcoma of bone: clinicopathologic, immunohistochemical, and molecular biologic aspects. Ann Surg Oncol 1998;5:635–41.

[14] Brewer P, Sumathi V, Grimer RJ, Carter SR, Tillman RM, Abudu A, et al. Primary Leiomyosarcoma of Bone: Analysis of Prognosis. Sarcoma 2012;2012:1–4.

[15] Berlin O, Angervall L, Kindblom LG, Berlin IC, Stener B. Primary leiomyosarcoma of bone. A clinical, radiographic, pathologic-anatomic, and prognostic study of 16 cases. Skeletal Radiol 1987;16:364–76.

[16] Dai X, Ma W, He X, Jha RK. Review of therapeutic strategies for osteosarcoma, chondrosarcoma, and Ewing's sarcoma. Med Sci Monit 2011;17:RA177–90.

[17] Damron TA, Ward WG, Stewart A. Osteosarcoma, chondrosarcoma, and Ewing's sarcoma: National Cancer Data Base Report. Clin Orthop Relat Res 2007;459:40–7.

[18] Atalar H, Gunay C, Yildiz Y, Saglik Y. Primary leiomyosarcoma of bone: a report on three patients. Clinical Imaging 2008;32:321–5.

[19] Jundt G, Moll C, Nidecker A, Schilt R, Remagen W. Primary leiomyosarcoma of bone: report of eight cases. Hum Pathol 1994;25:1205–12.

Using Anteriorly Eccentric Humeral Head Components to Manage Posterior Subluxation in Glenohumeral Arthroplasty

Jason E. Hsu, MD, Albert O. Gee, MD, Robert M. Lucas, MD, Stacy M. Russ, Winston J. Warme, MD, and Frederick A. Matsen III, MD

Posterior humeral subluxation presents a technical challenge in glenohumeral arthroplasty and is associated with inferior outcomes and higher complication rates. We have explored the use of anteriorly eccentric humeral head components to help center the humeral head articular surface on the glenoid while allowing the tuberosities to remain in a relatively posterior position. This report presents the degree of re-centering and the two year clinical outcomes achieved with this approach in 20 shoulders with pre-operative posterior subluxation and an average of 20.5 ± 8.7 degrees of retroversion. The procedures included 6 total shoulder arthroplasties and 14 hemiarthroplasties with concentric glenoid reaming; in these arthroplasties there was no attempt to normalize glenoid version. Rotator interval plication was performed in 10 of 20 patients. As determined by the mediatrice method, humeral subluxation was improved from 61.0% +/- 8.9% to 50.9% +/- 1.7% ($p<0.001$). No patient had posterior subluxation >55% on immediate post-operative axillary radiographs. At two years, two patients had 56% and 57% posterior subluxation on radiographs but were doing well clinically. Simple Shoulder Test (SST) scores improved from 5.2 to 10.3 ($p<0.001$), and SANE scores improved from 45.6 to 83.8 ($p<0.001$). Clinical failure occurred in one patient as a result of a *Propioinibacterium* infection. No patient had signs of subscapularis failure. This case series demonstrates that radiographic re-centering and substantial clinical improvement can be obtained with anteriorly eccentric humeral head components in the management of glenohumeral arthritis with posterior humeral head subluxation.

Introduction

Posterior subluxation of the humeral head is a common feature of glenohumeral osteoarthritis and capsulorrhaphy arthropathy. We have explored the use of an anteriorly eccentric humeral head components in the management of posterior subluxation of the humeral head to achieve re-centering of the head while allowing the proximal humerus to remain in a relatively posterior position[5]. In the past, eccentric head components have been used to assist in anatomically positioning the head component[9], but the use of humeral head eccentricity to manage posterior instability at shoulder arthroplasty has been described only recently[5].

The objectives of this study were 1) to determine the degree of posterior humeral head subluxation with the arm in the functional position of humeral elevation in the plane of the scapula pre-operatively, immediately after glenohumeral arthroplasty, and at two years post-operatively, 2) to report functional outcome scores before and at two years after these arthroplasties, and 3) to report any complications, particularly with regards to potential subscapularis failure as a result of increased tension on the subscapularis repair.

Materials and Methods

The medical records of patients having glenohumeral arthroplasty at the University of Washington were searched to identify those cases meeting the following inclusion criteria: (1) an eccentric humeral head prosthesis used to manage posterior subluxation, (2) pre-operative, immediate post-operative and two year post-operative radiographs including an anteroposterior view in the plane of the scapula and a standardized axillary view taken with the arm elevated in the plane of the scapula and that show the spinoglenoid notch as a verification of proper orientation, (3) pre-operative Simple Shoulder Test (SST) and Single Assessment Numeric Evaluation (SANE) scores recorded immediately before and two years after the arthroplasty. For these cases, demographic information including age, sex, diagnosis, and surgical procedure were recorded. Operative notes were reviewed to document the utilization of an eccentric humeral head prostheses along with concomitant procedures such as a rotator interval plication.

The indication for an anteriorly eccentric humeral head prosthesis was persistent posterior subluxation of appropriately sized non-eccentric trial components by more than 50% of the width of the glenoid when the arm was elevated in a forward direction. If sufficient stability did not result from the use of an anteriorly eccentric humeral head component, plication of the rotator interval[2] was added as an additional method for managing posterior instability. No attempt was made to alter glenoid version.

Radiographic Analysis

Three fellowship-trained shoulder surgeons evaluated the pre-operative, immediate post-operative, and two-year post-operative axillary radiographs taken with the arm elevated in the plane of the scapula and showing the spinoglenoid notch[4]. The Walch classification of glenoid morphology was determined based on the original descriptions by Walch et al[10]. If a consensus was not reached, the shoulder was assigned the category that at least two surgeons agreed upon. Glenoid retroversion was determined by measuring the angle between the plane of the scapula and a line connecting the anterior and posterior edges of the

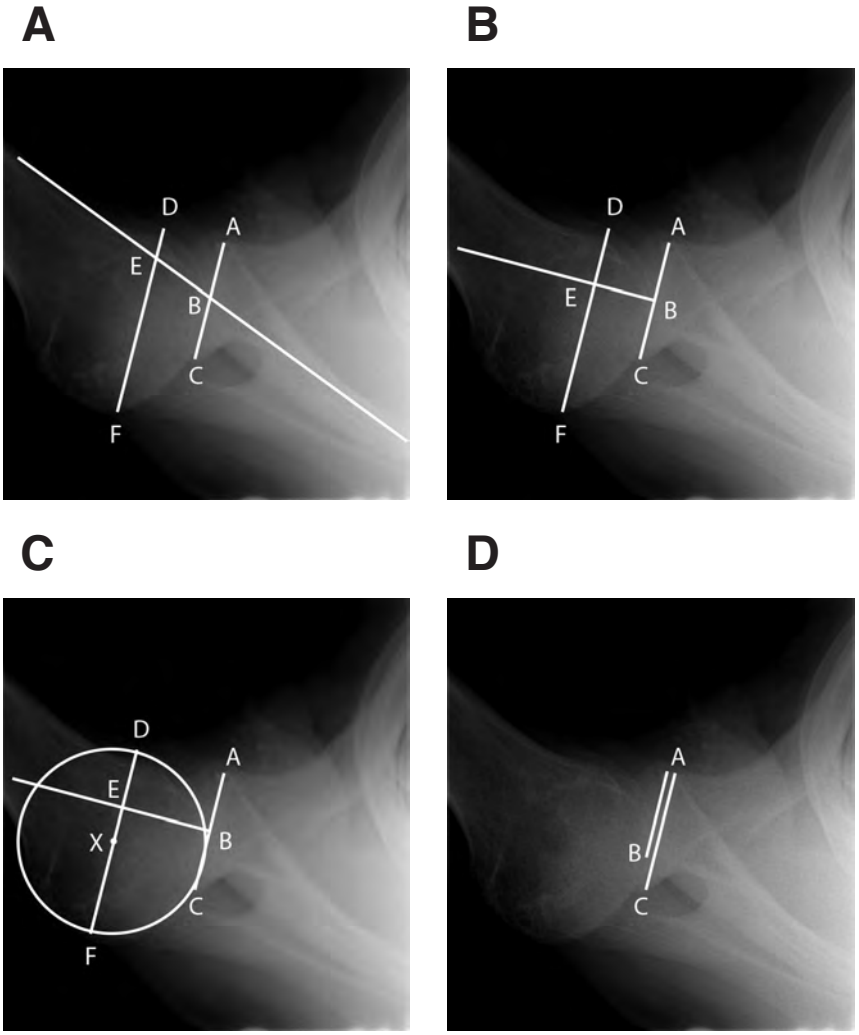

Figure 1: Four indices used to measure posterior humeral head subluxation. A) Scapular axis method (SAM): defined as ratio of EF to DF, where B is the midpoint between A and C, line BE defines the scapular axis, and line DF is parallel to line AC. B) Mediatrice method (MM): defined as ratio of EF to DF, where B is the midpoint between A and C, line BE is perpendicular to line AC, and line DF is parallel to line AC. C) Center of rotation method (COR): defined as ratio of EF to DF, where B is the midpoint between A and C, line BE is perpendicular to line AC, and line EX is a line parallel to AC with X being the center of a perfect circle around the humeral head. D) Point of contact method (POC): defined as the ratio between AB to AC, where B is the contact point or center of the contact arc of the humeral head on the glenoid.

glenoid [1].

Four separate indices of posterior subluxation were used to evaluate the position of the humeral head relative to the glenoid (Figure 1A-D): the scapular axis method (SA), the mediatrice method (MM), the center of rotation (COR), and the point of contact (POC). An index between 45% and 55% for the MM, COR, and POC was considered a well-centered humeral head. An index above 55% was considered to be posteriorly subluxated. Because no attempt was made to correct glenoid retroversion during these procedures, the SA index did not have a set threshold to define posterior subluxation.

Because anterior eccentric offset of the humeral head moves the prosthesis anteriorly on the proximal humerus, there is a concern that this may place increased stress on the subscapularis tendon while healing. Therefore, question #3 ("Can you reach the small of your back to tuck in your shirt with your hand?") and question #11 ("Can you wash the back of your opposite shoulder with the affected extremity?") of the SST questionnaire were specifically analyzed for evidence of subscapularis dysfunction.

Statistical Analysis

Inter-rater agreement was analyzed using intra-class correlation coefficients (ICC) for continuous variables and Fleiss' kappa statistics for categorical variables. Inter-rater agreement was categorized as indicating slight agreement (0.00 to 0.20), fair agreement (0.21 to 0.40), moderate agreement (0.41 to 0.60), substantial agreement (0.61 to 0.80), and almost perfect agreement (0.81 to 1.0)[3]. A paired T-test was used to compare pre-operative and post-operative SST and SANE scores. Significance was set at alpha < 0.05.

Results

Demographic characteristics are summarized in Table 1. Twenty arthroplasties were included. In sixteen, the diagnosis was degenerative disease, and in four the diagnosis was capsulorrhaphy arthropathy. Total shoulder arthroplasty was performed in six, and humeral hemiarthroplasty with concentric reaming of the glenoid was performed in 14. Ten of 20 patients required an additional rotator interval plication to provide adequate stability.

Kappa values for the Walch classification and ICC measurements for glenoid retroversion and each of the four subluxation indices is summarized in Table 2. Radiographic posterior subluxation (Figure 2) using MM measurements improved from 61.0% +/- 8.9% pre-operatively to 50.9% +/- 1.7% post-operatively ($p<0.001$). Subluxation was maintained at less than 55% in all patients on the MM and COR measurements on immediate post-operative radiographs. At two-years, the MM average remained at 51.0% +/- 3.3%; 2 of 20 (10%) patients had posterior subluxation above 55% (56% and 57%) on MM measurements, and 1 of 20 (5%) patients had posterior subluxation above 55% (56%) on COR measurements. Severity of pre-operative posterior subluxation did not have an effect on the ability to correct post-operative posterior subluxation (Figure 3).

Both post-operative SANE and post-operative SST scores improved significantly compared to pre-operative scores. SST scores improved from 5.2 +/- 2.3 to 10.3 +/- 1.8 ($p<0.001$). SANE scores improved from 45.6 +/- 20.8 to 83.8 +/- 12.5 ($p<0.001$). One patient developed pain and stiffness two years after his original operation and underwent revision arthroplasty. Cultures from this revision surgery grew *Propionibacterium* and coagulase-negative *Staphylococcus*. This was the only patient that had a decrease in either SST or SANE scores. The

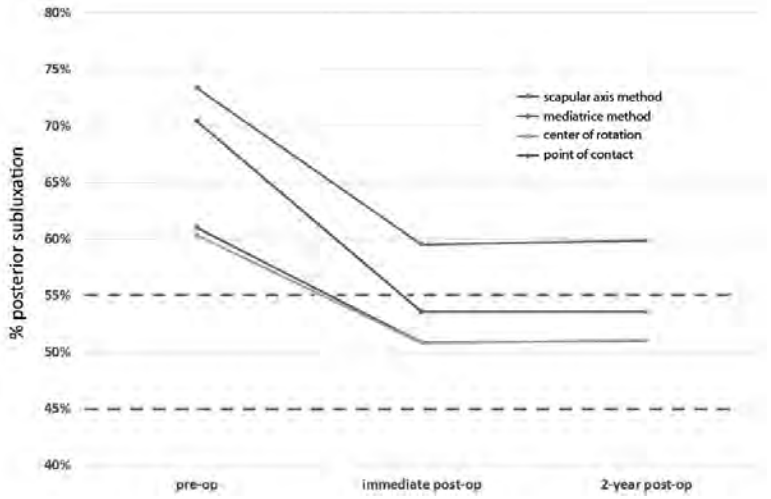

Figure 2: Posterior humeral head subluxation measured on pre-operative, immediate post-operative, and most recent post-operative radiographs.

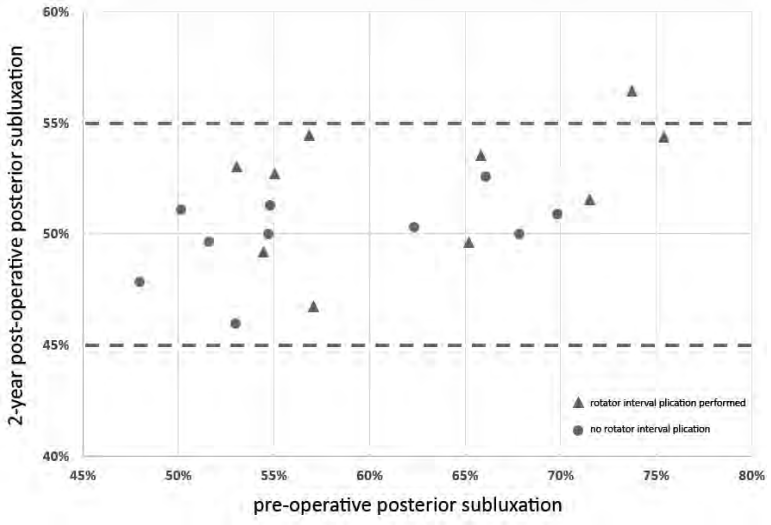

Figure 3: Posterior humeral head subluxation (based on the COR method) on two-year post-operative radiographs as a function of pre-operative posterior humeral head subluxation.

two patients with posterior subluxation >55% on MM measurements were both doing well (SST scores of 9 and 11) at two-year follow-up. No patient required revision surgery for recurrent posterior subluxation.

Question 3 of the SST ("Can you reach the small of your back to tuck in your shirt with your hand?") was answered "Yes" by 3 of 20 (15%) patients pre-operatively and 17 of 20 (85%) patients post-operatively. Question 11 of the SST ("Can you wash the back of your opposite shoulder with the affected extremity?") was answered "Yes" by 3 of 20 (15%) patients pre-operatively and 15 of 20 (75%) patients post-operatively.

Discussion

The goal of this study was to characterize the radiographic and functional outcomes of shoulder arthroplasty cases in which anterior eccentric offset of the humeral head was used to manage posterior subluxation associated with the arthritic triad. We collected radiographic and clinical outcome scores on 20 patients in which this method was utilized. Radiographic outcomes in this study show that posterior subluxation relative to the glenoid face can be corrected and is durable at a minimum two-year follow-up without correction of glenoid retroversion.

The use of the eccentric head has the advantage of allowing the proximal humerus to sit posteriorly where the soft tissues have adapted to over time. It is a relatively simple technique that does not require major changes in surgical intervention, does not risk soft tissue tightening that may loosen over time, and does not change the post-operative rehabilitation protocol. Because the head is allowed to sit concentrically within the glenoid during range of motion, the risk of early glenoid component failure is theoretically decreased. While other investigators have suggested the use of asymmetric reaming, bone grafting[7], augmented implants[8], and reverse arthroplasty[6] in cases of biconcavity and posterior subluxation, good clinical and radiographic results were obtainable with use of anterior eccentric offset of the humeral head and without correction of glenoid retroversion. Additional follow-up will be necessary to establish the longevity of these findings.

The major limitations of this study include the limited two-year follow-up, the retrospective study design, and the lack of three dimensional imaging.

To our knowledge, this is the first study to characterize the results following glenohumeral arthroplasty using anteriorly eccentric offset of the humeral head for posterior subluxation. In our study, the use of this technique was associated with improved posterior humeral head subluxation that was durable at a minimum two-year follow-up. Excellent clinical results were obtained without correction of glenoid version.

References

1. Friedman RJ, Hawthorne KB, Genez BM. The use of computerized tomography in the measurement of glenoid version. The Journal of bone and joint surgery American volume 1992;74:1032-1037.

2. Harryman DT, 2nd, Sidles JA, Harris SL, Matsen FA, 3rd. The role of the rotator interval capsule in passive motion and stability of the shoulder. The Journal of bone and joint surgery American volume 1992;74:53-66.

3. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-174.

TABLE I. DEMOGRAPHICS OF COHORT REQUIRING ANTERIOR ECCENTRIC HUMERAL HEAD PLACEMENT DURING SHOULDER ARTHROPLASTY	
Total patients, #	20
Age, mean (range)	61.8 (40.9-76.7)
Sex, # (percentage)	
Male	19 (95%)
Female	1 (5)
Etiology, # (percentage)	
Degenerative disease	16 (80%)
Capsulorraphy arthropathy	4 (20%)
Glenoid retroversion, mean (range)	20.5 deg (8.3-34.5)
Glenoid classification, # (percentage)	
A1	0
A2	1 (5%)
B1	4 (20%)
B2	11 (55%)
C	4 (20%)
Procedure, # (percentage)	
Total shoulder arthroplasty	6 (30%)
Hemiarthroplasty with concentric glenoid reaming	14 (70%)
Rotator interval plication, # (percentage)	
Rotator interval plication	10 (50%)
No rotator interval plication	10 (50%)

Table 1: Demographic characteristics of the study cohort.

TABLE II. INTEROBSERVER RELIABILITY OF GLENOID MEASUREMENTS		
	ICC / Kappa (95% CI)	**Agreement**
Walch classification	0.54 (0.38-0.70)	Moderate
Glenoid retroversion	0.76 (0.53-0.89)	Substantial
Indices of posterior subluxation		
Scapular axis method	0.82 (0.73-0.88)	Almost perfect
Mediatrice method	0.71 (0.59-0.80)	Substantial
Center of rotation method	0.70 (0.58-0.79)	Substantial
Point of contact method	0.46 (0.31-0.61)	Moderate

Table 2: Intra-observer reliability measurements.

4. Matsen FA, 3rd, Gupta A. Axillary view: arthritic glenohumeral anatomy and changes after ream and run. Clinical orthopaedics and related research 2014;472:894-902. 10.1007/s11999-013-3327-6

5. Matsen FA, 3rd, Lippitt SB. Current Technique for the Ream-and-Run Arthroplasty for Glenohumeral Osteoarthritis. JBJS Essent Surg Tech 2012;2:e20. http://dx.doi.org/10.2106/JBJS.ST.L.00009

6. Mizuno N, Denard PJ, Raiss P, Walch G. Reverse total shoulder arthroplasty for primary glenohumeral osteoarthritis in patients with a biconcave glenoid. The Journal of bone and joint surgery American volume 2013;95:1297-1304. 10.2106/JBJS.L.00820

7. Sabesan V, Callanan M, Ho J, Iannotti JP. Clinical and radiographic outcomes of total shoulder arthroplasty with bone graft for osteoarthritis with severe glenoid bone loss. The Journal of bone and joint surgery American volume 2013;95:1290-1296. 10.2106/JBJS.L.00097

8. Sabesan V, Callanan M, Sharma V, Iannotti JP. Correction of acquired glenoid bone loss in osteoarthritis with a standard versus an augmented glenoid component. Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al] 2014;23:964-973. 10.1016/j.jse.2013.09.019

9. Sassoon A, Schoch B, Rhee P, Schleck CD, Harmsen WS, Sperling JW et al. The role of eccentric and offset humeral head variations in total shoulder arthroplasty. Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al] 2013;22:886-893. 10.1016/j.jse.2012.09.008

10. Walch G, Badet R, Boulahia A, Khoury A. Morphologic study of the glenoid in primary glenohumeral osteoarthritis. The Journal of arthroplasty 1999;14:756-760.

The Utility of Bending and Traction X-Rays in Preoperative Radiographic Determination of Fusion Levels in Adolescent Idiopathic Scoliosis

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Introduction

Multiple preoperative radiographs are routinely ordered to determine fusion levels and classify curve patterns in Adolescent Idiopathic Scoliosis (AIS). This study investigates whether preoperative bending and traction films improve the selection of upper and lower instrumented levels compared to only preoperative PA and lateral full-length radiographs. Clinically, our goal is to limit the preoperative radiographs (thus limiting radiation exposure) that are ordered for AIS patients (i.e. eliminate bend films, traction films or both) and utilize only those films that clinically help surgeons determine fusion levels outside of the standard upright PA and lateral films. While previous investigations have highlighted the assessment of curve flexibility when assessing various supplementary pre-operative views (traction and bending), no study has been done that correlates their clinical impact on determining the actual instrumented levels chosen.

Methods

This is a retrospective analysis of pre-operative full-length thoracolumbar PA, lateral, bending and traction radiographs of 10 children who have undergone deformity correction for AIS at a single high volume children's hospital. Three Orthopedic Spine Surgeons were asked to examine 4 series of de-identified radiographic images for this randomized cohort of 10 children, distributed at 1 to 2 week intervals. The first series showed PA and lateral images. The second series contained PA, lateral and bending images. The third series contained PA, lateral and supine traction films. The fourth and final series contained PA, lateral, bending and supine traction films. All films were marked with relevant Cobb angles as determined by the institution's current spine fellow. With each series, the examiner was asked to record the Upper Instrumented Vertebra (UIV) and Lower Instrumented Vertebra (LIV) in their surgical correction. Fusion levels were recoded to an ordinal numeric scale for analysis. Intra-class correlations coefficients (ICCs) for two-way mixed-effects models with absolute agreement were calculated separately for UIV and LIV, for each surgeon. Secondarily, similar models were analyzed by film series.

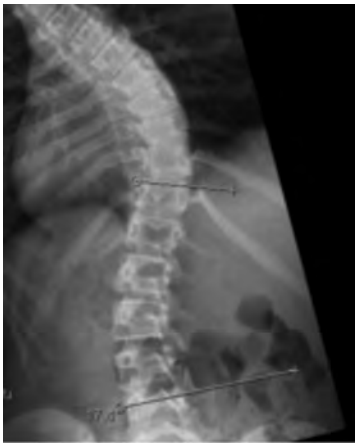


Figure 2: Some surgeons may have chosen to include a fusion to L3 or L4 based on the size of the Lumbar curve. Bending films are necessary to determine a Lenke Classification but sometimes of no value in determining levels, as the upper or lower curves are too small to need to consider.

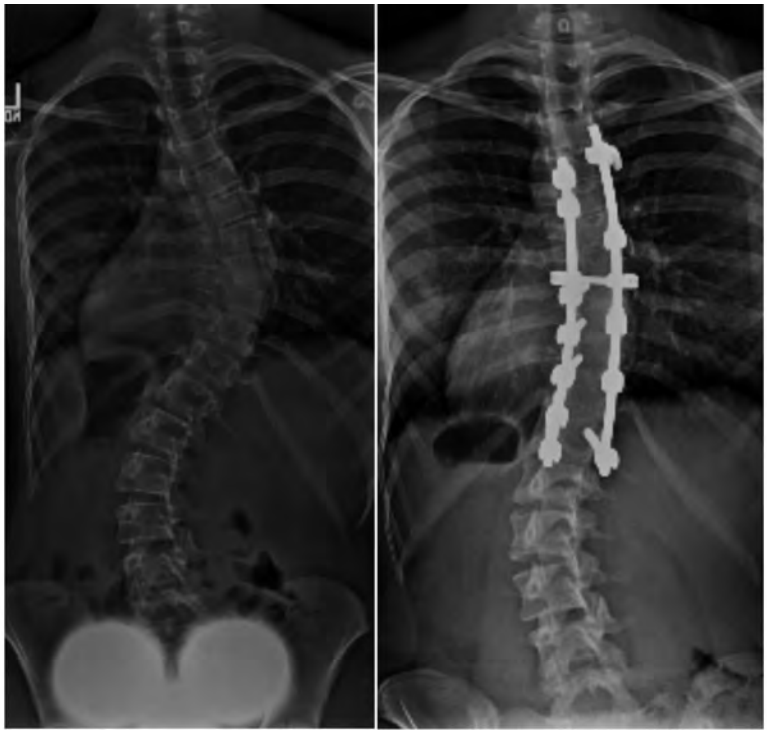


Figure 1: This patient had Posterior spinal fusion from T4 to T12 based on the flexibility of the lumbar curve and left Upper thoracic curve 5 years ago.

Results

Preliminary analysis was completed for 5/10 subjects. Agreement remained almost perfect for LIV for each regardless of film series presented to each individual surgeon (ICC ≥0.93, (95% CI: 0.75 – 0.99, p<0.001). For UIV, agreement was again almost perfect for

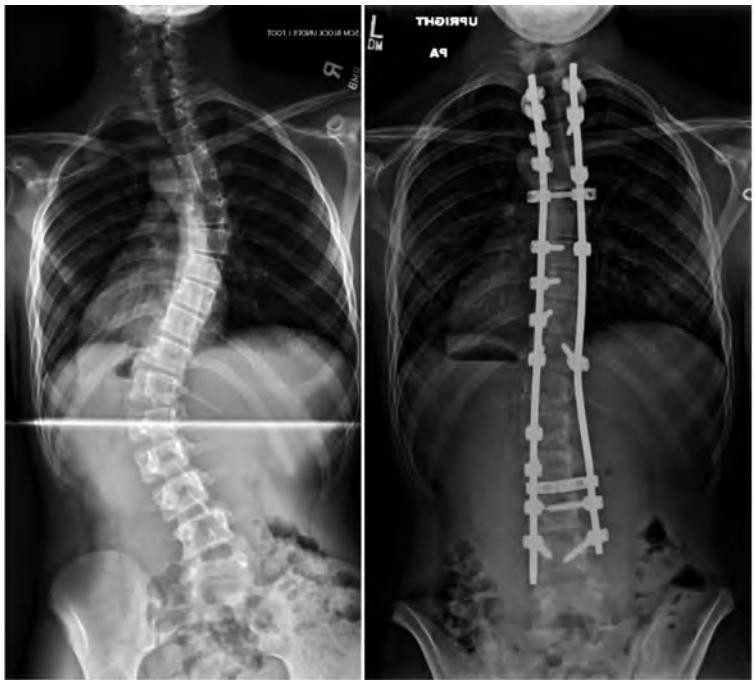


Figure 3: This patient had a stiffer lumbar curve and had a longer fusion from L3 to L4.

all but one surgeon (ICC ≥0.88, (95% CI: 0.54 – 0.99, p<0.003).

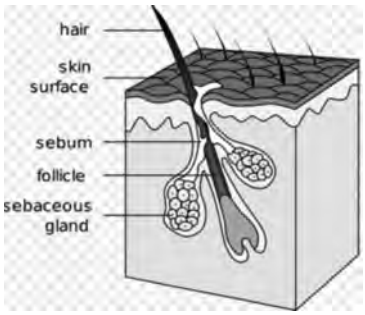
Conclusion

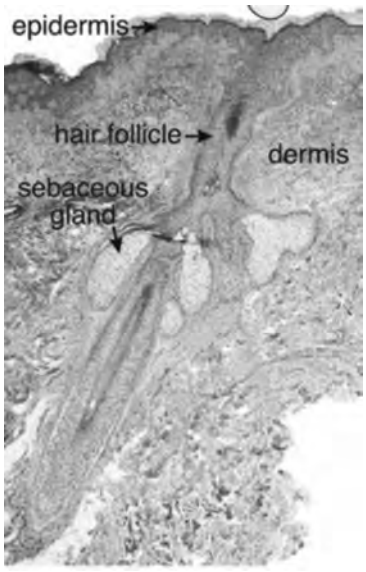
The preliminary data of this pilot study suggest that additional films such as bending and traction films may not be necessary for decision making with regards to UIV and LIV in the surgical management of Adolescent Idiopathic Scoliosis .

Propionibacterium – What We Think We Know Today

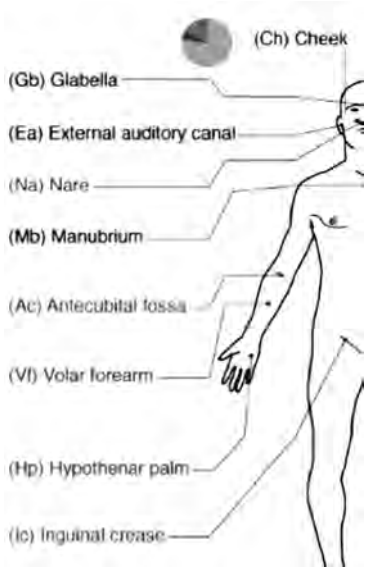
Frederick A. Matsen III, MD, Jason E. Hsu, MD, Winston J. Warme, MD,
Roger E. Bumgarner, PhD, Paul S. Pottinger, PhD, Susan Butler-Wu, PhD,
Robert M. Lucas, MD, and Ian J. Whitney, MD

Propionibacterium are slow growing, gram-positive rods that can live in aerobic and anaerobic environments. They are commensal, living on the epidermis and in the dermis of normal skin. They may be 'probiotic' against Staph Aureus and Strep.





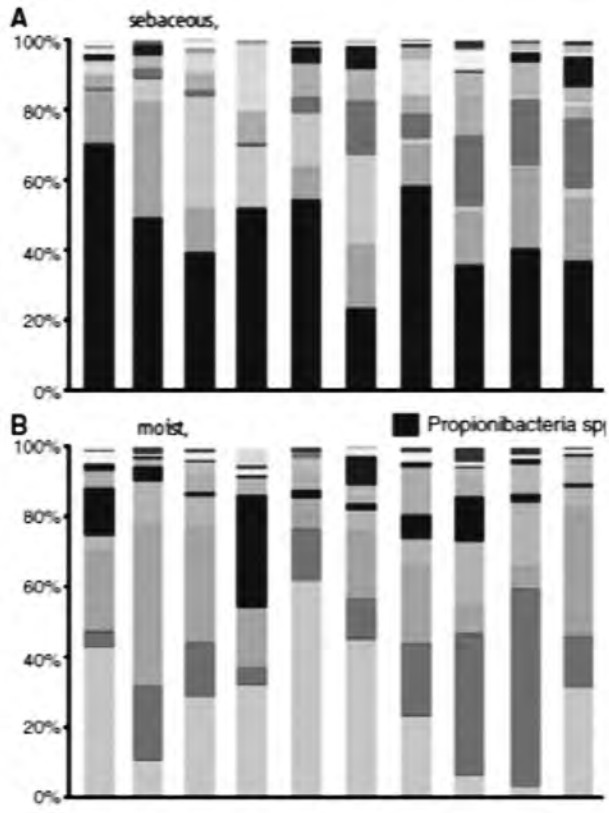
They are found on oily rather than wet skin.

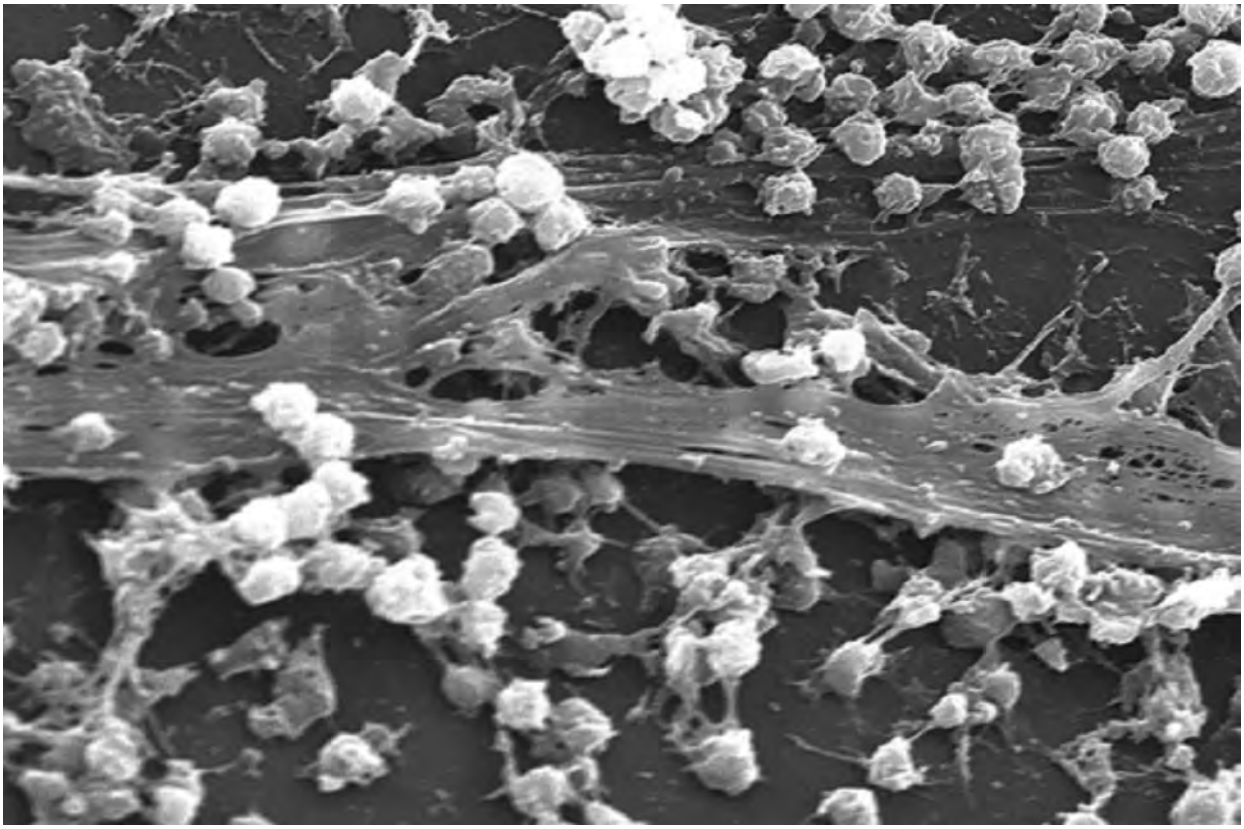


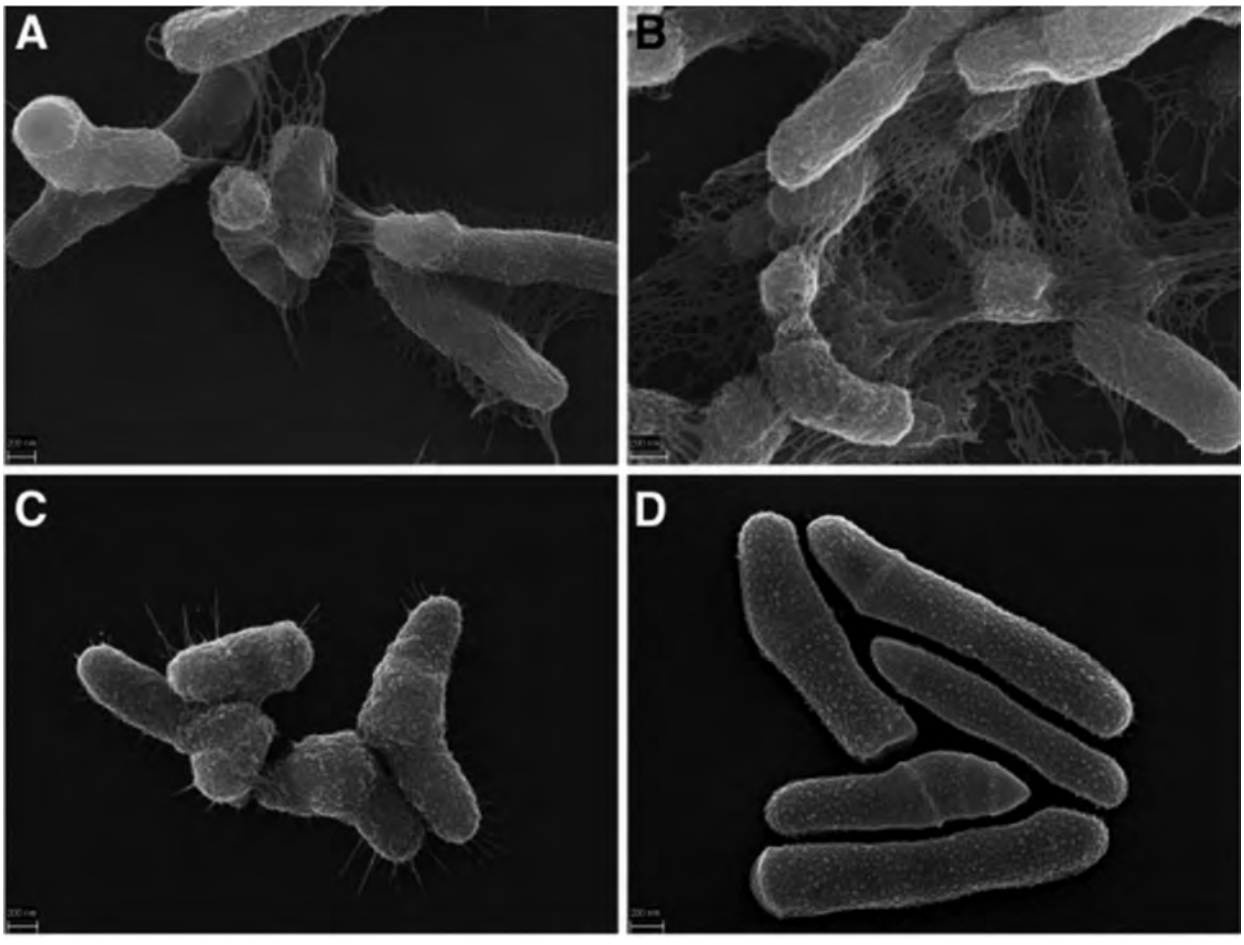
Propionibacterium stimulate bone resorption while hiding in biofilm niche on the surface of implants. The problem is not just P. Acnes, but also P. Humerusii and P. Avidum. Propi with pili may be better biofilm formers.

At the time of revision arthroplasty, Propionibacterium are recovered in over 40% of failed total shoulders. They may be recovered over 10 years after the index procedure, usually after a 'honeymoon' of good function. There is an increased risk for these organisms in young males having multiple prior surgeries showing signs of destruction without inflammation ("aseptic" failure).

It is likely that Propi are introduced into every surgical wound. The adverse effects of this contamination may be modulated by IV prophylaxis with Ceftriaxone and Vancomycin, discarding the skin knife, copious



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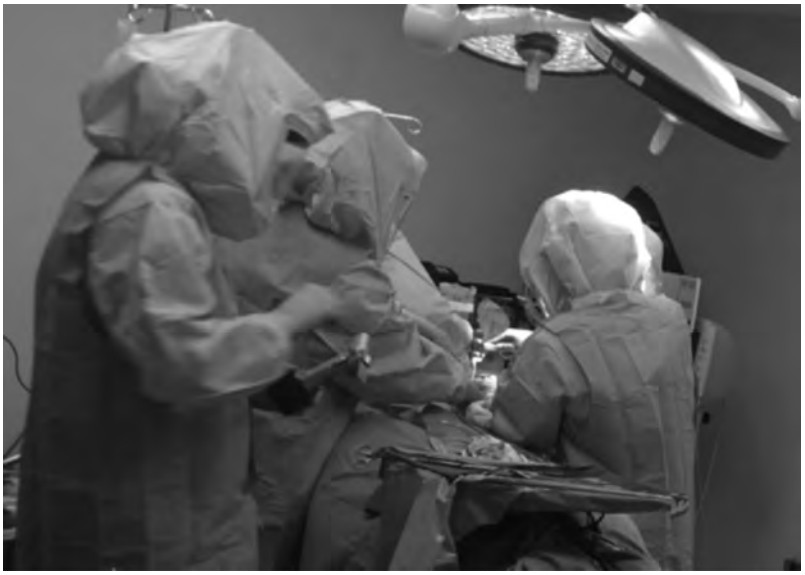
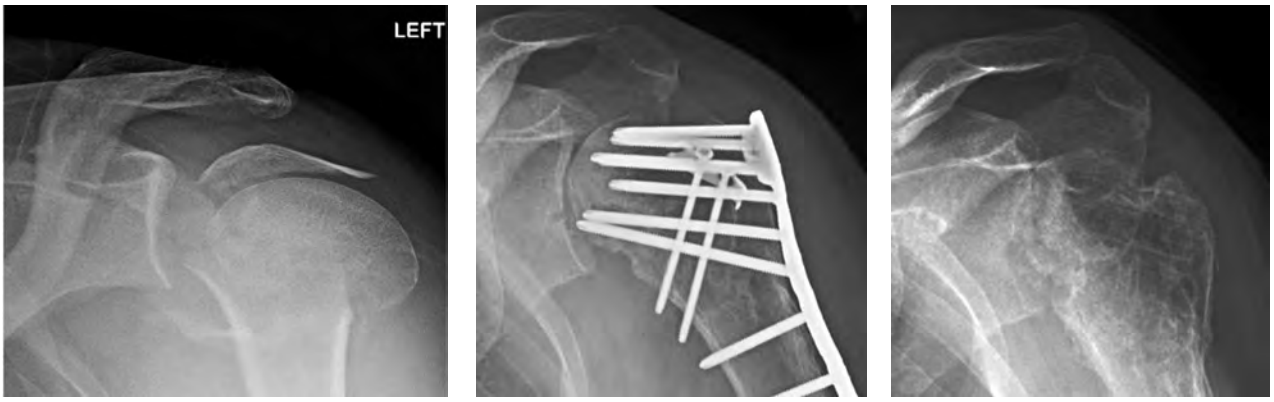


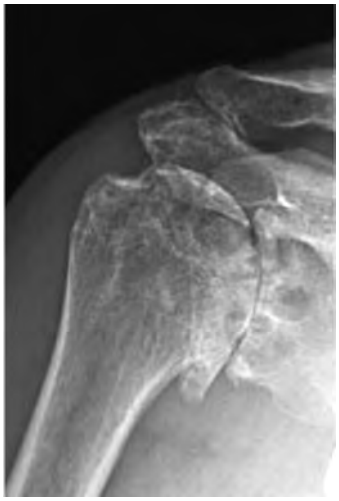
irrigation, minimizing contact of implants with the skin edge, and avoiding drains. It is doubtful that space suits play a role in prevention.

The clinical presentation of Propionibacterium is stealthy. If Staph Aureus and Strep are like fire destroying a house, Propi are like carpenter ants. They do not typically produce redness, swelling, tenderness, drainage, abnormal blood tests, or increased white cells per histologic high power field. The infection may present years after the index arthroplasty with the onset of unexplained pain, stiffness, or component loosening.

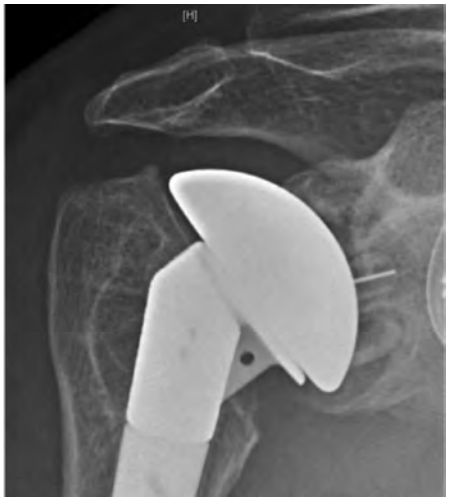
Optimizing the chances of recovering Propionibacterium requires culturing five specimens of tissue or explants before antibiotic administration,



Case Example:
#1 60-year-old male two years after ORIF and one year after hardware removal. Propi cultured from four of five tissue samples.



Case Example:
#2: 50 year old male with history of labral repair 7 years prior. Propi cultured from three of three suture cultures.



Case Example:
#3: 57 year old male two years after total shoulder after a failed labral repair. Propi cultured in four of four explant cultures and two of five tissue cultures.

culturing on anaerobic and aerobic media, and observing the cultures for 17 days.

Since culture results are not known at surgery, the surgeon must elect either the yellow protocol: prosthesis retention, oral Augmentin until cultures are finalized (If cultures are negative at three weeks, antibiotics are discontinued. If cultures become positive, convert to red protocol) or the red protocol: removal of all components, single stage insertion of new humeral component with Vancomycin- allograft, PICC line administration for six weeks of IV Ceftriaxone, possibly with Rifampin, followed by one year of oral Augmentin.

We observe that the typical patient with positive Propionibacterium cultures is an otherwise healthy 50-year-old male presenting 4 years after prior surgical procedures with pain, stiffness, and/or component loosening. While the usual laboratory test are usually normal, cultures of the explants and tissue are most likely to reveal the presence of this organism.

References

Butler-Wu, S.M., E. M. Burns, et al. (2011). "Optimization of periprosthetic culturefor diagnosis of Propionibacterium acnes prosthetic joint infection." JClin Microbiol 49(7): 2490-5.

Butler-Wu, S.M., D. J. Sengupta, et al. (2011). "Genome sequence of a novel species,Propionibacterium humerusii." J Bacteriol 193(14): 3678.

Hou, C., Gupta, A., et al. (2015). "How do revised shoulders that are culture positive for propionibacterium differ from those that are not?› accepted J Shoulder Elbow Surg.

Lee, M. J., P.S. Pottinger, et al. (2014). "Propionibacterium persists in the skin despite standard surgical preparation." J Bone Joint Surg Am 96(17):1447-50.

Matsen, F. A.,3rd, S. Butler-Wu, et al. (2013). "Origin of propionibacterium in surgical wounds and evidence-based approach for culturing propionibacterium from surgical sites." J Bone Joint Surg Am 95(23): e1811-7.

Matsen, F. A., 3rd, Russ, S.M, et al. (2014). "Propionibacterium can be isolated from deep cultures obtained at primary arthroplasty despite intravenous antimicrobial prophylaxis." J Shoulder Elbow Surg. Published Online: December 26, 2014

McGoldrick, E.,M. D. McElvany, et al. (2014). "Substantial cultures of Propionibacteriumcan be found in apparently aseptic shoulders revised three years or more afterthe index arthroplasty." J Shoulder Elbow Surg. 24(1):31-5

Pottinger, P.,S. Butler-Wu, et al. (2012). "Prognostic factors for bacterial culturespositive for Propionibacterium acnes and other organisms in a large series ofrevision shoulder arthroplasties performed for stiffness, pain, or loosening." J Bone Joint Surg Am 94(22): 2075-83.

Risk Factors for Conversion to Total Hip Arthroplasty After Posterior Wall Acetabular Fracture

David Shearer, MD, MPH, Benjamin Hamilton, MS, Paul Toogood, MD, and Reza Firoozabadi, MD, MA

Introduction

Fractures involving the posterior wall are the most common fractures of the acetabulum, accounting for approximately half of Letournel's originally published series[1,2]. Despite their frequency, the outcome of patients afflicted by these injuries is often disappointing[3–6]. The ability to predict poor outcome prior to initiating treatment would be useful for counseling patients and selecting appropriate treatment plans. Treatment options include non-operative treatment, percutaneous fixation, open reduction internal fixation[2,7], arthroplasty[8,9], and combinations of these techniques[10,11].

There is a growing interest in performing acute total hip arthroplasty (THA) for acetabular fractures in cases in which open reduction internal fixation (ORIF) is suspected to fail, particularly among elderly patients[9–11]. This is particularly relevant given the prevalence of geriatric acetabular fractures has more than doubled over the last three decades[12]. Compounding the increasing incidence is the fact that elderly patients are more likely to have unfavorable fracture characteristics such as marginal impaction and comminution[12]. A large meta-analysis demonstrated a 23% rate of conversion to total hip arthroplasty among patients over age 55 with acetabular fractures. Secondary conversion of an acetabular fracture managed with ORIF to a total hip arthroplasty has been shown to have substantially worse functional outcome and shorter survivorship compared to a primary THA for osteoarthritis[13,14].

The purpose of this study was to identify risk factors for early conversion to THA in an effort to aid in counseling patients and selecting the optimal treatment. We hypothesized that radiographic features of the injury, such as marginal impaction of the acetabulum and femoral head impaction would be associated with earlier conversion to total hip arthroplasty. We secondarily aimed to determine the effect of fracture reduction on the subsequent need for THA in an effort to establish goals of treatment for cases in which ORIF is undertaken.

	Overall	No THA	THA	p-value*
Age, mean	43.7	42.9	48.1	0.15
Gender, no. (%)				0.44
Male	51 (78.5)	43 (79.6)	8 (72.7)	
Female	14 (21.5)	11 (20.4)	3 (27.3)	
Mechanism, no. (%)				0.003
Fall	8 (12.3)	8 (14.8)	0 (0)	
MVC	36 (55.4)	33 (61.1)	3 (27.3)	
PVA	4 (6.2)	1 (1.9)	3 (27.3)	
MCC	13 (20)	10 (18.5)	3 (27.3)	
Other	4 (6.2)	2 (3.7)	2 (18.2)	
Fracture pattern, no. (%)				0.95
Isolated posterior wall	29 (44.6)	24 (44.4)	5 (45.5)	
Posterior column, posterior wall	6 (9.2)	5 (9.3)	1 (9.1)	
Transverse, posterior wall	25 (38.5)	20 (37)	5 (45.5)	
T-type, posterior wall	5 (7.7)	5 (9.3)	0 (0)	
Time to reduction (hours)	11.2	10	14.6	0.24
Time to surgery (days)	3.4	3.5	3	0.75

*Comparing THA group to no THA group

Table 1: Characteristics of patients included in the study.

Methods

After IRB approval, we searched our institutional trauma database for patients with acetabular fractures involving the posterior wall from 2005 to 2010 managed with open reduction internal fixation. We included elementary and associated fracture patterns that involved a posterior wall component managed using a Kocher-Langenbach approach. Patients who did not have both pre- and postoperative CT scans available for review and a minimum of 4 years of follow up were excluded from the study.

A chart review was conducted to obtain baseline clinical data and operative reports were reviewed. The preoperative radiographs, preoperative CT scans, intraoperative imaging, and postoperative CT scans were reviewed by two orthopaedic trauma fellows. Preoperative imaging was reviewed for evidence of dislocation, comminution of the posterior wall, impaction of the femoral head or acetabulum, and presence of intra-articular loose bodies. The postoperative CT scan was used to measure the quality of reduction. Specifically, the magnitude of the largest articular step-off and diastasis at the level of the acetabular dome was recorded using the method described by Moed et al.[4].

Given the broad catchment area of our institution, patients were contacted by telephone to inquire about secondary operative procedures and to administer the SF-8 and patient-components of the Merle d'Aubigne Hip Scale (ROM component excluded). The primary outcome of the study was conversion to total hip arthroplasty.

Data were analyzed using Stata version 13 (StataCorp, College Station, TX). Categorical variables were compared using Fisher's exact test while continuous variables were compared using Student's T-test. We considered a difference significant if the p-value was less than 0.05.

Results

Of the 150 patients with posterior wall acetabular fractures identified in our trauma database during the time period of the study, 65 patients were able to be evaluated in clinic or contacted by telephone more than 4 years postoperatively (43.3%). The mean follow up was 6.9 years (range 4 to 9.3 years) after surgery (Table 1). The average age was 43 and the majority of subjects were male (78.5%). There were 29 (44.6%) isolated posterior wall, 25 (38.5%) transverse posterior wall, 6 (9.2%) posterior-column posterior wall, and 5 (7.7%) T-types with an associated posterior wall fracture.

The overall rate of conversion to THA was 16.9% (11/65). The age, gender, fracture classification, time to closed reduction, and time to surgery were not associated the rate of conversion to THA (Table 1). However, road traffic related mechanisms were more commonly associated with subsequent need for THA than fall-related mechanisms (p=0.003).

With regard to radiographic features of injury, the presence of dislocation, comminution of the posterior wall, femoral head impaction, acetabular impaction, and intra-articular loose bodies all trended toward an association with conversion to THA, but none of these factors independently reached statistical significance in association with the primary outcome. However, the presence of all five radiographic features concomitantly was associated with a 50% (5/10) rate of conversion to THA in contrast to 10.9% (6/55) if four or less features were present (p=0.009).

Among cases with less than 1mm of diastasis and step-off on postoperative CT scan, there were no THA conversions (0/8) compared to 9.1% (4/40) for 1 to 4mm and 53.9% (7/13) if either step-off or diastasis was 4mm or more (p=0.001). The presence of all five radiographic features of severe injury was associated with a reduction step-off or diastasis greater than 4mm in 60% of cases (6/10) compared to 12.7% (7/55) of less severe injuries (p=0.005).

There was no difference in SF-8 (16.4 vs. 17.4, p=0.63) or modified Merle d'Aubigne scores (8.0 vs 8.9, p=0.39) comparing patients who underwent THA and those who did not.

Discussion

In a retrospective case series of patients managed operatively for acetabular fractures involving the posterior wall, we have demonstrated that high-energy mechanisms and a combination of radiographic features of severity portend a high rate of conversion to total hip arthroplasty. Furthermore, we have shown that reduction step-off or diastasis greater than 1mm, which cannot be detected with plain radiography, was strongly correlated with subsequent need for total hip arthroplasty.

The findings of this study are not entirely unprecedented. In a series of 182 patients with posterior wall fractures treated operatively over a 20-year period in Toronto, Kreder et al.[15] showed a similar correlation between radiographic severity and subsequent outcome. Specifically, they demonstrated that posterior wall comminution, marginal impaction, and older age were associated with a higher rate of conversion to total hip arthroplasty. However, they did not have postoperative CT scans for the majority of their patients and were not able to show a significant effect of postoperative reduction. In addition, their minimum follow up was only 1 year with a mean of 4 years.

Moed et al.[4] included 67 patients in a study evaluating the effect of fracture reduction on the outcome of posterior wall acetabular fractures using the modified Merle d'Aubigne Hip Scale as a primary outcome at an average of 4 years after surgery. While they did find that poor reduction was associated with lower outcome scores, the cutoff for reduction was a diastasis of more than 1 centimeter while step-off was not found to be significantly associated with the outcome. These results strongly contrast with our study in which reductions of less than 1 millimeter had much greater longevity than fractures with step-off or diastasis of greater than 4 millimeters. We believe the longer duration of follow up and more contemporary cohort with modern fine-cut CT scans may contribute to this discrepancy.

Authors from Greece reported the outcomes of 19 patients with posterior wall fractures with a minimum of 15 years of follow up[16]. The authors report only a single patient requiring conversion to total hip arthroplasty and overall strong correlation between reduction quality and outcome. However, they did not use postoperative CT to evaluate reduction quality, and it is unlikely that the incidence and accessibility of total hip arthroplasty for a patient population treated in the 1980s in Greece is equivalent to a modern US population.

There are several noteworthy limitations of this study. The follow up rate in our study was less than 50%, which results largely from the large geographic area served by our institution. We attempted to contact as many patients as possible by telephone, but were unsuccessful in reaching patients in many cases. We believe this is offset to some degree by the relatively long duration of follow up (mean 7 years), use of a firm primary endpoint (conversion to THA), and validated patient-centered outcome instruments (SF-8 and Merle d'Aubigne hip score). Another important limitation is that the study was retrospective, which may limit data quality, particularly for many baseline clinical variables. However, because many of the baseline injury characteristics were obtained from digital radiographs, there is not bias due to recordkeeping error or poor recall. Because the majority of our patients did not have long-term radiographic follow up, we could not comment on the reason for conversion to total hip arthroplasty, such as avascular necrosis or post-traumatic arthritis. However, we were able to correlate the primary outcome with postoperative reduction quality but not with time to closed reduction, which would suggest that failures occurred more often secondary to arthritis. Lastly, we did not have adequate sample size to demonstrate the association between several variables with statistical significance nor were we able to conduct a multivariate analysis to identify the strongest independent risk factors for conversion to THA.

Conclusions

Posterior wall acetabular fractures associated with the combination of dislocation, comminution, intra-articular loose bodies, femoral head impaction, and acetabular impaction are associated with more difficult reduction and higher rate of conversion to total hip arthroplasty in comparison to less severe injuries. Patients should be counseled accordingly about the need for future arthroplasty and consideration can be given to primary THA in these severe cases. When ORIF

is undertaken, anatomic restoration of the acetabulum to within 1mm of both step-off and diastasis, which cannot be accurately detected with plain radiographs, is associated with the lowest risk of post-traumatic arthritis.

References

1. Judet, R., Judet, J. & Letournel, E. Fractures of the acetabulum: Classification and surgical approaches. J Bone Jt. Surg Am 46, 1615–1646 (1964).

2. Letournel, E. & Judet, R. Fractures of the acetabulum. (Springer Science & Business Media, 1993)

3. Moed, B. R. & McMichael, J. C. Outcomes of posterior wall fractures of the acetabulum. J. Bone Joint Surg. Am. 89, 1170–1176 (2007).

4. Moed, B. R., Carr, S. E. W., Gruson, K. I., Watson, J. T. & Craig, J. G. Computed tomographic assessment of fractures of the posterior wall of the acetabulum after operative treatment. J. Bone Jt. Surg. 85, 512–522 (2003).

5. Moed, B. R., Carr, S. E. & Watson, J. T. Open reduction and internal fixation of posterior wall fractures of the acetabulum. Clin. Orthop. (2000).

6. Moed, B. R., WillsonCarr, S. E. & Watson, J. T. Results of operative treatment of fractures of the posterior wall of the acetabulum. J. Bone Joint Surg. Am. 84-A, 752–758 (2002).

7. Matta, J. M. Fractures of the Acetabulum: Accuracy of Reduction and Clinical Results in Patients Managed Operatively within Three Weeks after the Injury. J. Bone Jt. Surg. 78, 1632–45 (1996).

8. Enocson, A. & Blomfeldt, R. Acetabular fractures in the elderly treated with a primary Burch-Schneider reinforcement ring, autologous bone graft, and a total hip arthroplasty: a prospective study with a 4-year follow-up. J. Orthop. Trauma 28, 330–337 (2014).

9. Sierra, R. J., Mabry, T. M., Sems, S. A. & Berry, D. J. Acetabular fractures: the role of total hip replacement. Bone Jt. J. 95-B, 11–16 (2013).

10. Boraiah, S., Ragsdale, M., Achor, T., Zelicof, S. & Asprinio, D. E. Open reduction internal fixation and primary total hip arthroplasty of selected acetabular fractures. J. Orthop. Trauma 23, 243–248 (2009).

11. Herscovici, D. J., Lindvall, E., Bolhofner, B. & Scaduto, J. M. The combined hip procedure: open reduction internal fixation combined with total hip arthroplasty for the management of acetabular fractures in the elderly. J. Orthop. Trauma 24, 291–296 (2010).

12. Ferguson, T. A., Patel, R., Bhandari, M. & Matta, J. M. Fractures of the acetabulum in patients aged 60 years and older: an epidemiological and radiological study. J. Bone Joint Surg. Br. 92, 250–257 (2010).

13. Schnaser, E., Scarcella, N. R. & Vallier, H. A. Acetabular fractures converted to total hip arthroplasties in the elderly: how does function compare to primary total hip arthroplasty? J. Orthop. Trauma 28, 694–699 (2014).

14. Von Roth, P., Abdel, M. P., Harmsen, W. S. & Berry, D. J. Total hip arthroplasty after operatively treated acetabular fracture: a concise follow-up, at a mean of twenty years, of a previous report. J. Bone Joint Surg. Am. 97, 288–291 (2015).

15. Kreder, H. J. et al. Determinants of functional outcome after simple and complex acetabular fractures involving the posterior wall. J. Bone Joint Surg. Br. 88, 776–782 (2006).

16. Mitsionis, G. I. et al. Surgical management of posterior hip dislocations associated with posterior wall acetabular fracture: a study with a minimum follow-up of 15 years. J. Orthop. Trauma 26, 460–465 (2012).

Iliosacral Screw Removal: A Reliable Source of Pain Relief After Pelvic Fracture Fixation

Paul Toogood, MD and Reza Firoozabadi, MD, MA

The placement of percutaneous screws for the fixation of posterior pelvic ring injuries is a common and safe procedure. It is unknown whether residual pain after this procedure can be reliably relieved with implant removal once the injury has healed. The purpose of the current study was to evaluate the rates of pain relief, patient satisfaction, and complications associated with removal of iliosacral screws.

Ten patients who had undergone posterior pelvic fixation with later implant removal were identified and had their imaging and charts reviewed to obtain demographic, injury, and fixation data and also underwent a phone interview to obtain outcomes data.

The study cohort had a mean age of 36.1 years, were 70% female, and 90% white. Injury patterns were 70% lateral compression and 30% anterior-posterior compression, 70% Tile C and 30% Tile B. Injuries include 60% sacral fractures, 30% sacroiliac joint disruptions, and 10% crescent fractures. 90% of injuries were unilateral and 60% of patients also underwent anterior fixation.

Mean pain after implant removal was 2.8/10. Narcotic use reduced from 40% of patients prior to implant removal to 20% after removal. 90% of patients experienced pain relief and would have the removal procedure again. There were no complications related to implant removal.

This study thus appears to support the removal of iliosacral screws in the symptomatic patient.

Introduction

Fluoroscopically guided percutaneous screw fixation is a well described technique for the treatment of unstable posterior pelvic ring injuries, including sacral fractures, sacroiliac joint disruptions, and certain "crescent" fracture-dislocations of the sacroiliac joint.[1] Prior authors have reported high rates of successful maintenance of reduction, union, and functional outcomes with concomitantly low complications rates.[2] Despite its wide spread acceptance and seemingly good results the technique does require placement of implants across some portion of the sacroiliac joint, an articulation which does normally have a small amount of physiologic motion. Prior authors have noted rates of severe post-operative pain from 1-7% with this technique[3,4], but it is currently unknown whether this discomfort is due to sequella of the patient's original injury or the existence of rigid fixation across the sacroiliac articulation once the original injury has healed.

The available literature on iliosacral screw removal is extremely limited, with only two prior reports in the German literature specifically evaluating the topic[5,6] and only case reports and technical papers dedicated to the subject in the English literature.[7-9] As such, current management of post-operative pain after posterior pelvic fixation is based on clinical judgment of the surgeon and patient preferences.

The purpose of the current study was thus to evaluate the rates of pain relief, patient satisfaction, and complications associated with removal of iliosacral screws.

Materials and Methods

The raw data for this study was taken from a retrospective review of a prospectively collected institutional data-base. Skeletally mature patients from January 2008 to January 2014 who had been surgically treated by the Orthopedic Trauma Service were reviewed. Those who had undergone percutaneous posterior pelvic fixation, as identified by the CPT code 27216, and/or removal of a deep implant, as identified by the CPT code 20680, were first selected. This combined group was then manual screened for those patients having undergone both procedures. Finally, this group of patients then underwent a manual chart review to identify those in which the removal of the deep implant represented removal of the percutaneous placed posterior pelvic fixation and not an implant removal for a different area of the body. Patients were included if they had undergone implant removal due to pain and were at least one month out from their implant removal procedure. Patients were excluded if they had undergone implant removal for other reasons such as skeletal immaturity, infection, or a surgical complication (screw malposition on post-operative CT scan).

With the patient cohort identified data was gathered from two sources. First chart and radiographic review was used to identify patient demographics (age, sex, race), details regarding the timing of iliosacral screw placement and removal, injury pattern (Young & Burgess classification, Tile Classification, Sacroiliac joint disruption versus sacral fracture, unilateral versus bilateral injury), and details regarding fixation (presence of additional anterior fixation). Second, a phone interview was then used to collect patient outcomes data. To determine whether patients had experienced pain relief from the implant removal patients were asked to self report their current pain level, their need for narcotics before and after implant removal, and whether they perceived an improvement in their pain with screw removal. To evaluate for patient satisfaction with the removal procedure patients were asked whether they would have the screw removed again. Finally, patients were also asked whether they had experienced any complications related to the removal procedure.

Descriptive statistics (means, standard deviations, ranges)

Patient Demographics	
Age (Mean, Range)	36.1 (18-63)
Sex	70% Female, 30% Male
Race	90% White, 10% Hispanic

Table 1: Patient Demographics.

were calculated to report patient demographics and outcomes.

Results

From January 2008 to January 2014 two-thousand six-hundred sixty-one patients underwent either percutaneous fixation of a posterior pelvic ring injury or removal of a deep implant. Of these patients, seventy-one had undergone both procedures. Further manual review of patient records revealed that fifteen of these seventy-one patients had undergone removal of a posterior screw from their pelvic ring. One patient was excluded due to skeletal immaturity at the time of injury and one was excluded for having undergone screw removal due to a post-operative infection. Of the final thirteen qualified patients, three could not be contacted, leaving ten patients who were able to provide subjective outcomes data.

Patient demographics are listed in Table 1. As is typical for a trauma population the mean age was relatively young, though the range was broad. Atypical for a trauma population, the majority of individuals who underwent implant removal were female.

Details regarding injury pattern, additional fixation, and the timing of screw removal are listed in Table 2. The majority of injuries were lateral compression injuries by the Young and Burgess Classification and complete, type C injuries by the Tile classification. There were no vertical shear injuries and no stable, type A, injuries in the cohort. The most common posterior injury pattern was a sacral fracture, followed by SI joint disruptions, and a single crescent fracture. Almost all injuries were unilateral. The majority of individuals had some form of additional anterior fixation in the form of a symphyseal plate or superior ramus screw. The timing of screw removal varied widely, with a mean of over two years between initial fixation and implant removal.

Results of the subjective phone interview are listed in Table 3. Eight of ten individuals rated their current pain level as 2 or less on a ten point scale, while two individuals rated their pain as 7 and 8. Of the two individuals with higher pain levels, one patient reported this pain was not related to their posterior pelvic area and one reported their pain was related to their posterior pelvic area. Of note, the single patient that reported high pain levels in the region of their posterior pelvis had undergone implant removal only one month prior to the phone interview.

Prior to undergoing implant removal 4 patients required the use of narcotics for pain control. This number reduced to 2 following implant removal.

Finally, nine of ten patients reported significant pain relief with implant removal and would undergo the removal procedure again.

No patients experienced a complication related to the removal of a screw from the posterior portion of their pelvis. One patient who also had a screw removal from their anterior pelvic ring during the same procedure had a local infection from the anterior screw removal site which required antibiotics and local wound care. This infected screw was a retrograde superior ramus screw inserted and then removed from a stab incision adjacent to the groin.

Discussion

Iliosacral screw placement is a common, safe, and effective means by which to treat unstable injuries of the posterior portion of the pelvic ring. As previously reported by Routt et al, examining an early series of one-hundred seventy-seven consecutive patients, this technique resulted in clinical and radiographic union in 98% of cases and was associated with minimal blood loss, no infections, a fixation failure rate of < 4%, and screw misplacement rates of < 3%.

Despite its efficacy, there is the

Injury Pattern and Fixation Variables	
Young & Burgess Classification	70% LC, 30% APC
Tile Classification	70% C, 30% B
Posterior Injury Pattern	60% Sacral fracture, 30% SI joint dislocation, 10% posterior crescent fracture
Unilateral vs Bilateral Injury	90% unilateral, 10% bilateral
Presence of anterior fixation	60% with additional internal anterior fixation
Timing of Screw removal (mean, range)	28.9 months (2.5-132 months)

Table 2: Injury Pattern and Fixation Variables.

Phone Interview Results	
Pain	
Current pain level	2.8 (0-8)
Narcotic use prior to removal	40%
Narcotic use after removal	20%
Patient experienced pain relief	90%
Would you have the screw removed again?	90%

Table 3: Phone Interview Results.

known morbidity of crossing the sacroiliac joint, which may produce a treatable source of post-operative pain. Prior authors have reported rates of pain in this population from 1-7%.[3,4] Additionally, a single report in the German literature suggests potential benefit in implant removal in the symptomatic post-operative patient. Examining a group of twelve pelvic fracture patients who underwent implant removal, one group reported improvement in DGU pelvic scores in 83% following screw removal. Additionally, comparing this group to a cohort of 9 patients who declined implant removal, these authors found improved clinical outcomes in the implant removal group.[5]

In the current study, a limited cohort of patients who had undergone implant removal from a posterior pelvic ring injury were available for review. This small number is consistent with our institution's protocol not to routinely remove hardware, but rather to limit such a procedure to those patients who require it due to skeletal immaturity, infection associated with the original procedure, screw malposition as identified on routine post-operative CT scanning, and recalcitrant post-operative pain that does not respond to conservative treatment.

Regarding patient demographics, within the current study cohort we report a mean age of 36.1 years at the time of initial injury, which is consistent with a young trauma population, but noted a seemingly high proportion of removal procedures amongst females. This is despite the fact that prior authors report the majority of such injuries occurring in the male trauma population.[1] While the reasons for this can only be speculative, it is possible females are either more frequently symptomatic from their posterior pelvic hardware due to anatomic or physiologic differences at the SI joint or are more willing to report symptoms and/or undergo additional surgery to relieve pain.

Regarding details of the original injury sustained, the current study found that patients with a variety of injury patterns later requested implant removal with no pattern being obviously over represented and so be suspicious for producing post fixation symptoms. Specifically, using the Young and Burgess Classification, both lateral compression and anterior-posterior compression patterns were well represented in the cohort. No vertical shear patterns were present, however this is most likely due to the small size of the cohort and the relative rarity of the injury pattern. Similarly, both Tile B and C patterns were present in the cohort, suggesting both incomplete and complete posterior injury patterns had patients with posterior pelvic pain after fixation. No Tile A patterns were present, however stable pelvic injuries do not routinely require fixation, and as such would not be expected to frequently be amongst patients requesting implant remove for post-operative pain. Similarly, all forms of bony versus soft tissue injury appeared to present with post-operative pain after fixation. Specifically, both sacral fracture and SI joint disruption were well represented amongst the cohort. Combined bony and soft tissue injury, in the form of crescent fracture, was relatively infrequent, with only a single case in this study group, however this pattern of posterior injury is also rarer, and so its infrequency in this study is likely simply explained by pelvic fracture epidemiology, rather than an infrequency of post-operative pain with this injury pattern. Finally, unilateral injury was more frequent than bilateral injury, however again, this is most likely related to the infrequency of bilateral pelvic injuries relative to unilateral injuries in the pelvic fracture population.

Regarding additional anterior fixation, in the current study cohort this seemed to be neither protective nor predictive of the need for later hardware removal. This perhaps suggests posterior pelvic pain to be relatively independent of anterior injury and its fixation.

The primary purpose of the current study was to evaluate rates of pain relief, patient satisfaction, and complications associated with posterior pelvic implant removal. Our results seem to indicate very reliable pain relief and high patient satisfaction in this carefully selected population. The majority of patients experienced pain levels at or less than 2/10 after screw removal, fewer patients required the use of narcotics after implant removal, and 90% of patients self reported improved pain and a willingness to undergo the procedure again. The single patient in this study's cohort who experienced significant persistent pain in the region of the posterior pelvis was also the patient with the most limited follow-up, only one month. It is possible that patient's results may improve with later follow-up. Additionally, no patient experienced a complication directly related to the removal of their posterior pelvic implant, emphasizing the safety and ease of this outpatient procedure.

The current study does have numerous limitations. Despite the frequency of placement of iliosacral screws at our institution, their later removal is quite rare; only 15 cases

over a six year period. Combined with a follow-up rate of 77% in eligible patients, this produced a very small cohort available for study. Furthermore, all of the outcomes data was collected retrospectively, leading to potential recall bias by the study subjects.

In conclusion, the current study seems to support the removal of posterior pelvic implants in the symptomatic patient who has previously undergone iliosacral screw placement. These patients are most commonly young females who have sustained any variety of posterior pelvic injury pattern +/- anterior fixation and upwards of 90% experience improvements in pain and would undergo the procedure a second time. Additionally, complications from this simple procedure are rare, adding to the confidence to which a provider may recommend implant removal in symptomatic patients.

References

1) Routt ML, Kregor PJ, Simonian PT, et al. Early results of percutaneous iliosacral screws placed with the patient in the supine position. J Orthop Trauma. 1995, Jun;9(3):207-14.

2) Routt ML, Simonian PT, Mills WJ. Iliosacral screw fixation: early complications of the percutaneous technique. J Orthop Trauma. 1997 Nov;11(8):584-9.

3) Papakostidis C, Kanakaris NK, Kontakis G, et al. Pelvic ring disruptions: treatment modalities and analysis of outcomes. Inter Orthop. 2009;33:329-338.

4) Putnis SE, Pearce R, Wali UJ, et al. Open reduction and internal fixation of a traumatic diastasis of the pubic symphysis: One year radiological and functional outcomes. J Bone Joint Surg [Br] 2011;93-B:78-84.

5) Yucel N, Lefering R, Tiardes T, et al. Is implant removal after percutaneous iliosacral screw fixation of unstable posterior pelvic ring disruptions indicated? Unfallchirurg. 2004 Jun;107(6):468-74.

6) Stuby FM, Gonser CE, Baron HC, et al. Hardware removal after pelvic ring injury. Unfallchirurg. 2012 Apr;115(4):330-8.

7) Weil YA, Nousiainen MT, Helfet DL. Removal of an iliosacral screw entrapping the L5 nerve root after failed posterior pelvic ring fixation: a case report. J Orthop Trauma. 2007 Jul;21(6):414-7.

8) Langfitt MK1, Best BJ, Carroll EA. A useful tool for retained washer retrieval when removing iliosacral screws. J Surg Orthop Adv. 2013 Winter;22(4):330-2.

9) Valente A1, Nicodemo A, Bruno A, et al. Cerebrospinal fluid fistulas after iliosacral screw removal in post-traumatic pseudomeningocele. J Orthop Traumatol. 2012 Jun;13(2):111-4.

Do Antibiotic Beads Need to Be Removed?

Shawn E. Werner, MD and Reza Firoozabadi, MD, MA

Polymethylmethacrylate antibiotic beads can be an effective treatment for open fractures and chronic osteomyelitis. It is not clear whether the beads cause long-term adverse events if not removed. The aim of this study was to determine if removal of antibiotic beads was required to avoid long term complications. A retrospective chart review was conducted on patients with an extremity or pelvis fracture that had implantation of polymethylmethacrylate (PMMA) antibiotic beads from 2008-2013. Thirty-six patients (73.4%) did not have wound problems after surgical debridement and placement of PMMA antibiotic beads. Polymethylmethacrylate antibiotic beads can be utilized as a means of delivering high dose concentration of local antibiotics and do not have to be removed in all patients.

Introduction

Infections traverse every subspecialty in orthopaedics and continue to be a challenge to treat. Open fractures are at higher risk of infection and can progress to osteomyelitis. High drug concentrations can be delivered locally without having systemic effects with an additional benefit of not requiring patient compliance. Klemm was the first to describe the use of polymethylmethacrylate antibiotic beads in 1979, and achieved a 91.4 % cure rate of chronic osteomyelitis when used in conjunction with surgical debridement. It is not clear whether the beads cause long-term adverse events if not removed. Beads can continue to release antibiotics for months to decrease and diminish bacterial load, however they can theoretically serve as a substratum for bacteria. There are risks with performing an additional operation to remove the beads, and the risks are potentially higher in patients with a pre-existing infection and wound complications. The aim of this study was to determine if removal of antibiotic beads was required to avoid long term complications.

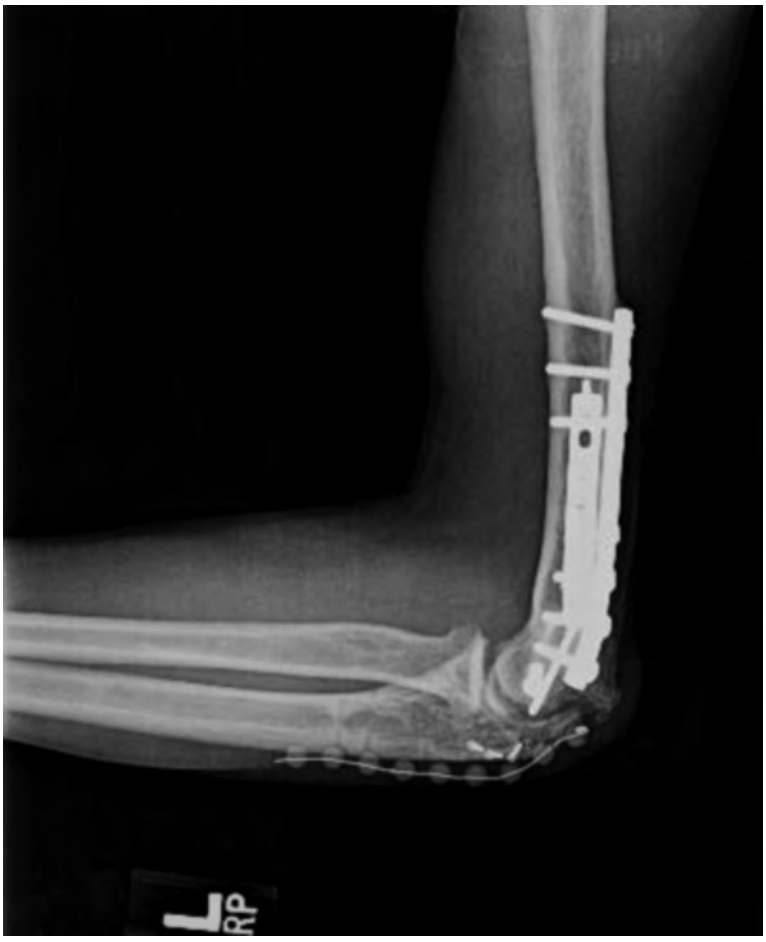


Figure 1: Lateral x-ray of elbow from a patient sustaining gunshot wound, resulting in a distal humerus and proximal ulna fractures. Initial management included open reduction and internal fixation of both fractures. After 13 years, the olecranon developed osteomyelitis and underwent hardware removal with placement of PMMA antibiotic beads. They were eventually removed six weeks after placement due to pain and skin irritation in an area with little subcutaneous tissue.

Methods

A retrospective chart review of prospectively gathered data at a Level I regional trauma center was conducted on patients with an extremity or pelvis fracture that had implantation of polymethylmethacrylate antibiotic (PMMA) beads from 2008-2013. The content of the PMMA beads was vancomycin, tobramycin, or both antibiotics. The beads are premade by the pharmacy with set concentrations of antibiotics per prefabricated bead. The operative reports were reviewed as to the plan for antibiotic bead management, and noted whether there was a plan for removal. Exclusion criteria include age less than 18, less than six week follow-up, and patients treated in staged surgical manner with planned bead removal. The orthopaedic outpatient notes were reviewed for the clinical evidence of infection or painful beads based on history or examination. Surgical reports and the intra-operative culture data were reviewed of the patents who had removal of beads.

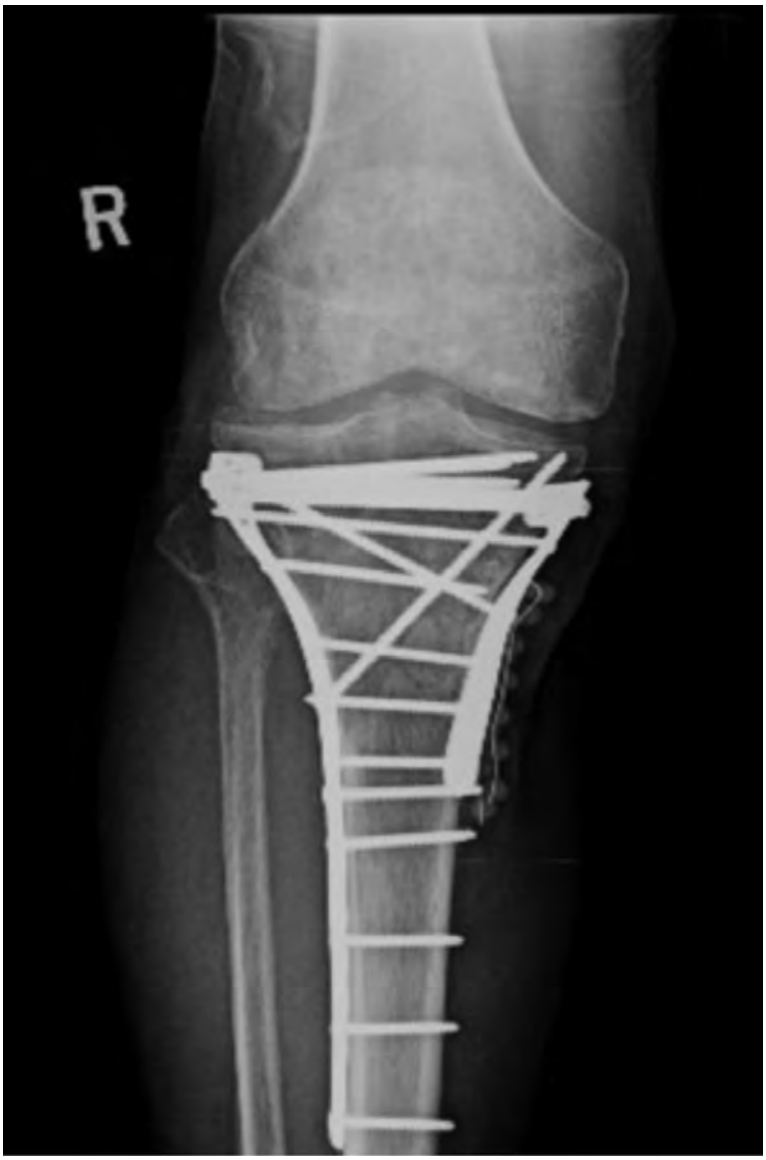


Figure 2.: AP x-ray of knee in patient who is status post open reduction and internal fixation of bicondylar tibial plateau fracture. He developed a deep infection six week post-operatively and underwent debridement with placement of beads. He went on to eradicate the infection, but the PMMA antibiotic beads cause persistent irritation on the medial aspect of the tibia and underwent removal six months after placement.

Results

Three hundred and seventy patients had PMMA beads placed by an orthopaedic surgeon at our institution from 2008-2013. Forty-nine patients met criteria for our study, the majority were excluded for planned staged surgical management. Forty-seven percent of fractures were open and most commonly involving the tibia (73%). Sixty-three percent of patients had PMMA antibiotic beads placed in the acute or subacute fracture healing phase. Average follow-up was 37 weeks (range of 6-269 weeks)

Thirty-one patients (63%) did not undergo bead removal and there were no wound complications at long-term follow-up. One patient (2%) had planned removal of pelvic PMMA antibiotic beads, but the wound had healed prior to removal. Seventeen patients (34.6%) underwent unplanned surgical bead removal. Eleven of those patients (22.4%) had delayed wound healing and removal within 90 days of placement during repeat surgical debridement. Four patients (8%) had complete wound healing, but had removal during fracture non-union repair or total joint arthroplasty. In patients with complete wound healing prior to unplanned removal, there was no purulence found intra-operatively during PMMA bead removal and intraoperative cultures were negative. Two patients (4%) had removal because of PMMA bead protuberance in areas of thin subcutaneous tissue causing pain. Methicillin-sensitive Staphylococcus aureus (MSSA) was the most common bacteria isolated in pre-PMMA bead placement, isolated in 56.7% of positive cultures. No patients developed resistance on subsequent cultures, one patient had progression to a polymicrobial infection without change in bacterial resistance.

Discussion

Open fractures and osteomyelitis are challenging and costly to treat. Adequate treatment of infected fracture sites and hardware biofilm, requires antibiotic concentrations 10 to 100 times the usual bactericidal concentration.[1] Often, this cannot be achieved by safe doses of parenteral antibiotics.[1] When PMMA antibiotic bead concentrations are measured in animal models at the site of a seroma/hematoma, granulation tissue, and bone, values exceeded the minimum inhibitory concentration (MIC) breakpoints of targeted pathogens.[2] When used in Gustilo type III fractures, PMMA antibiotic beads decrease the rates of infection when compared to systemic antibiotics alone.[3] The bead configuration can also have better elution properties when compared to cement blocks because of increased surface area.[4] Local delivery of antibiotics can be a safer alternative or addition to high dose parenteral therapy.

Of the patients in our study that required repeat unplanned surgical debridement, there was not interval wound healing issues after placement of the beads. This suggests that if the beads are placed and the wound goes on to heal, the surgeon should be confident future wound problems are unlikely.

Polymethylmethacrylate antibiotic beads may need to be removed for reasons not related to delayed wound healing. In our series, two patients required removal of beads placed at the medial proximal tibia and olecranon (Figures 1 & 2). If PMMA antibiotic beads are placed in areas with little

overlying subcutaneous tissue, these may be sites of persistent pain. In these scenarios, it is reasonable to remove the beads to reduce pain and prevent skin irritation. The PMMA antibiotic beads may also need to be removed prior to joint replacement or non-union fracture repair.

Prior literature has raised concern that not removing the beads may predispose to the development of bacterial resistance. In a case report of a patient with implanted PMMA gentamycin beads who underwent removal at five years, drug concentrations were still measureable, although at sub-inhibitory levels.[4] Furthermore, when cultures were taken of the beads, gentamycin-resistant bacteria was isolated. In our study, no patient developed drug resistance on subsequent cultures, although one patient had progression to a polymicrobial infection without change in bacterial resistance. Another patient eradicated a methicillin-resistant Staphylococcus aureus infection, but with subsequent isolation of Serratia marcescens on cultures during bead removal. The culture data from this study does not support the development of drug resistance related to PMMA antibiotic beads, however did find there can be progression to polymicrobial infections or development of bacteria not treated adequately by the antibiotics contained within the beads.

Conclusions

Polymethylmethacrylate antibiotic beads can be utilized as a means of delivering high dose concentration of local antibiotics. These can be effective in the treatment of acute fractures with gross contamination, subacute/chronic non-unions, or late infections with retained hardware. Our data suggest that PMMA beads do not necessarily harbor an environment for infection. Furthermore, antibiotic resistance does not appear to be an issue with placement of beads. However, the PMMA beads may need to be removed during repeat surgical debridement for delayed wound healing or in areas of thin subcutaneous tissue. Meticulous surgical debridement is the mainstay of treatment in infection and placement of PMMA antibiotic beads can be a potent adjunct.

References

1. Nelson CL. The current status of material used for depot delivery of drugs. Clin Orthop Relat Res. 2004(427):72-78.

2. Wininger DA, Fass RJ. Antibiotic-impregnated cement and beads for orthopedic infections. Antimicrob Agents Chemother. 1996;40(12):2675-2679.

3. Ostermann PA, Seligson D, Henry SL. Local antibiotic therapy for severe open fractures. A review of 1085 consecutive cases. J Bone Joint Surg Br. 1995;77(1):93-97.

4. Neut D, van de Belt H, van Horn JR, van der Mei HC, Busscher HJ. Residual gentamicin-release from antibiotic-loaded polymethylmethacrylate beads after 5 years of implantation. Biomaterials. 2003;24(10):1829-1831.

The Arthritic Triad of the Shoulder

Winston J. Warme, MD, Frederick A. Matsen III, MD, and Sarah E. Jackins, PT

Introduction

Standard total shoulder arthroplasty, in the setting of arthritis with minimal deformity, is straightforward and effective in reducing pain and improving motion. However, in more challenging cases which can account for up to 40% of patients seen, one is often presented with a scenario where the patient has glenoid biconcavity, (Walch B2 glenoid) (1), posterior humeral head subluxation and glenoid retroversion, (Figures 1A, 1B, 2A, 2B, 3A, 3B) (2). In this clinical situation, which we call the "Arthritic Triad of the Shoulder", (ATS), standard joint replacement techniques are associated with high failure rates due to glenoid implant loosening (3) (4), posterior polyethylene wear (5) (6) and posterior instability (2). This challenging trifecta is as yet an unsolved clinical dilemma.

Hypothesis

In a subpopulation of patient with the ATS, can a humeral hemiarthroplasty with non-prosthetic glenoid arthroplasty, (the "ream and run" procedure or RnR), provide durable results for patients as manifested by improved shoulder centering on radiographic follow-up and functional improvement on the Simple Shoulder Test (SST)?

Methods

From January 1, 2006 to December 14, 2011, we performed 531 primary shoulder arthroplasties for arthritis. Of these cases, 221 cases, (42%) were RnRs. Thirty of the RnRs met the criteria for inclusion, including: the clinical finding of ATS, (glenoid biconcavity, retroversion greater than 15 degrees, and posterior subluxation of the humeral head); standardized pre-operative and 2 year post-operative axillary radiographs that allowed for the measurement of glenoid version and posterior subluxation; and pre- and post-operative SSTs. Glenoid version was calculated as 90 degrees minus the angle between the glenoid face and the plane of the body of the scapula. The percent subluxation was the ratio of the distance from the anterior glenoid lip to the contact point, between the humerus and the glenoid, divided by the distance between the anterior and posterior glenoid lips.

Results

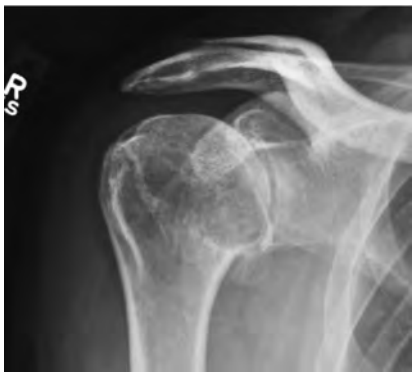
The average age of the patients was 56 +/- 8 years. Two patients requested revision surgery before the 2-year mark, and were not analyzed. There was only one female patient in the group of 28 patients studied. Mean follow-up was 3 years, (2-9.2 years). SST scores improved from 5 +/- 3, to 10 +/-4, mean difference 5 [95% CI 4-6], ($p<0.001$). The percent subluxation decreased from 75% +/- 7% pre-operatively to 59% +/- 10% post-operatively. The mean difference was 16% [95% CI, 13%-19%]; ($p<0.001$). Glenoid version was not appreciably altered, (Figures 1A-D, 2A-D, 3A-D).

Discussion

Management philosophies to address patients with the ATS vary widely across the country and overseas. Due to the high failure rates of conventional TSA, investigators have attempted to improve patient outcomes with posterior glenoid bone grafting (7), augmented polyethylene components, (such as Figure 4) (8) or even by performing reverse shoulder arthroplasties (9). Neither the technically demanding posterior bone grafting nor the placement of augmented glenoid implants have shown clinical efficacy to date. While reverse shoulder arthroplasty can work in this setting (10), it may be a more aggressive strategy than needed.

While not widely accepted, the RnR procedure has had very good results,

1A



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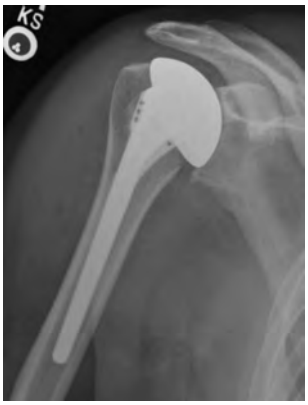
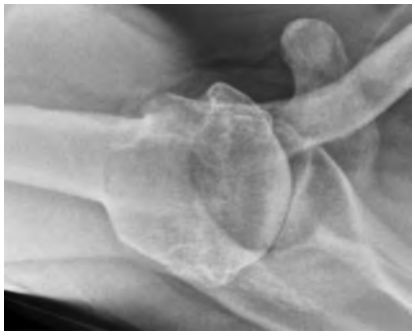
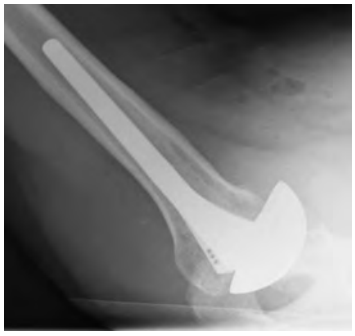


1B

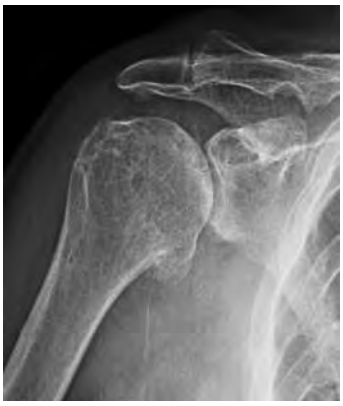


1D



Figures 1 A-D: Pre- and post-operative Grashey and axillary views of a patient treated for the ATS who had returned to work and athletics after a RnR showing a biconcave glenoid transformed into single glenoid concavity.

2A



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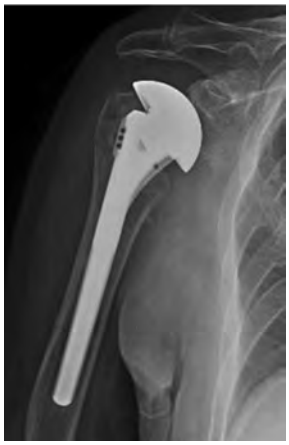
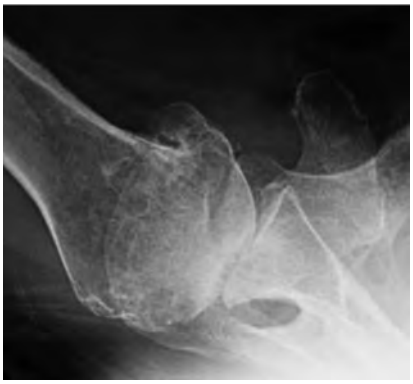
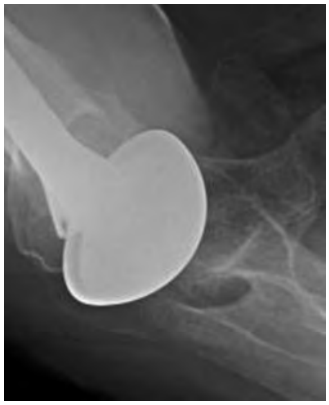


2B



2D



Figures 2 A-D: Pre- and post-operative Grashey and axillary views of this 78 year old man who returned to cattle ranching and big game hunting after a RnR for the ATS.

in select patients (11) (12) (13-15). This series of patients with challenging pathoanatomy shows that the RnR approach can yield reliably good results at mid-term follow up, while preserving glenoid bonestock and minimizing surgical implants (16). Only enough bone is removed from the glenoid to eliminate the biconcavity, without making any attempt to correct the version to a more "normal" degree (17). Moreover, no peg or keel holes are made for an implant, and no cement is utilized such that the bone is minimally effected. Avoiding the use of a glenoid implant is attractive, especially in the younger patient, as there is no risk of implant loosening, which is sadly still the most commonly reported cause for TSA failure (4). Humeral centering was improved as measured by statistically significantly decreased posterior subluxation. Clinical improvement was also manifested by statistically significant improvements in the SST.

One concern of other investigators is whether there is continued glenoid erosion in RnR patients, as there is no glenoid implant. Glenoid erosion has been reported to be more of a problem in patients who have had hemiarthroplasties performed without glenoid reaming in comparison to patients treated with a TSA (18). It is clear to us that hemiarthroplasty without reaming of the glenoid cannot be expected to work as one is still dealing with a biconcave glenoid, and point loading, glenoid wear and a painful shoulder is to be expected. However, with reaming of the glenoid, to a single concavity, we showed in a follow up study, that medial migration for the humeral head following a RnR procedure was less than 0.4mm per year (19), and postoperative glenoid wear has not been a clinical problem.

This level IV clinical case series shows that the RnR can work well in the daunting clinical scenario of ATS. More research is required to assess the long-term outcomes of these patients, and to contrast them with cohorts of patients treated with either posterior bone grafting and traditional TSA implants, glenoid implants with posterior augments and reverse shoulder arthroplasties.

References

1. Walch G, Boulahia A, Boileau P, Kempf JF. Primary glenohumeral osteoarthritis: clinical and radiographic classification. The Aequalis Group. Acta Orthop Belg. 1998;64 Suppl 2:46-52.

2. Gerber C, Costouros JG, Sukthankar A, Fucentese SF. Static posterior humeral head subluxation and total shoulder arthroplasty. J Shoulder Elbow Surg. 2009 Jul-Aug;18(4):505-10.

3. Matsen FA, 3rd, Clinton J, Lynch J, Bertelsen A, Richardson ML. Glenoid component failure in total shoulder arthroplasty. J Bone Joint Surg Am. 2008 Apr;90(4):885-96.

4. Papadonikolakis A, Neradilek MB, Matsen FA, 3rd. Failure of the glenoid component in anatomic total shoulder arthroplasty: a systematic review of the English-language literature between 2006 and 2012. J Bone Joint Surg Am. 2013 Dec 18;95(24):2205-12.

5. Scarlat MM, Matsen FA, 3rd. Observations on retrieved polyethylene glenoid components. J Arthroplasty. 2001 Sep;16(6):795-801.

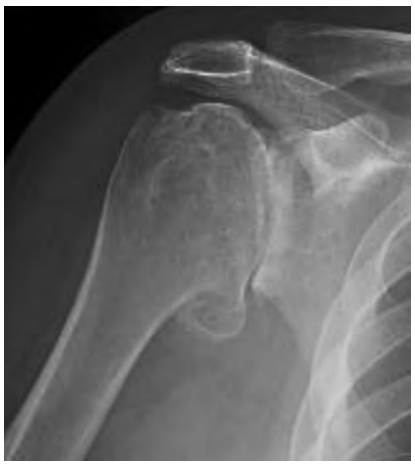
6. Collins D, Tencer A, Sidles J, Matsen F, 3rd. Edge displacement and deformation of glenoid components in response to eccentric loading. The effect of preparation of the glenoid bone. J Bone Joint Surg Am. 1992 Apr;74(4):501-7.

7. Sabesan V, Callanan M, Ho J, Iannotti JP. Clinical and radiographic outcomes of total shoulder arthroplasty with bone graft for osteoarthritis with severe glenoid bone loss. J Bone Joint Surg Am. 2013 Jul 17;95(14):1290-6.

8. Sabesan V, Callanan M, Sharma V. Guidelines for the selection of optimal glenoid augment size for moderate to severe glenohumeral osteoarthritis. J Shoulder Elbow Surg. 2014 Jul;23(7):974-81.

9. Hsu JE, Ricchetti ET, Huffman GR, Iannotti JP, Glaser DL. Addressing glenoid bone deficiency and asymmetric posterior erosion in

3A



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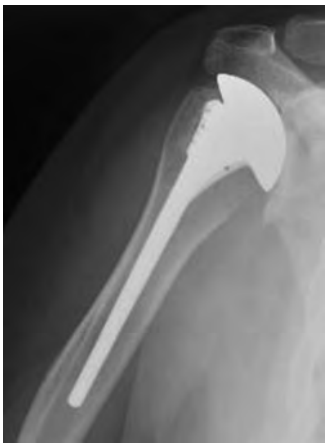

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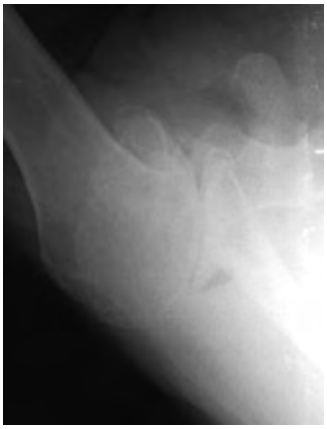

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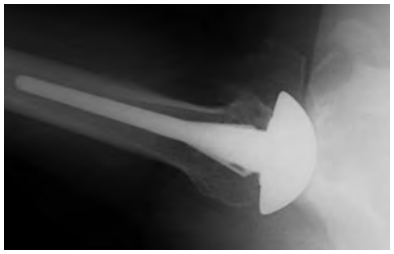


Figures 3 A-D: Pre- and post-operative Grashey and axillary views of a 58 year old construction supervisor and outdoorsman who returned to work as well as hunting after bilateral RnRs for the posterior subluxation, biconcavity and retroversion.

Figure 4: Example of an augmented glenoid.

shoulder arthroplasty. J Shoulder Elbow Surg. 2013 Sep;22(9):1298-308.

10. Mizuno N, Denard PJ, Raiss P, Walch G. Reverse total shoulder arthroplasty for primary glenohumeral osteoarthritis in patients with a biconcave glenoid. J Bone Joint Surg Am. 2013 Jul 17;95(14):1297-304.

11. Lynch JR, Franta AK, Montgomery WH, Jr., Lenters TR, Mounce D, Matsen FA, 3rd. Self-assessed outcome at two to four years after shoulder hemiarthroplasty with concentric glenoid reaming. J Bone Joint Surg Am. 2007 Jun;89(6):1284-92.

12. Saltzman MD, Chamberlain AM, Mercer DM, Warme WJ, Bertelsen AL, Matsen FA, 3rd. Shoulder hemiarthroplasty with concentric glenoid reaming in patients 55 years old or less. J Shoulder Elbow Surg. 2011 Jun;20(4):609-15.

13. Clinton J, Franta AK, Lenters TR, Mounce D, Matsen FA, 3rd. Nonprosthetic glenoid arthroplasty with humeral hemiarthroplasty and total shoulder arthroplasty yield similar self-assessed outcomes in the management of comparable patients with glenohumeral arthritis. J Shoulder Elbow Surg. 2007 Sep-Oct;16(5):534-8.

14. Gilmer BB, Comstock BA, Jette JL, Warme WJ, Jackins SE, Matsen FA. The prognosis for improvement in comfort and function after the ream-and-run arthroplasty for glenohumeral arthritis: an analysis of 176 consecutive cases. J Bone Joint Surg Am. 2012 Jul 18;94(14):e102.

15. Matsen FA, 3rd. The ream and run: not for every patient, every surgeon or every problem. Int Orthop. 2015 Feb;39(2):255-61.

16. Matsen FA, 3rd, Warme WJ, Jackins SE. Can the Ream and Run Procedure Improve Glenohumeral Relationships and Function for Shoulders With the Arthritic Triad? Clin Orthop Relat Res. 2014 Dec 9.

17. Matsen FA, 3rd, Gupta A. Axillary view: arthritic glenohumeral anatomy and changes after ream and run. Clin Orthop Relat Res. 2014 Mar;472(3):894-902.

18. Bryant D, Litchfield R, Sandow M, Gartsman GM, Guyatt G, Kirkley A. A comparison of pain, strength, range of motion, and functional outcomes after hemiarthroplasty and total shoulder arthroplasty in patients with osteoarthritis of the shoulder. A systematic review and meta-analysis. J Bone Joint Surg Am. 2005 Sep;87(9):1947-56.

19. Mercer DM, Gilmer BB, Saltzman MD, Bertelsen A, Warme WJ, Matsen FA, 3rd. A quantitative method for determining medial migration of the humeral head after shoulder arthroplasty: preliminary results in assessing glenoid wear at a minimum of two years after hemiarthroplasty with concentric glenoid reaming. J Shoulder Elbow Surg. 2011 Mar;20(2):301-7.

Geriatric Hip Fracture Program: Northwest Hospital & Medical Center

Robert S. Clawson, MD, Peter Rigby, PT, MBA, and Erich Koerner, MD

The Geriatric Hip Fracture Program was instituted at Northwest Hospital November 3, 2013. By mid-February 2015, 320 patients had been evaluated and treated. A comprehensive approach to management of Fragility Fractures has been developed named Strong Bones Program. It includes Orthopaedic Fracture Care, in-patient Co-Management with the Hospitalist Service, and Osteoporosis long term management with Rheumatologic consultation. Rehabilitation after injury and future fracture prevention remain challenges.

Long term follow-up and outcomes determination are not adequately addressed yet. Functional PT/OT Evaluation is needed and measurement tools are being developed with post-discharge outreach to Skilled Nursing Facilities and Outpatient interventions.

The goal of inclusion of all fragility fractures in the program is starting with Colles fracture and Vertebral compression fractures patients. Hand Surgeons and Interventional Radiologists have enthusiastically embraced the opportunity to help build this program.

Review of Program

Admission volume for 2014 was 176 hip fractures which is consistent with historical numbers at Northwest Hospital. Female-to-male ratio is stable at 3:1. Femoral neck fractures are the most common type of hip fractures and have the longest length of stay. The bar graphs demonstrate the demographics of the program and the surgical options used in the fracture care. Ongoing data accumulation as the program progresses is being developed to allow statistical evaluation of our care. The ability to assess the significance of our treatment is crucial to grow our program.

Inpatient care includes initial medical management by Hospitalists to clear patients for surgery and prompt restorative surgery by Orthopaedists. A Rheumatology ARNP sees every hip fracture patient in our program in consultation. Evaluation of secondary factors that contribute to Osteoporosis and post-discharge follow-up at 6 weeks to ensure ongoing Osteoporosis care are part of our program. Ongoing pharmacological treatment is assessed for appropriateness and in certain patients yearly IV bisphosphonate treatment with Zoledronic Acid is being trialed.

The Hip Fracture patients are registered in the Own The Bone Program developed by the American Orthopaedic Association. Participation in a national registry is essential to compare our patients care with other programs. Our program has received recognition for compliance in addressing the 10 prevention measures recommended by the Own The Bone Program.

In a review of re-admissions it was discovered the 11 of 135 admissions in 2013 and 17 of 176 in 2014 were inappropriate for surgical care. The unique difficulties this segment of our patient population presents were very evident. Cognitive impairment and medical frailty were the reasons for

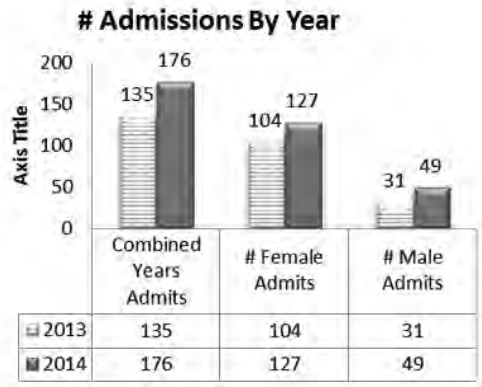


Figure 1: A 3:1 ratio exists between the # of female and male admitted with fragility fractures.

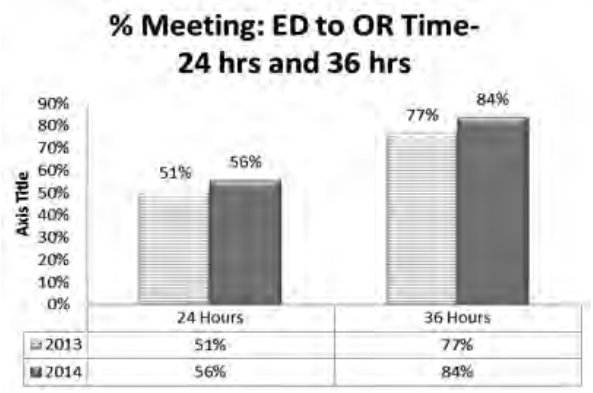


Figure 2: Inpatient Operations: Improvement has been noted in both the 24 hour and the 36 hour ED to OR standard established for this program.

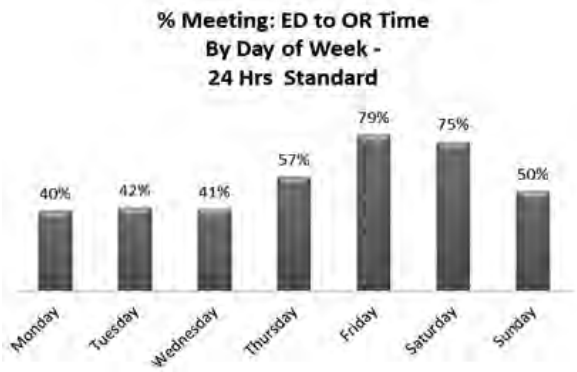
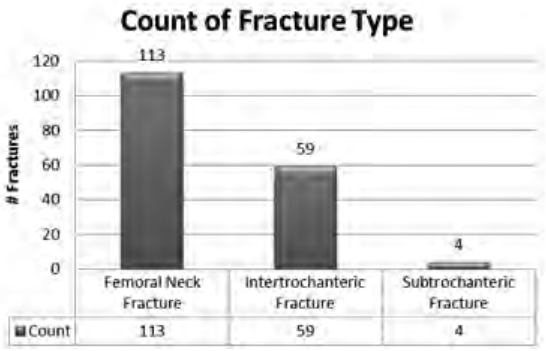
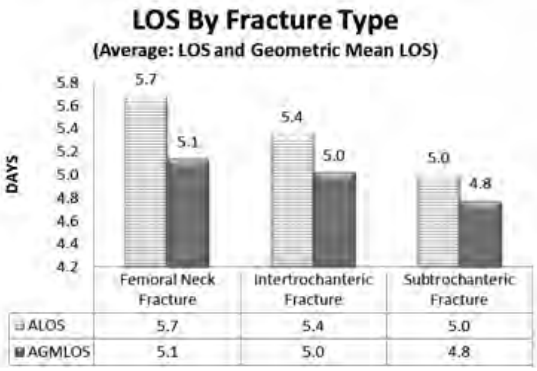


Figure 3: Inpatient Operations: Likelihood of meeting the ED to OR 24 hour standard:
- Most likely- Friday/Saturday
- Next most likely- Thursday/Sunday
- Least likely- Monday, Tuesday or Wednesday





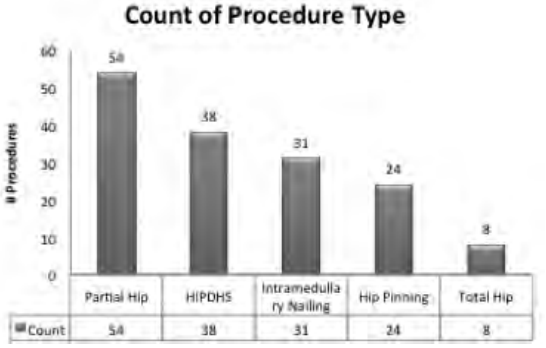


Figure 4: Surgical: NWH's 2014 ALOS better approximates the AGMLOS when 13 outliers, (LOS >= 10 days) are removed. The orthopedic department is committed to reviewing 2014 outliers by Q1 2015.

this clinical decision and reflect the increasing age of our elderly population.

Future Goals

Post-discharge follow-up has been historically difficult with multiple discharge dispositions and impaired mobility of the patients interfering with follow-up visits. A concise scoring technique for Basic Mobility: AM-PAC "6 click" functional assessment, offers a new method to grade outcome of treatment. This is a point in time assessment that is simple and can be utilized over time to document patient progress. A trial with local area SNF's is being pursued with the anticipation of a better uniform grading of our patients, particularly for the cognitively impaired who often are not able to do office follow-up post-op.

A 3-legged stool is a useful concept for describing the optimal treatment of fragility fractures. Orthopaedic care of the fracture and medical management of co-morbidities and Osteoporosis are 2 legs of the stool. The 3rd leg, rehabilitation which can hopefully lead to fall prevention, is perhaps the greatest challenge. Development of this element of care through a comprehensive, ongoing program of recovery and exercise is a major goal of the Strong Bones Program.

Harborview Medical Center Orthopaedics

Departmental Changes

After a year of transition, the 2014-15 academic year was one of consolidation and growth for Harborview Orthopaedics, during which we saw a considerable enhancement in our academic and clinical accomplishments.

The primary change to our faculty has been the welcome addition of H. Claude Sagi, MD, who will be joining us in the new academic year as the Director of Pelvis and Acetabular Trauma. Dr. Sagi is an internationally renowned orthopaedic trauma surgeon who has been the Director of Research and Fellowship Training for the Orthopaedic Trauma Service at Tampa General Hospital, recognized as being among one of the best orthopaedic trauma programs in the nation. Along with his vast experience in orthopaedic trauma as a whole, he is one of the most prominent pelvic and acetabular fracture surgeons in the country, and brings with him a set of clinical, research, teaching and leadership skills that will be invaluable to our training programs, our faculty, the local orthopaedic community and most importantly, to the population we serve over the 5-state WWAMI region.

Daphne Beingessner, MD, Associate Professor, who has done an exceptional job as the Director of Orthopaedic Quality Improvement over the past several years, has been appointed to a position of even greater responsibility hospital-wide. She was named the Surgical Director of Quality Improvement, a well-deserved recognition of her tireless efforts and tremendous accomplishments in helping provide the safest possible environment for our patients.

Medical Center

The medical center has also continued to emphasize patient safety and infection control, and is in the process of developing innovative methods to enhance patient outcomes and to determine the effect of specific interventions on treatment results, cost of care, patient-reported outcomes and patient satisfaction. From a surgical standpoint, these programs include various so-called pathway projects such as “Strong for Surgery,” “Enhanced Recovery after Surgery (ERAS),” and “Perioperative Enhanced Recovery for Major (Spine) Surgery (PERMS).” This coordinated multi-disciplinary focus on identifying at-risk patients, adjusting their perioperative care to enhance their outcome, and then tracking the effect of these changes represents a significant shift in the culture of health care, which will undoubtedly be of benefit to our patients. This burgeoning culture of safety has led to Harborview recently being one of only two hospitals in the greater Seattle area (along with Virginia Mason), to be awarded the elusive and highly regarded A-grade by the Leapfrog Group, a nonprofit watchdog group considered to be the nation’s premier advocate of transparency, quality of care and patient safety. This designation is awarded to only the top 25% of hospitals nationwide. As always, the ultimate goal of these efforts remains to provide high-quality, cost-effective care to our patients.

H. Claude Sagi, MD, our incoming Director of Pelvis and Acetabular Trauma

Clinical Care

Harborview orthopaedics has experienced considerable overall growth in clinical volumes during the past academic year, which now account for almost two-thirds of the adult orthopaedic care provided by the University of Washington system-wide. The four subspecialty divisions that comprise Harborview Orthopaedics either remained stable relative to the previous year (Hand, Foot & Ankle) or increased their clinical volume by double-digit percentages (Spine, Trauma). The Trauma Division remains one of the best and most influential globally, maintaining Harborview’s widely regarded status as one of the world’s premier trauma centers. The Foot and Ankle Division provides care for musculoskeletal disorders of the foot and ankle and podiatric services for diabetic foot care and limbs at risk. The Orthopedic component of the Hand Surgery Division collaborates closely with the Plastic Surgery and General Surgery Departments to provide complex reconstructive treatment of elective as well as traumatic conditions. The Spine Division, which collaborates closely with the Department of Neurological Surgery and the Department of Rehabilitation Medicine, treats the entire spectrum of spine injuries among all patient demographics. It has experienced the highest growth of the sub-specialties over the past academic year. All four sub-specialties continue to be a key resource for patients and clinicians alike in the WWAMI region.

Research

There continue to be approximately 70 retrospective research studies and a dozen prospective studies in progress within the Orthopaedics Department at Harborview Medical Center. New initiatives have been geared toward evaluating patient outcomes in the context of cost and resource expenditure. A collaborative role for the department with the Harborview Injury Prevention and Research Center (HIPRC) is being explored. Harborview continues to participate in the Major Extremity Trauma Research Consortium (METRC), a combined civilian and military clinical trial network

funded by the Department of Defense, which focuses on severe extremity injury, infection, limb impairment and loss. The prospective studies also include a NIH funded multicenter clinical trial comparing ankle fusion to ankle replacement, which is being done in conjunction with the Puget Sound VA Hospital.

Teaching

Harborview remains the busiest teaching hospital in the Orthopaedic Department at the University of Washington. 14 orthopaedic residents and a fourteen post-residency fellows are distributed among Harborview ortho's 4 subspecialty divisions at any given time, in addition to visiting residents and fellows. Teaching opportunities abound, as our trainees are able to choose from approximately a dozen different didactic conferences per week, in addition to the high volume of hands-on teaching that occurs in the operating rooms, inpatient wards and outpatient clinics.

Our faculty have remained instrumental in Continuing Medical Education projects world-wide, having managed to participate in a combined total of over 100 national and international courses and countless hours of local didactic teaching to students, paramedics, allied health professions, residents, fellows and other surgeons over the past year, despite maintaining busy clinical practices. Our faculty members have also published a combined total of greater than 30 book chapters in their respective areas of expertise over the same time period. Harborview continues to host visitors from throughout the globe. In the past academic year, 45 visitors, have come to observe our approach to the treatment of orthopaedic conditions, including neurosurgical colleagues with an interest in spine. Harborview's role as a worldwide leader in the treatment of orthopaedic conditions continues to be a source of motivation and pride for the faculty.

Carlo Bellabarba, MD
Professor & Acting Chief of Orthopaedics
Harborview Medical Center

Seattle Children's Hospital Orthopaedics

The Department of Pediatric Orthopedics and Sports Medicine is one of the largest surgical Departments at Seattle Children's Hospital. Our faculty are staffed by the Division of Pediatric Orthopedics and Sports Medicine from the University of Washington, Department of Orthopedics. This is a diverse group of 12 Pediatric Orthopedic Surgeons, many of whom have expanded fellowship training in spine, foot and ankle, tumor, sports medicine, skeletal dysplasia and upper extremity. A team of 5 Pediatricians compliment the department with subspecialty training in pediatric musculoskeletal health, sports medicine, including concussion treatment and pain disorders. Twelve PAs with in depth experience in children's musculoskeletal health improve the rapid access to care. The Sports Medicine Program includes 23 certified Athletic Trainers who provide coverage for 23 area high schools and over 100 community athletics events. This combined coverage results in over 56,000 encounters in our schools and communities. At the hospital there are specialty clinics for skeletal dysplasia and metabolic bone disorders as well as complex spine, clubfoot, arthrogryposis, concussion, neuromuscular disease, hand and upper extremity and sports medicine. Seattle Children's Hospital is currently supporting recruitment for both a pediatric spine surgeon and a sports medicine surgeon. There are also plans to recruit individuals with neuromuscular expertise as well as hip deformity expertise. Pediatric musculoskeletal trauma continues to grow and the Emergency Room is staffed 365 days/year, 24 hours/day to provide both trauma coverage, as well as evaluation for musculoskeletal infections in children. With over 40,000 out patient visits per year, the Pediatric Orthopedics and Sports Medicine clinic is the busiest out patient clinic at Seattle Children's. The expansion of the Children's mission to Bellevue has provided a "state of the art" out patient surgical facility. This facility was built and functions using the Continuous Process Improvement process that Seattle Children's is known for nationally with improvements in the Value equation for families: improved outcomes with decreased cost. It serves as a model for further growth and expansion. Below is a glimpse of a few of the outstanding programs offered by our Division and an overview of the clinical, educational and research activities.

Suzanne M. Yandow, MD
Director of Pediatric Orthopedics
Seattle Children's Hospital

Trauma/ Fracture

The care of fractures at Seattle Children's Hospital continues to grow. The national trend is increasingly for pediatric fractures to be referred to Pediatric care hospitals. This has clearly been seen at Seattle Children's, where the volume of acute fracture care has increased 86% between 2011 and 2014. Roughly 500 operative cases of acute fracture care were performed in 2014, representing nearly 20% of the total surgical volume. A significant number of secondary reconstructive procedures related to the sequelae of trauma (many of whom were initially cared for by our colleagues at Harborview Medical Center) were performed in addition. Increasingly, sophisticated skills are needed to properly manage pediatric fractures and their sequelae, and the Orthopedic department at Seattle Children's is aggressively embracing this reality, both in terms of clinical specialization as well as pioneering efforts at developing clinical standards for patient management and safety. Under the direction of Michael Goldberg, MD, pathways based on existing literature and consensus statements for supracondylar elbow and femur fractures, two of the most common operative pediatric fractures, have been developed which have been recognized as models by other major Pediatric facilities nationwide. With these, we have been able to improve resident education, assess faculty consistency, and maximize patient safety. Further pathways are in development. As with much of Orthopedics, outcomes are becoming increasingly looked at, and given Seattle Children's status as the primary referral center for pediatric fractures in the Northwest, we have the opportunity to become a national leader in pediatric fracture care. Over the next year, the departmental goal is to develop a directed trauma program with faculty whose specific interest is in fracture care. This will allow for both increased clinical and academic focus on fracture care and outcomes, as well as allowing the many departmental subspecialists in other areas to pursue their own areas of expertise and academic focus.

Mark C. Dales, MD
Chief, Pediatric Musculoskeletal Trauma

Evidence Based Clinical Pathways

Evidence Based Clinical Pathways are designed to reduce variation, promote safety, and increase value by standardizing care, anticipating adverse events, and collecting metrics in real time. In 2012 the department developed pathways for supracondylar fractures of the humerus and diaphysial fractures of femur. The over 600 patients cared for on the pathway have stimulated important research questions regarding both the care we provide and the systems used to support this care. Fracture pathways have also been introduced in the SCH emergency department and most recently in the Bellevue Surgical Center. In 2013 we implemented the spine pathway covering the episode of care from the clinic, the operating room, the in-hospital stay to a post-discharge nurses phone call. All our pathways include patient safety check lists requiring attending attestation and standard order-sets; all of which are imbedded in the electronic medical record.

Michael J. Goldberg, MD
Chief, Skeletal Health Program

Hand

To touch, sooth, pat, caress, only a few of the hundreds of words that describe what the hand does for us. These words and actions under score the beauty and the importance of the human hand. They underscore the importance that the hand surgeons at Seattle Children's Hospital view their

roll in the development of the child whose hand is made different by congenital difference or injury. The "Hand Service" is a hybrid of Plastic and Reconstructive Surgery, Pediatric orthopaedic surgery and Orthopaedic surgeons with special interest in hand problems. The four surgeons involved in this service cover every aspect upper extremity including Brachial Plexus (Nerve injury), congenital differences, and trauma. Their efforts are now being documented in registry that will serve as the basis for continued research and publication. Through the concerted effort of our scheduling department and the commitment of the hand team members the availability of some of the best "hand surgeons" in the country is now less seven days.

Douglas P. Hanel, MD
Chief, Pediatric Hand and Upper Extremity

Skeletal Health Program

The Skeletal Health Program continues to thrive with growth in its various divisions: skeletal dysplasia/ dwarfism, genetic and acquired metabolic bone disease, syndrome identification and management, and prenatal diagnosis of orthopedic disorders. Maryse Bouchard, MD has been added to our program faculty which includes physicians, surgeons, and nurse practitioners in orthopedics, endocrinology, genetics, and radiology. Our HIRB Dysplasia Registry focuses on functional health of affected individual now has over 500 entries.

Michael J. Goldberg, MD
Chief, Skeletal Health Program

Certified Athletic Trainers

The Seattle Children's Hospitals (SCH) Athletic Training Program began in 2008 when Children's was awarded the Seattle Public Schools contract to provide afterschool medical coverage for student athletes at the School District's 10 high schools. Since that time SCH Athletic Training program has expanded into 7 different school districts covering 23 high schools and over 100 different community organizations in the Puget Sound area. The Certified Athletic Trainers work with kids, teens, coaches, and parents to encourage children to take part in sports and remain safe when they do. They encourage children to take part in an active lifestyle and strive to keep young athletes in the game by making sure they are well prepared for activity and by properly treating injuries. They are experts at recognizing, treating and preventing musculoskeletal injuries. Evaluating any injuries that occur during play is one of the most important functions athletic trainers perform. They provide immediate treatment and refer teens and parents for additional care when needed. The SCH Athletic Training Program is also part of the Seattle Sports Concussion Program. Athletic Trainers are trained in the recognition and management of concussion and can be a valuable resource on the field of play by determining whether an athlete has a concussion as well as safely returning athletes to play after a concussion.

While working in the local high schools the SCH Athletic Trainers provide on-site medical coverage for practices and most home events at each school. We work with the school's Athletic Director to establish coverage needs and prioritize at risk sporting events. Over the past year the SCH Athletic Trainers have assessed over 11,000 student athletes in the high schools and provided just over 56,000 treatments.

Phil Heywood, MS, ATC, AT/L
Sports and Athletic Training Manager

Spine Surgery Program

The Spine Program at Seattle Children's is focused on improving quality, safety, effectiveness of care, and becoming a national leader in these areas. A brief summary of our progress is listed below.

Clinical Standard Work

We established standardized spine surgery preoperative and postoperative pathways, detailed surgical planning sets, clinical order sets and safety checklists. We continually monitor surgical site infection prevention strategies, readmissions, and reoperations, all of which are nationally tracked outcomes. Collaboration between our surgeons, operating room staff, and purchasing allow standardization of surgical implants, and a robust competitive bidding process, leading to a reduction in implant costs of over $1 million per year.

Early Onset Scoliosis

We developed a program for early Mehta casting of infantile and juvenile scoliosis. We added the Ellipse Magec magnetic growing rod implants for eligible patients requiring surgical management of scoliosis, which markedly decreases the number of surgical procedures required during the growing years. We participate in the Children's Spine Foundation, a national registry of spine surgical patients undergoing treatment for early onset scoliosis. We run specialized clinical programs in collaboration with pulmonary medicine for patients at risk for restrictive lung disease caused by spinal deformities.

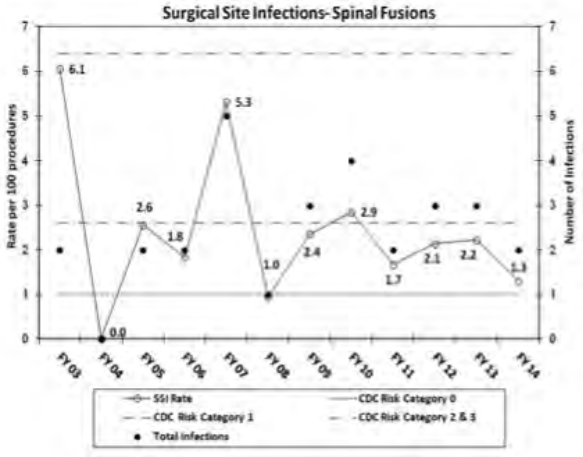
Skeletal Dysplasias

Our Skeletal Dysplasia programs is lead by internationally renowned experts Michael Goldberg and Klane White. Our team manages a large number of patients with severe skeletal dysplasias that create potentially life threatening spinal deformities, instability and spinal cord compression. A critical outcomes assessment registry enables objective assessments of the effects of treatments on quality of life and function. A Spine at Risk warning system in our electronic medical record identifies patients at risk for spinal cord injuries undergoing non-spinal surgical procedures, so that specialized precautions can be instituted.

Surgical Site infection

Strong collaborations with our Infectious Diseases, Infection Control, Nursing, Operating Room, Anesthesia colleagues has led to a remarkable improvement in postoperative infection rates, for which we have been recognized as a top performing pediatric institution in a national collaborative study. Standardization of perioperative care, tracking, and regular feedback and improvement strategies led to zero early postoperative infections in primary spinal fusion procedures in fiscal year 2014, despite a highly complex patient population. Our 1.3% infection rate for spinal fusion procedures includes patients undergoing revision operations and those with previous spinal infections, and is well below national norms despite a large growth in surgical volumes.

FY Year	Cases	# of Infections	Inf rate
2003	33	2	6.1%
2004	57	0	0%
2005	78	2	2.6%
2006	109	2	1.8%
2007	95	5	5.3%
2008	105	1	0.9%
2009	127	3	2.4%
2010	141	4	2.9%
2011	120	2	1.7%
2012	140	3	2.1%
2013	135	3	2.2%
2014	154	2	1.3%



Research

Ongoing research projects and collaborations mesh with our clinical programs, and have led to a number of publications and national presentations, including important contributions to limiting radiation exposure, screening of patients for cervical instability associated with Down Syndrome, Brace Treatment for Adolescent Idiopathic Scoliosis (AIS), Effects of Spinal Implant density on surgical outcomes, among others.

Efforts are underway to establish a biomechanics lab, and future studies on the effectiveness of physical therapy for AIS, and treatments for spondylosis and spondylolisthesis.

The Future

Our efforts toward quality, safety and cost effectiveness have led to increased volumes and improved outcomes for our patients with spinal deformities and conditions. As our regional population grows, and our quality and effectiveness bring patients from other regions to us for higher quality and more cost effective care, we hope to recruit more internationally regarded surgeons, non-surgical specialists and researchers.

Walter F. Krengel III, MD
Chief, Pediatric Spine

Foot and Ankle Program

Historically, deformities of the child's foot were generally considered to be easy to diagnose and treat. There was a cookbook approach in which an operation was associated with a deformity, despite a wide range in etiologies, severities, rigidities, and underlying neuromuscular disorders. That approach led to some good treatment results, but many poor results. For thirty years, I have studied and tried to understand the idiosyncrasies of pediatric foot deformities to improve treatment outcomes for children with the many common and rare idiopathic, acquired, and iatrogenic deformities. Approximately 85-90% of my patients have foot deformities and malformations, an unprecedented diagnostic patient practice profile. My strong interest in education has led to sharing this knowledge through journal publications, lectures around the world, and a recently published book. We are also fortunate to welcome Dr. Maryse Bouchard to the Department as a deliberate attempt to take the pediatric foot program to the next level. She brings experience and expertise in adult foot pathology, garnered in her first postgraduate fellowship, and combines it with the pediatric foot training she received here at Seattle Children's during her pediatric orthopedic fellowship. Children with foot pathology from all over the US, as well as around the world, often seek surgical care here. We will be better able to provide local, regional, national, and international care with our expanding capacity and capabilities. And we'll continue to expand the fund of medical knowledge through clinical research.

Vincent S. Mosca, MD
Chief, Foot and Limb Deformities

Research Program

The department of Orthopedics at Seattle Children's continues participating in multi-site clinical trials and in investigator initiated studies. With twelve prospective studies, including five registries with more than 1,500 participants, our faculty is actively involved in research for different pediatric conditions. Recently, The Journal of Bone and Joint Surgery recognized Dr. Schmale's prospective, randomized study on the effectiveness of physical therapy after supracondylar fracture as one of the best pediatric orthopedic studies of 2014.

Dr. Vincent Mosca published his book Principles and Management of Pediatric Foot an Ankle Deformities and Malformations. The book received excellent reviews and it is on its way to becoming a classic. Dr. Klane White and Dr. Wally Krengel have been participating in the Children's Spine Foundation national registry and received a grant to study preoperative pulmonary indicators of complications in children with early onset scoliosis. Our sports medicine research team lead by Dr. Tom Jinguji has been collaborating with the departments of radiology and neurosurgery in NIH funded concussion research projects, trying to identify markers for early diagnosis of sports related concussions. We continue our work on best practice guidelines and this year, Dr. White and Dr. Goldberg convened an international panel to determine best practices for the diagnosis and treatment of foramen magnum stenosis in infants with achondroplasia. It is our goal to strengthen our involvement in outcomes research, and soon basic science, and continue increase the national recognition of our research program.

Viviana Bompadre, PhD
Research Manager

University of Washington Medical Center Orthopaedics

The University of Washington Medical Center and Northwest Hospital are grouped together in this report due to their geographic proximity and the flow of faculty back and forth between the two medical centers. In addition both hospitals care for a similar population of patients and problems.

At the UWMC we have robust programs in upper extremity, sports, tumor, general orthopaedics and we still have a small adult reconstruction program. In each of these programs the focus is on complex cases that are best handled in an academic center. In fact, our orthopaedic case mix index, a national measure of complexity of care, has continued to increase. We have one of the highest measures of complexity in the University Health Systems Consortium, a group consisting of the nation's premier academic medical centers. Despite this high case mix index our infection and mortality rates remain lower than expected. At NWH we have focused on adult reconstruction, geriatric fractures and hand surgery. Dr. Robert Clawson continues to lead our efforts to develop an evidence–based and pathway directed surgical fragility fracture program. Stephen Kennedy, MD continues to build his hand and upper extremity practice at NWH as well as at UWMC. Adam Sassoon, MD and Navin Fernando, MD are both using all of their block time and taking care of challenging total joint cases from around the region. As at the UWMC, our NWH practices encompass difficult cases that often belie the community-like feel of Northwest Hospital. We have gradually ramped up the complexity of cases performed at NWH and have become very comfortable practicing there. It is an efficient and nurturing environment with an abundance of professionalism and a great can-do spirit.

We have partnered with the respective administrations to appoint two new Clinic Medical Directors of our orthopaedic clinics at the UW Bone and Joint Clinic and at the UW NWH orthopaedic clinic. Jerry Huang, MD and Sarah Beshlian, MD respectively, are directing these clinics and both bring great enthusiasm and ideas to these positions. They are already at work to improve the flow of patients through clinic and enhance access. We also have a newly appointed Director of Orthopaedic Quality Improvement in Darin Davidson, MD. As we move forward in this era of Accountable Care, Dr. Davidson will be responsible for streamlining clinical processes while ensuring safe and cost effective care.

University of Washington Medical Center Surgery Pavilion

We are always sorry to see partners leave our Department and as reported in the Forward to this issue of Discoveries, one of the anchors of our Department for over thirty years, Dr. Roger Larson will soon be retiring. In addition, Dr. Bruce Twaddle will be returning to his practice in New Zealand this coming October. Bruce was very generous with his willingness to assist with call at both Harborview and the UWMC. Dr. Twaddle also cared for all of the multi-ligament knee injury patients at HMC with great expertise and experience.

There are a wide variety of scientific research interests in our Department and these are strongly reflected in the publication of this year's research report. This year, Ron Y. Kwon, PhD and Edith M. Gardiner, PhD were both awarded their first grants from the National Institutes of Health. Dr. Kwon was awarded a grant for "Neuroskeletal Systems Biology in Zebrafish" and Dr. Gardiner for "Suppression of Bone Mechanotransduction by the Beta 2 Adrenergic Receptor". Though based at Harborview, the efforts of Drs. Kwon and Gardiner ripple through our department. Their recent success in obtaining funding is most impressive in an era of decreasing federal grant support. David Eyre, PhD, the holder of the Burgess Chair for Orthopaedic Investigation, has had NIH funding for 30 consecutive years and his funding has just been renewed for another 5 years. We are most grateful that Dr. Eyre will be continuing his investigations into collagen biochemistry and genetics.

Howard A. Chansky, MD
Professor and Acting Chair

VA Puget Sound Orthopaedics

State of the Union: The Puget Sound Veteran's Administration Medical Center

As it has now for many years, the Puget Sound Veteran's Administration Medical Center (VA) remains an active and busy orthopaedic surgery practice. As a tertiary care center for orthopaedics, we see Veterans from the entire northwest United States. The VA system nationwide has faced challenges to increase capacity to accommodate the many Veterans who require care. We are continuing to do our part at the Puget Sound VA and remain one of the busiest VA orthopaedic programs in the country.

Our work-horse surgeon remains Dr. Howard Chansky who anchors our orthopaedic team and performs the vast majority of the arthroplasty surgery at our VA. This is in addition to his responsibilities running the Orthopaedic Surgery Department at the University of Washington. Dr. Sangeorzan continues to provide great foot and ankle specialty care and I do my part taking care of knee and shoulder ailments. To this core faculty, we eagerly await the addition of Dr. Nicholas Iannuzzi this fall. Dr. Iannuzzi was one of our residents at the University of Washington and is currently completing his Hand Surgery fellowship at the prestigious Curtis National Hand Center in Baltimore, Maryland.

VA Puget Sound Health Care System

On March 25th, VA Puget Sound Health Care System had a visit by Hughes Turner, the Deputy Chief of Staff to Secretary of the VA Mr. Robert McDonald. The Director of VAPSHCS Mr. Michael Murphy asked the staff to display the center's research to Mr. Hughes Turner.

Dr. Jerry Huang continues to provide expert hand and upper extremity care to our Vets in a part-time role. Another former resident, Dr. Fred Huang continues to provide general orthopaedic care on a part-time basis as well. We've added Dr. Jason Hsu from the University of Washington who provides us with his expertise in complex shoulder and elbow surgery as well on a once per month basis.

We could not do any of the important work we do for our Vets if it were not for the help of our wonderful support staff at the Puget Sound VA. Steve Casowitz, PA-C and Dustin Higbee, PA-C are the backbone of our surgical service and Amy Katzenmeyer, ARNP remains dedicated to outpatient care and is a sharp clinician in the clinic. We have added another physician assistant, Renato Rafi, PA-C, who is a wonderful team member and helps us carry the load of a very demanding clinic. And we are thankful to Annette Testa, LPN, who continues her great care of patients in our cast clinic.

Monette Manio, RN and Katherine German, RN coordinate our busy surgical schedules and this is no small feat considering our patients often come to us from neighboring states and with very complex problems and medical co-morbidities.

Our day-to-day lives at the VA would not be possible without the administrative help of Cindy Lostoski and Lyra Bryant. They are great to work with and have shown true dedication to our team and to the care of our Vets.

In the operating room, the orthopaedic service is dependent on our amazing surgical team which includes Anne Dinsmore, RN, Amy Arce, Leo Cruz and Adrian Sisson. We are indebted to these individuals and could not do our jobs in the OR without them.

Research remains a big part of the VA mission. The Seattle Center of Excellence in Limb Loss Prevention and Prosthetic Engineering (www.amputation.research.va.gov), which is directed by Dr. Bruce Sangeorzan,

The Orthopaedic Surgery team pictured sitting in what has now been dedicated as Greenlee's Corner in the surgical lounge.

continues its important work in improving the lives of Veterans who have lost limbs or are in danger of doing so. The center, which began in 1997, has grown from four investigators and administrator to over 30 staff/ investigators/students with the 2015 budget of $2.2 million which includes grants from the NIH, Department of Defense and the VA.

In the Molecular Orthopaedics Lab run by Dr. Liu Yang, we are continuing to look into the epigenetic mechanisms that regulate tendon and ligament healing after injury. These exciting discoveries may one-day have significant impact on the care of Veterans with ligament and tendon injuries such as rotator cuff tears, Achilles tendon tears and ACL tears.

The Puget Sound VA Medical Center remains a vital part of the medical care provided in the Northwest region of the United States and Orthopaedic Surgery remains a strong division that strives for excellence in patient care, education and musculoskeletal research. We are proud of our continuing dedication to the important mission of improving the lives of those who have served.

Albert O. Gee, MD
Acting Chief
Division of Orthopaedic Surgery
VA Puget Sound Health Care System

Graduating Residents

Timothy Alton, MD

Following residency, Tim will complete a fellowship in Orthopaedic Traumatology at Harborview Medical Center in Seattle, WA. He and his wife Ann Marie and their daughter Stella are considering career locations in the Northwest and the Southeast.

Daniel Holtzman, MD

Following residency, Dan and Genee (and their new daughter) will move to Boston for an Adult Hip & Knee Arthroplasty fellowship at Massachusetts General Hospital. Upon completion, they hope to move back to the West Coast where Dan can pursue his career in Orthopaedics and Genee can continue her career as a GI nurse practitioner.

Kenneth Gundle, MD

Following graduation, Kenny will move with wife Megan and 5-month-old Robert to Canada for a musculoskeletal oncology fellowship at the University of Toronto. In the fall of 2016, he plans to join an academic practice on the West Coast.

Amanda Roof Larson, MD

Following residency, Amanda will complete a fellowship in Pediatric Orthopaedics at Cincinnati Children's Hospital. She and her husband, Kurt, are considering practices in the Northwest and beyond.

Graduating Residents

Paige Mallette, MD

Following residency, Paige and Patrick plan to move to California where Paige will continue her training at the Hoag Orthopaedic Institute. After completing her fellowship in Adult Joint Reconstruction, they hope to live and work in the Northwest or New England.

Daniel Patton, MD

Daniel Patton will complete a fellowship in foot and ankle surgery in Grand Rapids, Michigan. After fellowship he will pursue a job in private practice.

Courtney O'Donnell, MD

Courtney will be doing a Pediatric Orthopaedics fellowship at Colorado Children's in Denver, CO followed by a second fellowship in Spine Surgery at Oregon Health and Sciences University (OHSU) in Portland, OR.

Laura Stoll, MD

Following graduation, Laura will complete a Hand Fellowship at Washington University in St. Louis. The following year, she and her fiance, Ryan, will move to Philadelphia where she will pursue a second fellowship in Shoulder and Elbow at Thomas Jefferson University. They then hope to return to the Northwest.

Incoming Residents

Zahab Ahsan, MD

From West Lafayette, Indiana, Zahab attended Purdue University and went to medical school at Indiana University School of Medicine. In orthopaedics he is interested in sports medicine, hand & upper extremity, trauma, and biomechanics. Outside of work, he enjoys football, basketball, soccer, golf, great food, and exploring the outdoors.

Kate Bellevue, MD

Kate Bellevue is from Lafayette, California. She attended University of California Berkeley and medical school at the University of California San Francisco. In the field of orthopaedics she is most interested in hand, upper extremity, pediatrics, and sports medicine. In her spare time, she enjoys climbing, biking, lifting, pull-ups, traveling, and camping.

Matthew Baron, MD

From Naples, Florida, Matthew completed his undergraduate education at Duke University and medical school at the University of Pennsylvania. His areas of interest include spine, trauma, and biomedical engineering/device design. His favorite activities include exploring Seattle, lacrosse, running, biking, and enjoying the great outdoors.

Claudia Christman-Skieller, MD

Hailing from Redwood City, California, Claudia went to Stanford University followed by medical school at the University of Illinois at Chicago. Hand, sports medicine, and pediatrics are the focus of her interest in orthopaedics. Outside of work she likes to play and watch sports, ski, hike, and root for her favorite Bay Area sports teams.

Incoming Residents

Jonathan Kark, MD

From Denver, Colorado, Jonathan attended the University of Colorado for his undergraduate and medical school education. In orthopaedics, he is chiefly interested in the field of trauma. When not spending his free time with his wife and new daughter, he likes canyoneering in the Utah desert.

Adam O'Brien, MD

Adam is from Crosbyton, Texas. He completed his undergraduate education at Baylor University and medical school at the University of Texas Medical Branch, Galveston. His areas of interest in orthopaedics include sports medicine and trauma. His favorite pastimes include skiing, fly fishing, watching college sports, and two-stepping.

Erik Magnusson, MD

From Wyoming, Minnesota, Erik attended Loyola University Maryland and medical school at the University of Minnesota. For orthopaedics he is interested in hand, pediatrics, and trauma. His favorite activities include bar trivia, live comedy, college lacrosse, playing the cello and spending time with his fiancée, Carly.

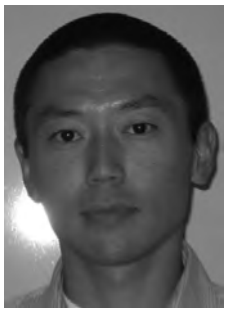
Mary Kate Thayer, MD

Mary Kate joins us from Mukilteo, Washington. She attended the University of Washington and went to medical school at Saint Louis University. She is interested in trauma, hand, and sports medicine. Away from Orthopaedics she enjoys running, hiking, traveling, cooking, and cheering for the Huskies.

ACEs and Fellows

Alireza Anissipour, DO
Spine

Jason Dahl, MD
Hand



John Lee, MD
Trauma

Matthew Beuchel, MD
Foot & Ankle

Casimir Dowd, MD
Hand

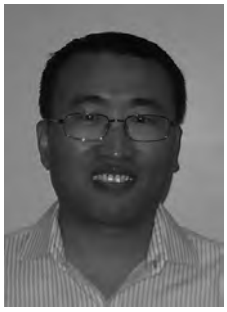
Robert Lucas, MD
Shoulder & Elbow

Debut Biswas, MD
Hand

Saad Elrahmany, MBBCH
Spine

Mital Patel, MBBS
Oncology

William Braaksma, MD
Foot & Ankle



Yi Guo, MD
Oncology

Viral Patel, MD
Spine

ACEs and Fellows

Jonathan Pribaz, MD
Hand

Paul Toogood, MD
Trauma

Uma Ramadorai, MD
Foot & Ankle

Ian Whitney, MD
Shoulder & Elbow

Mara Schenker, MD
Trauma

Amy Williams, MD
Pediatrics

David Shearer, MD, MPH
Trauma

Brandon Yuan, MD
Trauma

Research Grants

National Institutes of Health

Brief Rest Intervals Amplify the Response of Bone Mechanical Loading
Ted S. Gross, PhD
Steven D. Bain, PhD
Sundar Srinivasan, PhD

Collagen Assembly in Tissue-Engineered Cartilage
Russell J. Fernandes, PhD
Jiann-Jiu Wu, PhD

Collagen Cross-Linking in Skeletal Aging and Diseases
David R. Eyre, PhD
Jiann-Jiu Wu, PhD

Collagen Diversity and Pathobiology in Skeletal Tissues
David R. Eyre, PhD
Jiann-Jiu Wu, PhD

Comparing Ankle Arthrodesis to Ankle Arthroplasty
Bruce J. Sangeorzan, MD

Muscle Atrophy and Bone Anabolism
Ted S. Gross, PhD
Steven D. Bain, PhD
Ronald Y. Kwon, PhD
Edith M. Gardiner, PhD

Neuronal Modulation of Focal Bone Homeostasis
Ted S. Gross, PhD
Steven D. Bain, PhD
Edith M. Gardiner, PhD
Ronald Y. Kwon, PhD

Neuroskeletal Systems Biology in Zebrafish
Ronald Y. Kwon, PhD

Suppression of Bone Mechanotransduction by the Beta 2 Adrenergic Receptor
Edith M. Gardiner, PhD
Sundar Srinivasan, PhD
Steven D. Bain, PhD
Leah E. Worton, PhD
Ronald Y. Kwon, PhD

Veterans Affairs Rehabilitation Research and Development Service

Dynamic Foot Bone Motion: Evaluation of Reconstructive Procedures
Bruce J. Sangeorzan, MD

EWS-Fli1 Fusion Protein and Ewing's Sarcoma
Howard A. Chansky, MD

Foot Bone Motion in End Stage Ankle Arthritis Patients
Bruce J. Sangeorzan, MD

VA Center of Excellence in Amputation Prevention and Prosthetic Engineering
Bruce J. Sangeorzan, MD

AO Foundation

Quality of Fracture Reduction and Its Influence on Functional Outcome in Patients With Pilon Fractures
Sean E. Nork, MD

5.0 vs. Standard Locking Screws in Fracture of Distal Femur Treated with Locked Plate Fixation
David P. Barei, MD

AO North America

AO North America Orthopaedic Trauma Fellowship
David P. Barei, MD

AO Spine North America Fellowship
Richard Bransford, MD

The Role of ESET Histone Methyltransferase in Fracture Healing
Howard A. Chansky, MD

AO Spine International

AO Spine Injury Case Collection
Carlo Bellabarba, MD

Acumed

Acumed Educational Grant 2014
Jerry I. Huang, M.D.

Arthrex, Inc.

UW Hand Fellowship Education Grant
Jerry I. Huang, MD

Baylor College of Medicine

Pathogenesis of Novel Forms of Osteogenesis Imperfecta
David R. Eyre, PhD

Boston Medical Center

Intramedullary Nails versus Plate Fixation Re-Evaluation Study in Proximal Tibia Fractures: A Multi-Center Randomized Trial Comparing Nails and Plate Fixation
Robert P. Dunbar, MD

Glasgow Caledonian University

Design of Novel Insoles for Foot Ulceration in Persons with Diabetes
Peter R. Cavanagh, PhD, DSc

Research Grants

Johns Hopkins University

A Prospective Randomized Trial to Assess PO versus IV Antibiotics for the Treatment of Early Post-Op Wound Infection after Extremity Fractures
Reza Firoozabadi, MD

Streamlining Trauma Research Evaluation with Advanced Measurement: STREAM Study
Conor P. Kleweno, MD

The Major Extremity Trauma Research Consortium
Reza Firoozabadi, MD

Medartis AG

Medartis Grant
Jerry I. Huang, MD

OMeGA Medical Grants Association, LLC

Electronic Milestone Tracking & Resident Competency System
Douglas P. Hanel, MD

OMeGA Shoulder and Elbow Fellowship Program Grant
Winston J. Warme, MD

OMeGA Spine Fellowship
Richard Bransford, MD

OMeGA Trauma Fellowship
David P. Barei, MD

Orthopaedic Research and Education Foundation

Does the Radius of Curvature of the Lateral Tibial Plateau Affect ACL Strain? A Biomechanical Study
Albert O. Gee. MD

OREF Spine Fellowship
Carlo Bellabarba, MD

Orthopaedic Trauma Association

A Multi-Center Prospective Cohort Study of Sacral Fractures Using Patient Based and Objective Outcomes
Carlo Bellabarba, MD

COTA Trauma Fellowship
David P. Barei, MD

Royalty Research Fund

Osteoactive Compound Screening in the Regenerating Zebrafish Fin
Ronald Y. Kwon, PhD

Synthes USA

Biomechanical Assessment of the Dorsal Spanning Plate in Distal Radius Fracture Fixation: Implications for Immediate Weightbearing
Jerry I. Huang, MD

PRODISC-C Versus Anterior Cervical Discectomy and Fusion (ACDF)
Richard Bransford, MD

Spine End-Results Research Fund
Howard A. Chansky, MD

Synthes Request for Basic AO Course R2s
Douglas P. Hanel, MD

The Boeing Company

Randomized Clinical Trial of Open versus Endoscopic Carpal Tunnel Release and Hand Therapy Comparing Patient Satisfaction, Functional Outcome and Cost Effectiveness
Jerry I. Huang, MD

US Army Research Office

Exogenous Blastema Delivery to Injured Human Digits
Christopher H. Allan, MD

Patient Enrollment
Reza Firoozabadi, MD

UW Department of Bioengineering

Remote Monitoring of Knee Function after Total Joint Replacement (Coulter Grant)
Peter R. Cavanagh, PhD, DSc
Paul A. Manner, MD

US Department of Defense

Engineered Osteoclasts for the Treatment and Prevention of Heterotopic Ossification
Bruce J. Sangeorzan, MD
Steven D. Bain, PhD

Department Publications 2014-2015

A list of publications authored by our faculty from January 2014 through April 2015. Our faculty members names are in **bold type**.

1. Abdel MP, **Leopold SS**. Editor's Spotlight/Take 5: Small improvements in mechanical axis alignment achieved with MRI versus CT-based patient-specific instruments in TKA: a randomized clinical trial. Clin Orthop Relat Res. 2014 Oct;472(10):2909-12.

2. Agnew SP, Ljungquist KL, **Huang JI**. Danger Zones for Flexor Tendons in Volar Plating of Distal Radius Fractures. J Hand Surg Am. 2015 Apr 2.

3. Alton T, Patton DJ, **Gee AO**. Classifications in Brief: The Hawkins Classification for Talus Fractures. Clin Orthop Relat Res. 2015 Jan 14.

4. Alton TB, **Firoozabadi R**. Management of Pelvic Ring Fractures in the Geriatric Patient. Current Geriatrics Reports. 2014;3(2):101-8.

5. Alton TB, **Gee AO**. Classifications in brief: Letournel classification for acetabular fractures. Clin Orthop Relat Res. 2014 Jan;472(1):35-8.

6. Alton TB, **Gee AO**. Classifications in brief: young and burgess classification of pelvic ring injuries. Clin Orthop Relat Res. 2014 Aug;472(8):2338-42.

7. Alton TB, Harnden E, Hagen J, **Firoozabadi R**. Single Provider Reduction and Splinting of Displaced Ankle Fractures: A Modification of Quigley's Classic Technique. J Orthop Trauma. 2015 Apr;29(4):e166-71.

8. Alton TB, Patel AR, **Bransford RJ**, **Bellabarba C**, Lee MJ, Chapman JR. Is there a difference in neurologic outcome in medical versus early operative management of cervical epidural abscesses? Spine J. 2015 Jan 1;15(1):10-7.

9. Alton TB, Werner SE, **Gee AO**. Classifications in brief: the Gartland classification of supracondylar humerus fractures. Clin Orthop Relat Res. 2015 Feb;473(2):738-41.

10. Apostle KL, Coleman NW, **Sangeorzan BJ**. Subtalar joint axis in patients with symptomatic peritalar subluxation compared to normal controls. Foot Ankle Int. 2014 Nov;35(11):1153-8.

11. Ausk BJ, **Gross TS**, **Bain SD**. Botulinum Toxin-induced Muscle Paralysis Inhibits Heterotopic Bone Formation. Clin Orthop Relat Res. 2015 Mar 25.

12. Avin KG, Bloomfield SA, **Gross TS**, Warden SJ. Biomechanical aspects of the muscle-bone interaction. Current osteoporosis reports. 2015 Feb;13(1):1-8.

13. Bogdan Y, Tornetta P, Jones C, Schemitsch E, Horwitz D, Sanders D, **Firoozabadi R**, Leighton R, Marcantonio M. Neurologic Injury in Operatively Treated Acetabular Fractures. J Orthop Trauma. 2015(5).

14. Bompadre V, Jinguji TM, Yanez ND, Satchell EK, Gilbert K, Burton M, **Conrad EU, 3rd**, Herring SA. Washington State's Lystedt law in concussion documentation in Seattle public high schools. Journal of athletic training. 2014 Jul-Aug;49(4):486-92.

15. **Bouchard M**, **Mosca VS**. Flatfoot Deformity in Children and Adolescents: Surgical Indications and Management. J Am Acad Orthop Surg. 2014 Oct;22(10):623-32.

16. **Bransford RJ**, Alton TB, Patel AR, **Bellabarba C**. Upper Cervical Spine Trauma. J Am Acad Orthop Surg. 2014 Nov;22(11):718-29.

17. Cabral WA, Perdivara I, Weis M, Terajima M, Blissett AR, Chang W, Perosky JE, Makareeva EN, Mertz EL, Leikin S, Tomer KB, Kozloff KM, **Eyre DR**, Yamauchi M, Marini JC. Abnormal type I collagen post-translational modification and crosslinking in a cyclophilin B KO mouse model of recessive osteogenesis imperfecta. PLoS Genet. 2014 Jun;10(6):e1004465.

18. Coleman NW, Fleckman P, **Huang JI**. Fungal Nail Infections. J Hand Surg Am. 2014 May;39(5):985-8.

19. **Davidson D**. CORR Insights(R): what are the results using the modified trapdoor procedure to treat chondroblastoma of the femoral head? Clin Orthop Relat Res. 2014 Nov;472(11):3468-70.

20. Della Rocca GJ, **Dunbar RP**, Burgess AR, Smith MJ. Opportunities for knowledge translation in the decade of road traffic safety. J Orthop Trauma. 2014;28 Suppl 1:S18-21.

21. Dietz MJ, Springer BD, Barnes PD, Falciglia MM, Friedrich AD, Berendt AR, Calhoun JH, **Manner PA**. Best practices for centers of excellence in addressing periprosthetic joint infection. J Am Acad Orthop Surg. 2015 Apr;23 Suppl:S12-7.

22. Duran I, Nevarez L, Sarukhanov A, Wu S, Lee K, Krejci P, Weis M, **Eyre D**, Krakow D, Cohn DH. HSP47 and FKBP65 cooperate in the synthesis of type I procollagen. Hum Mol Genet. 2015 Apr 1;24(7):1918-28.

23. Eary JF, **Conrad EU**, O'Sullivan J, Hawkins DS, Schuetze SM, O'Sullivan F. Sarcoma mid-therapy [F-18]fluorodeoxyglucose positron emission tomography (FDG PET) and patient outcome. J Bone Joint Surg Am. 2014 Jan 15;96(2):152-8.

24. Eastman JG, **Firoozabadi R**, **Benirschke SK**, **Barei DP**, **Dunbar RP**. Entrapped posteromedial structures in pilon fractures. J Orthop Trauma. 2014 Sep;28(9):528-33.

25. Favinger JL, Porrino JA, Richardson ML, Mulcahy H, Chew FS, **Brage ME**. Epidemiology and imaging appearance of the normal Bi-/multipartite hallux sesamoid bone. Foot Ankle Int. 2015 Feb;36(2):197-202.

26. **Firoozabadi R**, Alton T, Wenke J. Advances in Diagnosing Orthopaedic Trauma Infections. Journal of the American Academy of Orthopaedic Surgeons 2015(6).

27. **Firoozabadi R**, Graves ML, Krieg JC, Eastman J, **Nork SE**. Achieving Construct Stability in Periprosthetic Femur Fracture Treatment. Advances in Orthopedic Surgery. 2014;2014.

28. **Firoozabadi R**, Harnden E, Krieg JC. Immediate weight-bearing after ankle fracture fixation. Advances in orthopedics. 2015;2015:491976.

29. **Firoozabadi R**, O'Mara TJ, Swenson A, Agel J, Beck JD, Routt M. Risk factors for the development of heterotopic ossification after acetabular fracture fixation. Clinical Orthopaedics and Related Research®. 2014;472(11):3383-8.

30. **Firoozabadi R**, Oldenburg F, Krieg J, Routt C. Prevention of Iliosacral Intrusion. Techniques of Orthopaedics. 2015;30:56-9.

31. **Firoozabadi R**, Spitler C, Schlepp C, Hamilton B, Routt C, Tornetta P. Determining Stability in Posterior Wall Acetabular Fractures. J Orthop Trauma. 2015(5).

32. **Firoozabadi R**, Swenson A, **Kleweno C**, Routt MC. Cell Saver Use in Acetabular Surgery: Does Approach Matter? J Orthop Trauma. 2015 Jan 29.

33. Gebhart S, Alton TB, Bompadre V, **Krengel WF**. Do anchor density or pedicle screw density correlate with short-term outcome measures in adolescent idiopathic scoliosis surgery? Spine (Phila Pa 1976). 2014 Jan 15;39(2):E104-10.

34. **Gee AO**, Angeline ME, Dines JS, Dines DM. Shoulder instability after total shoulder arthroplasty: a case of arthroscopic repair. Hss J. 2014 Feb;10(1):88-91.

35. Gilmer BB, Guerrero DM, Coleman NW, Chamberlain AM, **Warme WJ**. Orthopaedic Residents Improve Confidence and Knot-Tying Speed With a Skills Course. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2015 Apr 9.

36. Grafe I, Yang T, Alexander S, Homan EP, Lietman C, Jiang MM, Bertin T, Munivez E, Chen Y, Dawson B, Ishikawa Y, Weis MA, Sampath TK, Ambrose C, **Eyre D**, Bachinger HP, Lee B. Excessive transforming growth factor-beta signaling is a common mechanism in osteogenesis imperfecta. Nature medicine. 2014 Jun;20(6):670-5.

37. Grauer JN, **Leopold SS**. Editorial: large database studies-what they can do, what they cannot do, and which ones we will publish. Clin Orthop Relat Res. 2015 May;473(5):1537-9.

38. Gruenwald K, Castagnola P, Besio R, Dimori M, Chen Y, Akel NS, Swain FL, Skinner RA, **Eyre DR**, Gaddy D, Suva LJ, Morello R. Sc65 is a novel endoplasmic reticulum protein that regulates bone mass homeostasis. J Bone Miner Res. 2014 Mar;29(3):666-75.

39. Gundle KR, Cizik AM, Jones RL, **Davidson DJ**. Quality of life measures in soft tissue sarcoma. Expert Rev Anticancer Ther. 2015 Jan;15(1):95-100.

40. Gundle KR, Cizik AM, Punt SE, **Conrad EU, 3rd**, **Davidson DJ**. Validation of the SF-6D Health State Utilities Measure in Lower Extremity Sarcoma. Sarcoma. 2014;2014:450902.

41. Gupta A, **Barei D**, Khwaja A, **Beingessner D**. Single-staged Treatment Using a Standardized Protocol Results in Functional Motion in the Majority of Patients With a Terrible Triad Elbow Injury. Clin Orthop Relat Res. 2014 Jan 29.

42. Hackett DJ, Rothenberg AC, Chen AF, Gutowski C, Jaekel D, Tomek IM, Parsley BS, Ducheyne P, **Manner PA**. The economic significance of orthopaedic infections. J Am Acad Orthop Surg. 2015 Apr;23 Suppl:S1-7.

43. **Hansen ST**, **Brage ME**, Johnson MD. Revision Joint-Sparing Surgical Procedures for the Management of Hallux Valgus. In: Alexander IJ BE, Greisberg JK, editor. Advanced Reconstruction Foot and Ankle 2: American Academy of Orthopaedic Surgeons; 2015.

44. Homan EP, Lietman C, Grafe I, Lennington J, Morello R, Napierala D, Jiang MM, Munivez EM, Dawson B, Bertin TK, Chen Y, Lua R, Lichtarge O, Hicks J, Weis MA, **Eyre D**, Lee BH. Differential effects of collagen prolyl 3-hydroxylation on skeletal tissues. PLoS Genet. 2014 Jan;10(1):e1004121.

45. Hou C, Gupta A, Chen M, **Matsen FA, 3rd**. How do revised shoulders that are culture positive for Propionibacterium differ from those that are not? Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]. 2015 Feb 25.

46. Hsu JW, Kollitz KM, Jegapragasan M, **Huang JI**. Radiographic Evaluation of the Modified Brunelli Technique Versus a Scapholunotriquetral Transosseous Tenodesis Technique for Scapholunate Dissociation. J Hand Surg Am. 2014 Apr 25.

47. Hudson DM, Joeng KS, Werther R, Rajagopal A, Weis M, Lee BH, **Eyre DR**. Post-translationally Abnormal Collagens of Prolyl 3-Hydroxylase-2 Null Mice Offer a Pathobiological Mechanism for the High Myopia Linked to Human LEPREL1 Mutations. J Biol Chem. 2015 Mar 27;290(13):8613-22.

48. Hudson DM, Werther R, Weis M, Wu JJ, **Eyre DR**. Evolutionary Origins of C-Terminal (GPP)n 3-Hydroxyproline Formation in Vertebrate Tendon Collagen. PLoS One. 2014;9(4):e93467.

49. Hug KT, Alton TB, **Gee AO**. In Brief: Classifications in Brief: Brooker Classification of Heterotopic Ossification After Total Hip Arthroplasty. Clin Orthop Relat Res. 2014 Nov 27.

50. Iaquinto JM, Tsai R, Haynor DR, Fassbind MJ, **Sangeorzan BJ**, Ledoux WR. Marker-based validation of a biplane fluoroscopy system for quantifying foot kinematics. Med Eng Phys. 2014 Mar;36(3):391-6.

51. Iorio ML, Bayomy AF, **Huang JI**. Morphology of the extensor carpi ulnaris groove and tendon. J Hand Surg Am. 2014 Dec;39(12):2412-6.

52. Iorio ML, **Huang JI**. Extensor carpi ulnaris subluxation. J Hand Surg Am. 2014 Jul;39(7):1400-2.

53. Jacobsen CM, Barber LA, Ayturk UM, Roberts HJ, Deal LE, Schwartz MA, Weis M, **Eyre D**, Zurakowski D, Robling AG, Warman ML. Targeting the LRP5 pathway improves bone properties in a mouse model of osteogenesis imperfecta. J Bone Miner Res. 2014 Oct;29(10):2297-306.

54. Jeong Y, Carleton SM, Gentry BA, Yao X, Ferreira JA, Salamango DJ, Weis M, Oestreich AK, Williams AM, McCray MG, **Eyre DR**, Brown M, Wang Y, Phillips CL. Hindlimb Skeletal Muscle Function and Skeletal Quality and Strength in +/G610C Mice With and Without Weight-Bearing Exercise. J Bone Miner Res. 2015 Mar 31.

55. Johnson MD, **Brage ME**, Zickuhr KR. Total Ankle Allograft Reconstruction in Patients with Ankle Arthritis. In: Alexander IJ BE, Greisberg JK, editor. Advanced Reconstruction Foot and Ankle 2: American Academy of Orthopaedic Surgeons; 2015.

56. Juneja SC, Vonica A, Zeiss C, Lezon-Geyda K, Yatsula B, Sell DR, Monnier VM, Lin S, Ardito T, **Eyre D**, Reynolds D, Yao Z, Awad HA, Yu H, Wilson M, Honnons S, Boyce BF, Xing L, Zhang Y, Perkins AS. Deletion of Mecom in mouse results in early-onset spinal deformity and osteopenia. Bone. 2014 Mar;60:148-61.

57. Kalamajski S, Liu C, Tillgren V, Rubin K, Oldberg A, Rai J, Weis M, **Eyre DR**. Increased C-telopeptide cross-linking of tendon type I collagen in fibromodulin-deficient mice. J Biol Chem. 2014 Jul 4;289(27):18873-9.

58. Kearney SP, **Mosca VS**. Selective hemiepiphyseodesis for patellar instability with associated genu valgum. Journal of orthopaedics. 2015 Mar;12(1):17-22.

59. **Kennedy SA**. CORR Insights: To What Degree Do Pain-coping Strategies Affect Joint Stiffness and Functional Outcomes in Patients With Hand Fractures? Clin Orthop Relat Res. 2015 Apr 17.

60. **Kennedy SA**, Stoll LE, Lauder AS. Human and Other Mammalian Bite Injuries of the Hand: Evaluation and Management. J Am Acad Orthop Surg. 2015 Jan;23(1):47-57.

61. Kepler CK, Vaccaro AR, Koerner JD, Dvorak MF, Kandziora F, Rajasekaran S, Aarabi B, Vialle LR, Fehlings MG, Schroeder GD, Reinhold M, Schnake KJ, **Bellabarba C**, Cumhur Oner F. Reliability analysis of the AOSpine thoracolumbar spine injury classification system by a worldwide group of naive spinal surgeons. Eur Spine J. 2015 Jan 20.

62. Khoshbin A, **Bouchard M**, Wasserstein D, Leroux T, Law PW, Kreder HJ, Daniels TR, Wright JG. Reoperations after tarsal coalition resection: a population-based study. The Journal of foot and ankle surgery : official publication of the American College of Foot and Ankle Surgeons. 2015 May-Jun;54(3):306-10.

63. Kiewiet NJ, **Benirschke SK**, **Brage ME**. Triple arthrodesis: tips and tricks to navigate trouble. Foot and ankle clinics. 2014 Sep;19(3):483-97.

64. Kim JE, Lee SM, Kim SH, Tatman P, **Gee AO**, Kim DH, Lee KE, Jung Y, Kim SJ. Effect of self-assembled peptide-mesenchymal stem cell complex on the progression of osteoarthritis in a rat model. International journal of nanomedicine. 2014;9 Suppl 1:141-57.

65. Kollitz KM, Hammert WC, Vedder NB, **Huang JI**. Metacarpal fractures: treatment and complications. Hand (N Y). 2014 Mar;9(1):16-23.

66. Kollitz KM, Parsons EM, Weaver MS, **Huang JI**. Platelet-rich plasma for zone II flexor tendon repair. Hand (N Y). 2014 Jun;9(2):217-24.

67. Kumar A, Donley B, **Cavanagh PR**. Design of an implant for first metatarsophalangeal hemi-arthroplasty. Computer methods in biomechanics and biomedical engineering. 2014;17(16):1777-84.

68. Lachman RS, Burton BK, Clarke LA, Hoffinger S, Ikegawa S, Jin DK, Kano H, Kim OH, Lampe C, Mendelsohn NJ, Shediac R, Tanpaiboon P, **White KK**. Mucopolysaccharidosis IVA (Morquio A syndrome) and VI (Maroteaux-Lamy syndrome): under-recognized and challenging to diagnose. Skeletal Radiol. 2014 Mar;43(3):359-69.

69. Lang TF, Saeed IH, Streeper T, Carballido-Gamio J, Harnish RJ, Frassetto LA, Lee SM, Sibonga JD, Keyak JH, Spiering BA, Grodsinsky CM, Bloomberg JJ, **Cavanagh PR**. Spatial heterogeneity in the response of the proximal femur to two lower-body resistance exercise regimens. J Bone Miner Res. 2014 Jun;29(6):1337-45.

70. Large TM, Agel J, Holtzman DJ, **Benirschke SK**, Krieg JC. Interobserver Variability in the Measurement of Lower Leg Compartment Pressures. J Orthop Trauma. 2015 Mar 9.

71. Le Corre S, **Eyre D**, Drummond IA. Modulation of the secretory pathway rescues zebrafish polycystic kidney disease pathology. J Am Soc Nephrol. 2014 Aug;25(8):1749-59.

72. Lee MJ, Pottinger PS, Butler-Wu S, Bumgarner RE, Russ SM, **Matsen FA, 3rd**. Propionibacterium persists in the skin despite standard surgical preparation. J Bone Joint Surg Am. 2014 Sep 3;96(17):1447-50.

73. **Leopold SS**. Editorial: Paying to Publish - What is Open Access and Why is it Important? Clin Orthop Relat Res. 2014 Apr 4.

74. **Leopold SS**. Editorial: Transition from Training to Practice-Is there a Better Way? Clin Orthop Relat Res. 2014 May;472(5):1351-2.

75. **Leopold SS**. Editor's Spotlight/Take 5: Osteogenic Gene Expression Correlates With Development of Heterotopic Ossification in War Wounds. Clinical Orthopaedics and Related Research¬Æ. 2014;472(2):393-5.

76. **Leopold SS**. Editorial: Proceedings and Symposia in CORR: What They Are, and Why We Publish Them. Clin Orthop Relat Res. 2014;472(1):1-2.

77. **Leopold SS**. Editor's spotlight/Take 5: CORR(R) ORS Richard A. Brand Award for Outstanding Orthopaedic Research: Engineering flexor tendon repair with lubricant, cells, and cytokines in a canine model. Clin Orthop Relat Res. 2014 Sep;472(9):2564-8.

78. **Leopold SS**. Editor's spotlight/Take 5: Nationwide inpatient sample and national surgical quality improvement program give different results in hip fracture studies. Clin Orthop Relat Res. 2014 Jun;472(6):1667-71.

79. **Leopold SS**. Editor's Spotlight/Take 5: Hospital readmissions after treatment of proximal humerus fractures: is arthroplasty safer than open reduction internal fixation? Clin Orthop Relat Res. 2014 Aug;472(8):2313-6.

80. **Leopold SS**. Editor's Spotlight/Take 5: Magnetic resonance imaging of the hip: poor cost utility for treatment of adult patients with hip pain. Clin Orthop Relat Res. 2014 Mar;472(3):783-6.

81. **Leopold SS**. Editor's spotlight/take 5: How does accounting for worker productivity affect the measured cost-effectiveness of lumbar discectomy? Clin Orthop Relat Res. 2014 Apr;472(4):1065-8.

82. **Leopold SS**. Editor's Spotlight/Take 5: The 2014 ABJS Nicolas Andry Award: The puzzle of the thumb: mobility, stability, and demands in opposition. Clin Orthop Relat Res. 2014 Dec;472(12):3601-4.

83. **Leopold SS**. Editorial: Thanks to our peer reviewers. Clin Orthop Relat Res. 2014 Dec;472(12):3599-600.

84. **Leopold SS**. Editorial: Our love affair with technology and the choices we make. Clin Orthop Relat Res. 2014 Oct;472(10):2907-8.

85. **Leopold SS**. Editorial: When "safe and effective" becomes dangerous. Clin Orthop Relat Res. 2014 Jul;472(7):1999-2001.

86. **Leopold SS**. Editorial: Paying to publish--what is open access and why is it important? Clin Orthop Relat Res. 2014 Jun;472(6):1665-6.

87. **Leopold SS**. Editorial: Transition from training to practice--is there a better way? Clin Orthop Relat Res. 2014 May;472(5):1351-2.

88. **Leopold SS**. Editorial: Trust in science. Clin Orthop Relat Res. 2014 Apr;472(4):1063-4.

89. **Leopold SS**. Editorial: Going Far: CORR(R)'s newest affiliated societies. Clin Orthop Relat Res. 2014 Mar;472(3):781-2.

90. **Leopold SS**. Editor's Spotlight/Take 5: What are the levels of evidence on which we base decisions for surgical management of lower extremity bone tumors? Clin Orthop Relat Res. 2014 Jan;472(1):3-7.

91. **Leopold SS**. Editor's Spotlight/Take 5: Is changing hospitals for revision total joint arthroplasty associated with more complications? Clin Orthop Relat Res. 2014 Jul;472(7):2002-5.

92. **Leopold SS**. Editor's spotlight/Take 5: Mesenchymal stem cells in synovial fluid increase after meniscus injury. Clin Orthop Relat Res. 2014 May;472(5):1353-6.

93. **Leopold SS**. Editor's Spotlight/Take 5: Most American Academy of Orthopaedic Surgeons' online patient education material exceeds average patient reading level. Clin Orthop Relat Res. 2015 Apr;473(4):1177-80.

94. **Leopold SS**. Editor's spotlight/take 5: Do patient race and sex change surgeon recommendations for TKA? Clin Orthop Relat Res. 2015 Feb;473(2):406-9.

95. **Leopold SS**. Editor's spotlight/take 5: Natural polyphenols enhance stability of crosslinked UHMWPE for joint implants. Clin Orthop Relat Res. 2015 Mar;473(3):756-9.

96. **Leopold SS**. Editor's spotlight/take 5: Is single-stage revision according to a strict protocol effective in treatment of chronic knee arthroplasty infections? Clin Orthop Relat Res. 2015 Jan;473(1):4-7.

97. **Leopold SS**. Editorial: "Pencil and Paper" Research? Network Meta-analysis and Other Study Designs That Do Not Enroll Patients. Clin Orthop Relat Res. 2015 Apr 28.

98. **Leopold SS**. Editor's Spotlight/Take 5: Future Patient Demand for Shoulder Arthroplasty by Younger Patients: National Projections. Clin Orthop Relat Res. 2015 Apr 3.

99. **Leopold SS**. Editorial: What Makes Young Surgeons Tick (or Cut)? Clin Orthop Relat Res. 2015 Mar 14.

100. **Leopold SS**. Editor's Spotlight/Take 5: Surgeons' Attitudes Are Associated With Reoperation and Readmission Rates. Clin Orthop Relat Res. 2015 May;473(5):1540-3.

101. **Leopold SS**. Editorial: Increased manuscript submissions prompt journals to make hard choices. Clin Orthop Relat Res. 2015 Mar;473(3):753-5.

102. **Leopold SS**. Editorial: peer review and the editorial process--a look behind the curtain. Clin Orthop Relat Res. 2015 Jan;473(1):1-3.

103. **Leopold SS**, Beadling L, Dobbs MB, Gebhardt MC, Lotke PA, **Manner PA**, Rimnac CM, Wongworawat MD. Editorial: Fairness to all: gender and sex in scientific reporting. Clin Orthop Relat Res. 2014 Feb;472(2):391-2.

104. **Leopold SS**, Beadling L, Gebhardt MC, Gioe TJ, Potter BK, Rimnac CM, Wongworawat MD. Editorial: Words hurt--avoiding dehumanizing language in orthopaedic research and practice. Clin Orthop Relat Res. 2014 Sep;472(9):2561-3.

105. **Leopold SS**, Sabharwal S. Editorial: indications--on the fringes and in the mainstream. Clin Orthop Relat Res. 2014 Nov;472(11):3247-9.

106. Lichstein P, Gehrke T, Lombardi A, Romano C, Stockley I, Babis G, Bialecki J, Bucsi L, Cai X, Cao L, de Beaubien B, Erhardt J, Goodman S, Jiranek W, Keogh P, Lewallen D, **Manner P**, Marczynski W, Mason JB, Mulhall K, Paprosky W, Patel P, Piccaluga F, Polkowski G, Pulido L, Stockley I, Suarez J, Thorey F, Tikhilov R, Velazquez JD, Winkler H. One-stage versus two-stage exchange. J Orthop Res. 2014 Jan;32 Suppl 1:S141-6.

107. Lichstein P, Gehrke T, Lombardi A, Romano C, Stockley I, Babis G, Bialecki J, Bucsi L, Cai X, Cao L, de Beaubien B, Erhardt J, Goodman S, Jiranek W, Keogh P, Lewallen D, **Manner P**, Marczynski W, Mason JB, Mulhall K, Paprosky W, Patel P, Piccaluga F, Polkowski G, Pulido L, Stockley I, Suarez J, Thorey F, Tikhilov R, Velazquez JD, Winkler H. One-stage vs two-stage exchange. J Arthroplasty. 2014 Feb;29(2 Suppl):108-11.

108. Lietman CD, Marom R, Munivez E, Bertin TK, Jiang MM, Chen Y, Dawson B, Weis MA, **Eyre D**, Lee B. A transgenic mouse model of OI type V supports a neomorphic mechanism of the IFITM5 mutation. J Bone Miner Res. 2015 Mar;30(3):489-98.

109. Lietman CD, Rajagopal A, Homan EP, Munivez E, Jiang MM, Bertin TK, Chen Y, Hicks J, Weis M, **Eyre D**, Lee B, Krakow D. Connective tissue alterations in Fkbp10-/- mice. Hum Mol Genet. 2014 Sep 15;23(18):4822-31.

110. Litrenta J, Tornetta P, Vallier H, **Firoozabadi R**, Leighton R, Egol K, Kruppa C, Jones C, Cllinge C, Bhandari M, Schemitsch E,

Sanders D, Mullis B. Dynamizations and Exchanges: Success Rates and Indications. J Orthop Trauma. 2015(5).

111. Littman AJ, Boyko EJ, Thompson ML, Haselkorn JK, **Sangeorzan BJ**, Arterburn DE. Physical activity barriers and enablers in older Veterans with lower-limb amputation. Journal of rehabilitation research and development. 2014;51(6):895-906.

112. Ljungquist KL, Agnew SP, **Huang JI**. Predicting a safe screw length for volar plate fixation of distal radius fractures: lunate depth as a marker for distal radius depth. J Hand Surg Am. 2015 May;40(5):940-4.

113. Ljungquist KL, Martineau P, **Allan C**. Radial nerve injuries. J Hand Surg Am. 2015 Jan;40(1):166-72.

114. Louie PK, **Sangeorzan BJ**, Fassbind MJ, Ledoux WR. Talonavicular joint coverage and bone morphology between different foot types. J Orthop Res. 2014 Jul;32(7):958-66.

115. Luszczyk MJ, Blaisdell GY, Wiater BP, **Bellabarba C**, Chapman JR, Agel JA, **Bransford RJ**. Traumatic dural tears: what do we know and are they a problem? Spine J. 2014 Jan;14(1):49-56.

116. Maddox JJ, Pruitt DR, Agel J, **Bransford RJ**. Unstaged versus staged posterior-only thoracolumbar fusions in deformity: a retrospective comparison of perioperative complications. Spine J. 2014 Jul 1;14(7):1159-65.

117. Manoso MW, Cizik AM, **Bransford RJ**, **Bellabarba C**, Chapman J, Lee MJ. Medicaid status is associated with higher surgical site infection rates after spine surgery. Spine (Phila Pa 1976). 2014 Sep 15;39(20):1707-13.

118. Mardula KL, Balasubramanian R, **Allan CH**. Implanted passive engineering mechanism improves hand function after tendon transfer surgery: a cadaver-based study. Hand (N Y). 2015 Mar;10(1):116-22.

119. **Matsen FA, 3rd**. Shoulder pain does not parallel rotator cuff tear size-what does that tell us?: Commentary on an article by Warren R. Dunn, MD, MPH, et al.: "symptoms of pain do not correlate with rotator cuff tear severity. A cross-sectional study of 393 patients with a symptomatic atraumatic full-thickness rotator cuff tear". J Bone Joint Surg Am. 2014 May 21;96(10):e86.

120. **Matsen FA, 3rd**. CORR Insights(R): Factors that influence the choice to undergo surgery for shoulder and elbow conditions. Clin Orthop Relat Res. 2014 Mar;472(3):892-3.

121. **Matsen FA, 3rd**. The ream and run: not for every patient, every surgeon or every problem. Int Orthop. 2015 Feb;39(2):255-61.

122. **Matsen FA, 3rd**, Gupta A. Axillary view: arthritic glenohumeral anatomy and changes after ream and run. Clin Orthop Relat Res. 2014 Mar;472(3):894-902.

123. **Matsen FA, 3rd**, Russ SM, Bertelsen A, Butler-Wu S, Pottinger PS. Propionibacterium can be isolated from deep cultures obtained at primary arthroplasty despite intravenous antimicrobial prophylaxis. Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]. 2014 Dec 26.

124. **Matsen FA, 3rd**, Stephens L, Jette JL, **Warme WJ**, **Huang JI**, Posner KL. The quality of upper extremity orthopedic care in liability claims filed and claims paid. J Hand Surg Am. 2014 Jan;39(1):91-9.

125. **Matsen FA, 3rd**, **Warme WJ**, Jackins SE. Can the Ream and Run Procedure Improve Glenohumeral Relationships and Function for Shoulders With the Arthritic Triad? Clin Orthop Relat Res. 2014 Dec 9.

126. McAlinden A, Traeger G, Hansen U, Weis MA, Ravindran S, Wirthlin L, **Eyre DR**, **Fernandes RJ**. Molecular properties and fibril ultrastructure of types II and XI collagens in cartilage of mice expressing exclusively the alpha1(IIA) collagen isoform. Matrix Biol. 2014 Feb;34:105-13.

127. McElvany MD, McGoldrick E, **Gee AO**, Neradilek MB, **Matsen FA, 3rd**. Rotator Cuff Repair: Published Evidence on Factors Associated With Repair Integrity and Clinical Outcome. Am J Sports Med. 2014 Apr 21.

128. McGoldrick E, McElvany MD, Butler-Wu S, Pottinger PS, **Matsen FA, 3rd**. Substantial cultures of Propionibacterium can be found in apparently aseptic shoulders revised three years or more after the index arthroplasty. Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]. 2015 Jan;24(1):31-5.

129. Mickelson DT, Noland SS, Watt AJ, Kollitz KM, Vedder NB, **Huang JI**. Prospective randomized controlled trial comparing 1- versus 7-day manipulation following collagenase injection for dupuytren contracture. J Hand Surg Am. 2014 Oct;39(10):1933-41 e1.

130. **Mosca V**. Principles and Management of Pediatric Foot and Ankle Deformities and Malformations. Philadelphia, PA: Lippincott Williams & Wilkins; 2014.

131. **Mosca V**. The Foot. In: JM WSaF, editor. Lovell and Winter's Pediatric Orthopedics. 7th ed ed. Philadelphia: Wolters Kluwer/ Lippincott Williams & Wilkins; 2014. p. 1425-562.

132. **Mosca VS**. Management of the Painful Adolescent Flatfoot. Techniques in Foot & Ankle Surgery. 2014(13):3-13.

133. Ng VY, **Davidson DJ**, Kim EY, Pollack SM, **Conrad Iii EU**, Jones RL. The multidisciplinary management of giant cell tumor of bone. Expert Rev Anticancer Ther. 2014 Jul;14(7):783-90.

134. O'Brien A, Bompadre V, Hale S, **White KK**. Musculoskeletal function in patients with mucopolysaccharidosis using the pediatric outcomes data collection instrument. J Pediatr Orthop. 2014 Sep;34(6):650-4.

135. O'Donnell C, Maertens A, Bompadre V, **Wagner TA**, **Krengel W, 3rd**. Comparative radiation exposure using standard fluoroscopy versus cone-beam computed tomography for posterior instrumented fusion in adolescent idiopathic scoliosis. Spine (Phila Pa 1976). 2014 Jun 15;39(14):E850-5.

136. Papadonikolakis A, **Matsen FA, 3rd**. Metal-Backed Glenoid Components Have a Higher Rate of Failure and Fail by Different Modes in Comparison with All-Polyethylene Components: A Systematic Review. J Bone Joint Surg Am. 2014 Jun 18;96(12):1041-7.

137. Parsons EM, **Gee AO**, Spiekerman C, **Cavanagh PR**. The biomechanical function of the anterolateral ligament of the knee. Am J Sports Med. 2015 Mar;43(3):669-74.

138. Patel AR, Alton TB, **Bransford RJ**, Lee MJ, **Bellabarba CB**, Chapman JR. Spinal epidural abscesses: risk factors, medical versus surgical management, a retrospective review of 128 cases. Spine J. 2014 Feb 1;14(2):326-30.

139. Patton D, Kiewiet N, **Brage M**. Infected Total Ankle Arthroplasty: Risk Factors and Treatment Options. Foot Ankle Int. 2015 Feb 18.

140. Pet MA, Ko JH, Friedly JL, Mourad PD, **Smith DG**. Does targeted nerve implantation reduce neuroma pain in amputees? Clin Orthop Relat Res. 2014 Oct;472(10):2991-3001.

141. Pet MA, Ko JH, Friedly JL, **Smith DG**. Traction Neurectomy for Treatment of Painful Residual Limb Neuroma in Lower Extremity Amputees. J Orthop Trauma. 2015 Mar 28.

142. Pingel J, Lu Y, Starborg T, Fredberg U, Langberg H, Nedergaard A, Weis M, **Eyre D**, Kjaer M, Kadler KE. 3-D ultrastructure and collagen composition of healthy and overloaded human tendon: evidence of tenocyte and matrix buckling. J Anat. 2014 May;224(5):548-55.

143. Pollack SM, Jones RL, Farrar EA, Lai IP, Lee SM, Cao J, Pillarisetty VG, Hoch BL, Gullett A, Bleakley M, **Conrad EU, 3rd**, Eary JF, Shibuya KC, Warren EH, Carstens JN, Heimfeld S, Riddell SR, Yee C. Tetramer guided, cell sorter assisted production of clinical grade autologous NY-ESO-1 specific CD8(+) T cells. Journal for immunotherapy of cancer. 2014;2(1):36.

144. Porrino JA, Jr., Maloney E, Scherer K, Mulcahy H, Ha AS, **Allan C**. Fracture of the distal radius: epidemiology and premanagement radiographic characterization. AJR Am J Roentgenol. 2014 Sep;203(3):551-9.

145. Probasco W, Haleem AM, Yu J, **Sangeorzan BJ**, Deland JT, Ellis SJ. Assessment of coronal plane subtalar joint alignment in peritalar subluxation via weight-bearing multiplanar imaging. Foot Ankle Int. 2015 Mar;36(3):302-9.

146. Recidoro AM, Roof AC, Schmitt M, Worton LE, Petrie T, Strand N, Ausk BJ, **Srinivasan S**, Moon RT, **Gardiner EM**, Kaminsky W, **Bain SD**, **Allan CH**, **Gross TS**, **Kwon RY**. Botulinum toxin induces muscle paralysis and inhibits bone regeneration in zebrafish. J Bone Miner Res. 2014 Nov;29(11):2346-56.

147. Reed EB, Hanson AM, **Cavanagh PR**. Optimising muscle parameters in musculoskeletal models using Monte Carlo simulation. Computer methods in biomechanics and biomedical engineering. 2015;18(6):607-17.

148. Ricci WM, Streubel PN, Morshed S, Collinge CA, **Nork SE**, Gardner MJ. Risk factors for failure of locked plate fixation of distal femur fractures: an analysis of 335 cases. J Orthop Trauma. 2014 Feb;28(2):83-9.

149. Rimnac CM, **Leopold SS**. Editorial: basic science, applied science, and product testing. Clin Orthop Relat Res. 2014 Aug;472(8):2311-2.

150. Sagi HC, Jordan CJ, **Barei DP**, Serrano-Riera R, Steverson B. Indomethacin prophylaxis for heterotopic ossification after acetabular fracture surgery increases the risk for nonunion of the posterior wall. J Orthop Trauma. 2014 Jul;28(7):377-83.

151. Sandstrom CK, **Kennedy SA**, Gross JA. Acute shoulder trauma: what the surgeon wants to know. Radiographics : a review publication of the Radiological Society of North America, Inc. 2015 Mar-Apr;35(2):475-92.

152. **Sangeorzan BJ**, Brodsky JW, Thordarson DB. FAI Update 2014. Foot Ankle Int. 2014 Nov;35(11):1101.

153. **Sassoon A**, Nam D, Nunley R, Barrack R. Systematic review of patient-specific instrumentation in total knee arthroplasty: new but not improved. Clin Orthop Relat Res. 2015 Jan;473(1):151-8.

154. **Schmale GA**, Kweon C, **Larson RV**, Bompadre V. High satisfaction yet decreased activity 4 years after transphyseal ACL reconstruction. Clin Orthop Relat Res. 2014 Jul;472(7):2168-74.

155. **Schmale GA**, Mazor S, Mercer LD, Bompadre V. Lack of Benefit of Physical Therapy on Function Following Supracondylar Humeral Fracture: A Randomized Controlled Trial. J Bone Joint Surg Am. 2014 Jun 4;96(11):944-50.

156. Schroeder GD, Vaccaro AR, Kepler CK, Koerner JD, Oner FC, Dvorak MF, Vialle LR, Aarabi B, **Bellabarba C**, Fehlings MG, Schnake KJ, Kandziora F. Establishing the Injury Severity of Thoracolumbar Trauma: Confirmation of the Hierarchical Structure of the AOSpine Thoracolumbar Spine Injury Classification System. Spine (Phila Pa 1976). 2015 Apr 15;40(8):E498-503.

157. Scully MA, **White KK**, Song KM, **Mosca VS**. Injection-induced gluteus muscle contractures: diagnosis with the “reverse Ober test” and surgical management. J Pediatr Orthop. 2015 Mar;35(2):192-8.

158. Sousa T, Bompadre V, **White KK**. Musculoskeletal functional outcomes in children with osteogenesis imperfecta: associations with disease severity and pamidronate therapy. J Pediatr Orthop. 2014 Jan;34(1):118-22.

159. Spirka TA, Erdemir A, Ewers Spaulding S, Yamane A, Telfer S, **Cavanagh PR**. Simple finite element models for use in the design of therapeutic footwear. Journal of biomechanics. 2014 Sep 22;47(12):2948-55.

160. **Srinivasan S**, Ausk BJ, **Bain SD**, **Gardiner EM**, **Kwon RY**, **Gross TS**. Rest intervals reduce the number of loading bouts required to enhance bone formation. Medicine and science in sports and exercise. 2015 May;47(5):1095-103.

161. **Srinivasan S**, Threet D, Worton LE, Ausk BJ, **Bain SD**, **Gardiner EM**, **Kwon RY**, **Gross TS**. Distinct cyclosporin a doses are required to enhance bone formation induced by cyclic and rest-inserted loading in the senescent skeleton. PLoS One. 2014;9(1):e84868.

162. Stokke J, Sung L, Gupta A, **Lindberg A**, Rosenberg AR. Systematic review and meta-analysis of objective and subjective quality of life among pediatric, adolescent, and young adult bone tumor survivors. Pediatric blood & cancer. 2015 Mar 27.

163. Stoll KE, Miles JD, White JK, Punt SE, **Conrad EU, 3rd**, Ching RP. Assessment of registration accuracy during computer-aided oncologic limb-salvage surgery. International journal of computer assisted radiology and surgery. 2015 Jan 13.

164. Swords MP, Alton TB, Holt S, **Sangeorzan BJ**, Shank JR, **Benirschke SK**. Prognostic value of computed tomography classification systems for intra-articular calcaneus fractures. Foot Ankle Int. 2014 Oct;35(10):975-80.

165. Telfer S, Erdemir A, Woodburn J, **Cavanagh PR**. What has finite element analysis taught us about diabetic foot disease and its management? A systematic review. PLoS One. 2014;9(10):e109994.

166. Trask DJ, Ledoux WR, Whittaker EC, Roush GC, **Sangeorzan BJ**. Second metatarsal osteotomies for metatarsalgia: a robotic cadaveric study of the effect of osteotomy plane and metatarsal shortening on plantar pressure. J Orthop Res. 2014 Mar;32(3):385-93.

167. Ulbrecht JS, Hurley T, Mauger DT, **Cavanagh PR**. Prevention of recurrent foot ulcers with plantar pressure-based in-shoe orthoses: the CareFUL prevention multicenter randomized controlled trial. Diabetes care. 2014 Jul;37(7):1982-9.

168. Vaudreuil NJ, Ledoux WR, Roush GC, Whittaker EC, **Sangeorzan BJ**. Comparison of transfer sites for flexor digitorum longus in a cadaveric adult acquired flatfoot model. J Orthop Res. 2014 Jan;32(1):102-9.

169. Vilela MD, Kim LJ, **Bellabarba C**, **Bransford RJ**. Blunt cerebrovascular injuries in association with craniocervical distraction injuries: a retrospective review of consecutive cases. Spine J. 2015 Mar 1;15(3):499-505.

170. von Mehren M, Randall RL, Benjamin RS, Boles S, Bui MM, Casper ES, **Conrad EU, 3rd**, DeLaney TF, Ganjoo KN, George S, Gonzalez RJ, Heslin MJ, Kane JM, 3rd, Mayerson J, McGarry SV, Meyer C, O'Donnell RJ, Pappo AS, Paz IB, Pfeifer JD, Riedel RF, Schuetze S, Schupak KD, Schwartz HS, Van Tine BA, Wayne JD, Bergman MA, Sundar H. Gastrointestinal stromal tumors, version 2.2014. J Natl Compr Canc Netw. 2014 Jun;12(6):853-62.

171. von Mehren M, Randall RL, Benjamin RS, Boles S, Bui MM, Casper ES, **Conrad EU, 3rd**, Delaney TF, Ganjoo KN, George S, Gonzalez RJ, Heslin MJ, Kane JM, 3rd, Mayerson J, McGarry SV, Meyer C, O'Donnell RJ, Pappo AS, Paz IB, Pfeifer JD, Riedel RF, Schuetze S, Schupak KD, Schwartz HS, Van Tine BA, Wayne JD, Bergman MA, Sundar H, National Comprehensive Cancer N. Soft tissue sarcoma, version 2.2014. J Natl Compr Canc Netw. 2014 Apr;12(4):473-83.

172. Walsh SJ, **Twaddle BC**, Rosenfeldt MP, Boyle MJ. Arthroscopic treatment of anterior ankle impingement: a prospective study of 46 patients with 5-year follow-up. Am J Sports Med. 2014 Nov;42(11):2722-6.

173. Wang H, Chen T, **Gee AO**, Hutchinson ID, Stoner K, Warren RF, Rodeo SA, Maher SA. Altered regional loading patterns on articular cartilage following meniscectomy are not fully restored by autograft meniscal transplantation. Osteoarthritis Cartilage. 2015 Mar;23(3):462-8.

174. Watt AJ, Ching RP, **Huang JI**. Biomechanical evaluation of metacarpal fracture fixation: application of a 90 degrees internal fixation model. Hand (N Y). 2015 Mar;10(1):94-9.

175. **White KK**, Jester A, Bache CE, Harmatz PR, Shediac R, Thacker MM, Mackenzie WG. Orthopedic management of the extremities in patients with Morquio A syndrome. Journal of children's orthopaedics. 2014 Aug;8(4):295-304.

176. Willauer P, **Sangeorzan BJ**, Whittaker EC, Shofer JB, Ledoux WR. The sensitivity of standard radiographic foot measures to misalignment. Foot Ankle Int. 2014 Dec;35(12):1334-40.

177. Williams JR, Wegner NJ, **Sangeorzan BJ**, **Brage ME**. Intraoperative and perioperative complications during revision arthroplasty for salvage of a failed total ankle arthroplasty. Foot Ankle Int. 2015 Feb;36(2):135-42.

178. Wongworawat MD, Dobbs MB, Gebhardt MC, Gioe TJ, **Leopold SS**, **Manner PA**, Rimnac CM, Porcher R. Editorial: Estimating survivorship in the face of competing risks. Clin Orthop Relat Res. 2015 Apr;473(4):1173-6.

179. Worton LE, **Kwon RY**, **Gardiner EM**, **Gross TS**, **Srinivasan S**. Enhancement of Flow-Induced AP-1 Gene Expression by Cyclosporin A Requires NFAT-Independent Signaling in Bone Cells. Cellular and molecular bioengineering. 2014 Jun 1;7(2):254-65.

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