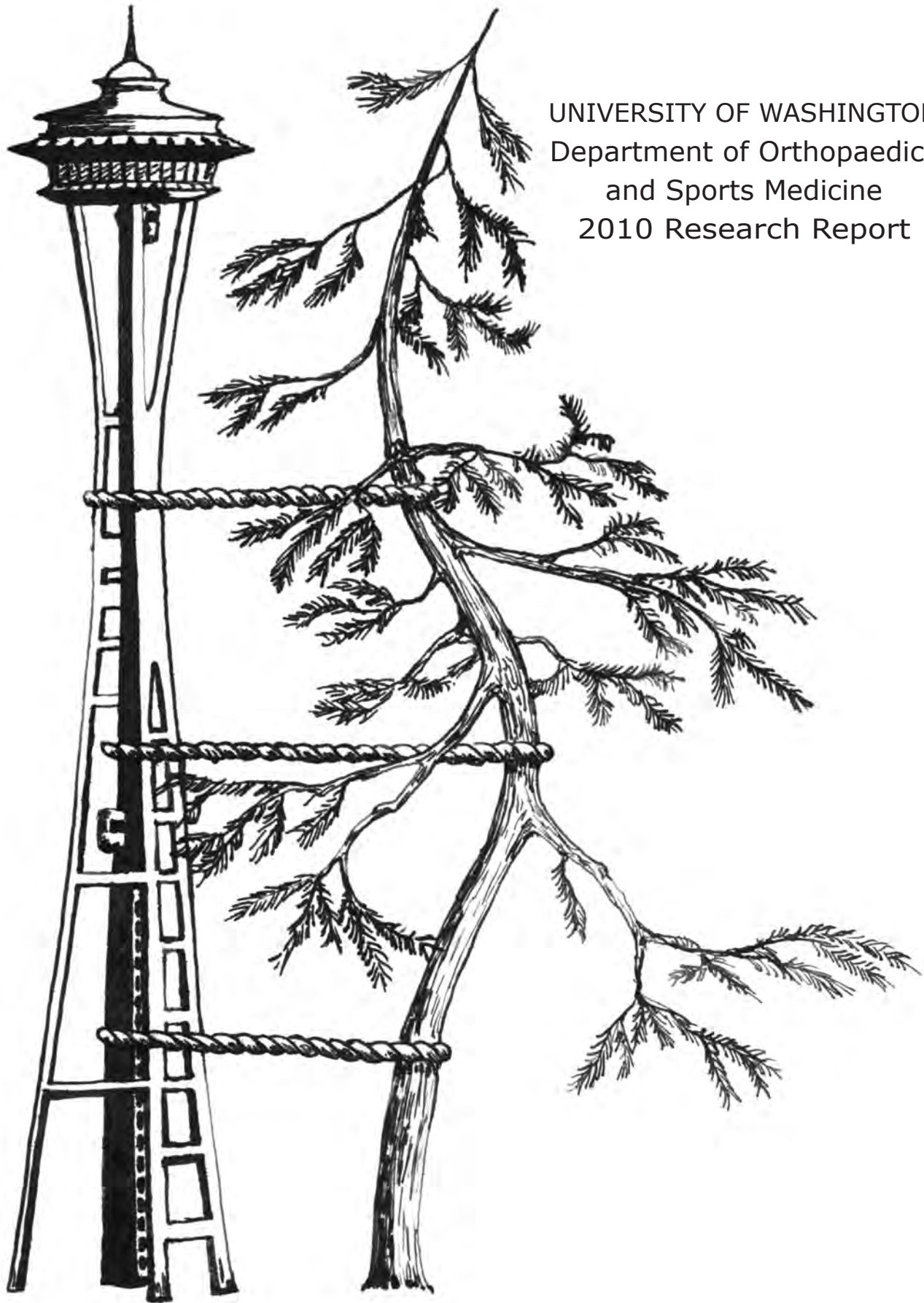


ORTHOPAEDIC DISCOVERIES 2010



UNIVERSITY OF WASHINGTON ORTHOPAEDICS AND SPORTS MEDICINE

UNIVERSITY OF WASHINGTON
Department of Orthopaedics
and Sports Medicine
2010 Research Report



UW Medicine
SCHOOL OF MEDICINE

Department of Orthopaedics and Sports Medicine
University of Washington
Seattle, WA 98195

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Front Cover Illustration: "Max on Dock" by Liz Schein Krengel.

Liz Schein Krengel lives in Seattle with her husband, spine surgeon, Wally Krengel, and their sons. Artistic expression has taken various forms throughout her life; most recently she has focused on watercolor painting, studying for the last two years at Gage Academy of Art with Tom Hoffman, local teacher and painter.

"Painting has opened up an entirely new way of seeing the world around me. Now, even a grey Seattle day is full of color! This painting of Max, our family dog, is from a photograph that I took at the park on the first sunny day last spring. During the long, dark winter I had been wanting to paint Max, but knew that I would need a sunny day in order to get an accurate image of his remarkably shiny fur. He is a bird dog, and in this piece he is scanning the water -- assessing the possibilities. I hope that we all can look to our futures with such hope and excitement."

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Foreword



Dear Friends of UW Orthopaedics and Sports Medicine,

Adaptation or evolution: responding to changes

Change has come upon our Department in many and rather sudden ways over the past year. Internally, a major change occurred with our Chairman of an unprecedented nearly quarter century tenure, **Frederick A. Matsen III, M.D.** stepping down and continuing on as full-time faculty member on our Shoulder & Elbow Service. We have attempted to capture the tremendous impact of his tenure on our Department, musculoskeletal patient care and medical careers development in our region in the next article. Some examples of the dramatic developments of our department during Dr. Matsen's tenure as chair can be seen in the development of surgical volumes (Figure 1) and research funding (Figure 2) over time.

Externally, there are well publicized seismic shifts in the health care environment under way, for instance in form of the Patient Protection and Affordable Care Act of 2010, also publicized as "Health Care Reform". Regardless of its final manifestations its lasting imprimatur will consist of an increasing application of metrics and the concept of rewarding measurable improvements in quality of care and patient safety. In light of this, UWMedicine has rolled out a comprehensive Strategic Plan of which our Department is a vital part. The evolving external circumstances of health care politics provide us with the challenge to adapt in the short term to set the stage for long term evolution in order to better pursue our mission of excellence in research, education, and patient care. Undoubtedly, Academic Medicine is entering 'uncharted waters in a sea of change'. While troubling to some, the very fact that there are so many unknowns offers a major opportunity for us to provide critical contributions to how and why we best deliver medical care and thus 'lead the way' into a better future of health care. Translational research and integration of patient reported outcomes and safety data into our routine patient interactions are obvious major opportunities eminently available to our Department to guide health care delivery of the future.

Along these lines we are intending to position ourselves to be active participants in a changing Health care environment by undergoing a systematic self-assessment and initiating a process of 'reinvention'

through a combination of adaptations leading to subsequent evolution. Fortunately we have so many strengths to draw from that a number of pathways to reorganization come as relatively straightforward initiatives, which I will describe in 3 overarching initiatives dubbed the '**Three linked R's**':

- **Reintegration:** Our Department in its multiple operational sites will benefit from enhanced communication through application of a variety of electronic media and tools as well as development of system-wide overarching projects.

- **Research:** This is one of the main driving forces that distinguish academic practices from purely clinically driven enterprises. By transcending all medical and basic sciences subspecialties research has the unique power to inspire and to unite all of those involved.

- **Responsibility:** In the new model of health care delivery traditional industrial productivity parameters will be replaced by measures that quantify how well our patients are actually doing and how wisely we have used available resources and technologies. We need to provide all those around us with a new set of data that represents our efforts more fairly and transparently.

Reintegration in a physical sense is impractical in our region with dense population centers and high priced real estate and is also undesirable due to lack of crosspollination. The task at hand, however, is to reconnect between 8 and 13 different sites of practice or research (depending how you define 'sites') in this environment. Since direct collocation is not feasible, an increased emphasis needs to be placed on effective communications to facilitate connections within our Department and provide crystallization points for engagement.

Our response to this need for reintegration of our Department has been to use informational technologies to help us reconnect. One example is our new periodic electronic newsletter, which represents all groups of our Department ranging from our staff to our surgeons and colleagues in other specialties to keep everyone apprised of the multifaceted developments and many accomplishments. It also helps us stay in touch with our incredible Alumni and their many accomplishments and recognize their unwavering support (<http://www.orthop.washington.edu/UserFiles/File/eNews/eNews.pdf>). This effort has been very capably led by our UWMC manager **Calina Brown Garcia** and has uncovered many hitherto unknown hidden talents in our Department, such as screenwriters, photographers and even painters, such as seen in the cover art of this year's Orthopaedic

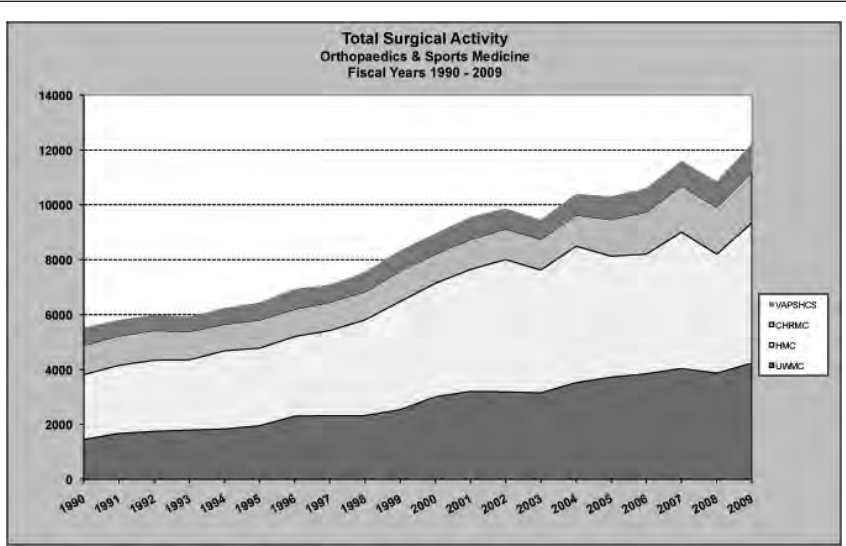


Figure 1: Total Surgical Activity 1990-2009

a new monthly Grand Rounds format in form of Mini-symposia which will feature a combination of residents and faculty from within and outside our Departments to create a high value regional magnet event for anyone interested in musculoskeletal medicine. Many of these events are available through UWTV and the Research Channel on TV, online and through Podcasts (http://www.orthop.washington.edu/uw/tabID__3441/Default.aspx). The need for reintegration is also being applied in our

Discoveries created by **Liz Krengel**, the wife of our own **Wally Krengel, Jr.**

Another example of using information systems for reintegration is our effort at remodeling our Departmental Website through our newly created 'Internet Forum' to better serve diverse public informational needs, enhance internal links as well as provide access for residents and fellows. This project seeks to improve on what many perceive to be one of the trendsetting websites in Academic surgical programs by showcasing our multiple subspecialties and by offering intriguing insights in education and research as well as interactive communication features. We are also educationally reintegrating by offering

renewed focus on our Research efforts.

Research has been identified as our single most transformative quality. In order to enhance this and incubate new larger ideas beyond subspecialty barriers we have formed 6 Project Task Forces (PTF's) which are poised to bring together experts from different backgrounds, campuses and include members of other Departments. Each of these PTF's is tasked to identify major problems, formulate visions and then establish realistic goals to make significant measurable progress in the targeted areas.

Coordination of our individually eminently successful Basic Sciences labs and Clinical Outcomes Research efforts into larger strategic initiatives that can support the PTF's from a scientific perspective will be a great challenge. We are fortunate to have been able to create a position of Vice Chair of Research and fill this position with **Peter Cavanagh, Ph.D.** from our Orthopaedic Biomotor lab. He will coordinate our research efforts among our various labs and different campuses and thereby improve connections between researchers, clinicians, students and our residents/fellows and ACE's. This in turn will create many new research opportunities throughout

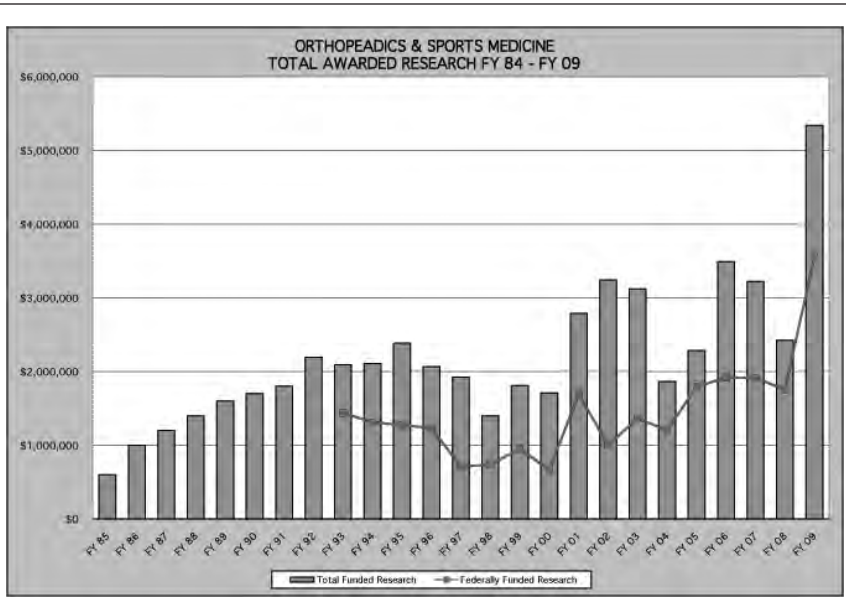
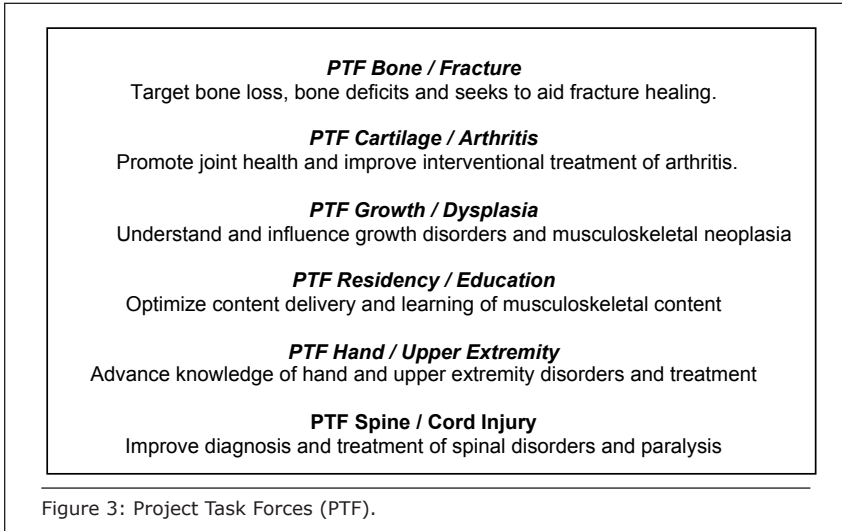


Figure 2: Total Awarded Research 1984-2009



our core mission – patient care. UW Orthopaedics is an active part of the major organizational change of UW Medicine to make Health Care in our region easier and better by decreasing obstacles to patient access and improving all aspects of communication for patients and providers alike. Within our organization our Vice Chair at UW Medical Center and the VA Puget Sound Healthcare System, **Howard Chansky, M.D.** has taken on a pivotal role of identifying and removing barriers to patient access and improving

our Department and beyond by networking with other likeminded groups. Creation of an atmosphere that fosters translational research will make us a competitive force for the future. A first step in this direction are the monthly Research meetings of the PTF Bone/Fracture group chaired by **M. Bradford Henley, M.D.** at our Harborview site. Such robust research initiatives not only stand on their own merits, but also provide critical balance to the Department’s revenue composition while establishing academic prestige that distinguishes the UW program from our local and national competitors alike.

Responsibility: One of the fundamental changes of our ‘information age’ that affects society in general has been the heightened emphasis on organizational and individual transparency and accountability. Documentation and collection of meaningful metrics is key for any organization to be able to respond to new sets of expectations. With the help of our capable Central Administrative team under **Ken Karbowski, M.P.H.** and **Karl Engdahl, M.B.A.** we have set upon a course of creating a Comprehensive Faculty Report (CFR) which seeks to represent the complexity of our multimodal lives as surgeons, researchers and teachers in a single repository and provides productivity numbers and activities of individuals and teams in a transparent and fair graphic fashion. A key aspect of any organization is that of being able to improve its efficiency through periodic review. To help us in this important effort we have formed a Finance Committee chaired by **M. Bradford Henley, M.D.** and is composed of both faculty and administrative leadership, to critically evaluate both revenue streams and the cost of our business operations. Our Department is truly blessed with an enormous wealth of knowledge of our members as can be readily witnessed by looking at the experiences of our committee members outside of the traditional confinements of Medicine.

Ultimately our responsibility has to be directed at

directed care flow to our practitioners so that every patient entering our system for a musculoskeletal problem will end up with the best possible care in the least time necessary. Our partnership with our colleagues from Puget Sound Sports and Spine under direction of **Stan Herring, M.D.** has provided us with a pivotal advantage to improved patient access through integrated efforts across departmental lines.

Change never comes easy under any circumstances. Responding to changes can take many forms ranging from subtle adaptations to outright revolution with its penchant for inflicting trauma. Our Department’s latest initiatives to re-engineer are prompted by major transformations our society at large is experiencing. Based upon our solid foundation I see no reason for a revolution within our Department, but a strong need for a series of strategic adaptations. By focusing on the ‘3 linked R’s’, **Reintegration** through communication, **Research** through transformation and **Responsibility** through changes in attitudes, we can evolve through reorganization and set the stage to the launch of new initiatives and create strategic partnerships to fulfill our mission even better. In doing so we are strongly positioned to not only respond to the many threats to Academic Medicine but can actually thrive and contribute to society in unprecedented fashion.

Thank you for your interest in and support of UW Orthopaedics and Sports Medicine.

Jens R. Chapman, M.D.
Professor and Acting Chair
HansJörg Wyss Endowed Chair
Department of Orthopaedics and Sports Medicine
Adjunct Professor of Neurological Surgery

Frederick A. Matsen III, M.D.

A Measure of Greatness...

With the transition of Dr. Frederick A. Matsen III into the status of Chairman Emeritus December 2009 it seems appropriate to try to sum up the impact of his tenure as Chairman over the last near-quarter century. Undoubtedly, Dr. Matsen qualifies for the lofty category of 'great' in his impact on our Department of Orthopaedics and Sports Medicine, the field of Shoulder and Elbow surgery with his practice, research and teachings and the field of Orthopaedic Surgery through countless interactions with students, residents, fellows, ACE's, faculty, visitors and guests and further through his publications such as some of the seminal textbooks in shoulder surgery. But how do you quantify greatness in his case – with so many domains of activities to consider and such a rich output by so many?

I found three popular quotations,

which can guide us in 'measuring his greatness':

1) Man's greatness lies in his power of thought. Blaise Pascal

Dr. Matsen envisioned Orthopaedic Surgery to be a powerhouse specialty at a time when jokes about the selection criteria to our specialty were common and usually tied to weightlifting and other manifestations of brawn rather than cerebral acumen. Through convergent application of clinical practice, documentation of results presented through quality research and concise education through clear delivery of content he was one of the pioneers in establishing Orthopaedics as a serious specialty capable of improving patient's quality of life. He assembled a faculty at the UW Department of Orthopaedics and Sports Medicine with remarkable output in all measurable ways – clinical productivity, research funding,

presentations and representation in national and international associations. Through his work this Department has been a top ten program in virtually all aspects – hospitals, NIH research funding, program rankings, endowed chairs, etc. It was also due to the leadership of colleagues like Dr. Matsen that Orthopaedic Surgery has become one of the respected major clinical specialties that medical centers rely on for their fiscal success.

2) To be simple is to be great. Ralph Waldo Emerson

Developments in any field generally tend to become more complex and unwieldy over time. Certainly Medicine and Orthopaedics are no exception in this. Again, Dr. Matsen showed greatness by countering conventional trends and advancing medicine by simplifying things. Clarity of thought pervades his writings, straightforward precision of delivery characterizes his



At a tribute for Dr. Matsen supported by Valley Orthopaedic Associates, several generations of shoulder surgeons can be seen together from left to right: Caroline Chebli, M.D. Shoulder & Elbow ACE '06; Charles Rockwood, M.D. UTSW SanAntonio; Frederick A Matsen III; Craig Arntz, M.D., Shoulder & Elbow ACE '89.



Rick and Anne Matsen with their first grandchild – Madeline.

truly revolutionary when Dr. Matsen, inspired by Dr. E.A.Codman’s original End Results idea, was instrumental in bringing it into Orthopaedics through his use in shoulder and elbow surgery.

3) The measure of a man’s greatness is not the number of servants he had, but the number of people he serves. Unknown

There is probably no better way to describe Dr. Matsen’s approach to those around him in our Department than complete dedication to any and all associated with it. He has been instrumental in launching generations of Orthopaedic careers through his guidance and personal support. Throughout his career Dr. Matsen has served as inspiration and example to all of us around him. His dedication to his Department has been limitless and his efforts to maximize opportunities for our Department tireless. Please take a brief look at some of the numbers in Table 1.

teachings. However, take a look at these other examples as well:

- In the area of total shoulder arthroplasties replacing the glenoid fossa with an implant had for a long time produced major challenges. It took a man of his extraordinary vision to identify that a much simpler answer – not using a glenoid implant but instead relying on the patient’s own recontoured scapular bone – would actually render superior results with less complications. Hence the ‘ream and run’ concept for shoulder replacement surgery was borne and remains a valid option for patients to date.

- Measuring shoulder function had stymied a good many shoulder surgeons throughout the history of the subspecialty. Dr. Matsen developed

and/or validated a simple series of reproducible tests using short questionnaires and low-tech tools such as a ruler to very comprehensively report on results of shoulder surgery in a most meaningful way. These tests have become the standard for shoulder-elbow functional assessments around the world.

- Reporting results of surgeries historically had been a privilege of senior surgeons - with little or no input from patients. Early in his career Dr. Matsen identified the well-being of patients following a procedure as being the actually relevant result – and not a surgeon’s perception. In this current era of ‘Evidence-Based-Medicine’ speaking of ‘patient outcomes’ has become commonplace, but this simple concept of looking at patient’s perspective was

Lasting Impact:

Ultimately the measure of a man’s greatness lies in his legacy. Without a doubt the many disciples of Dr. Matsen’s vision are living testament to his impact reflecting his dedication to excellence in patient care, as well as appreciation of research and education. Within his own family Rick and Anne Matsen can be proud of their legacy with three eminently successful children destined to leave their mark in their respective fields. To preserve the name and spirit of Dr. Matsen and his impact on Orthopaedic Surgery residency training, the UW Alumni Association has recently launched a campaign to fund a chair tentatively titled “**The Anne and Rick Matsen Endowed Chair for Residency Education**”. For

Acting Chairman: 1983 - 1984
Chairman: 1986 – 2009

Category	1985 and before	2009
Residency positions	4-5/yr	8/yr
Total residents trained	115 (’52-’85)	133 (’86-’09)
Faculty (including Research Faculty)	12	48
Endowed Chairs	1	8

Table 1: Frederick A. Matsen III, M.D. Chairmanship Metrics. It bears mention that well over half of UW Orthopaedic residents received their training with Dr. Matsen as Chairman. If his years as Acting Chair are included, 143 of 248 Orthopaedic residents had Dr. Matsen listed as their Chair.



During his 23 years of tenure, Dr. Matsen attracted a most accomplished group of researchers and clinicians. There was remarkably little turnover during his chairmanship.



Pictured here are our two most recent chairs of the Department of Orthopaedics and Sports Medicine.

Further reading on Dr. Matsen's many accomplishments can be found at these sites:

www.orthop.washington.edu/faculty/Matsen

ryortho.com/largeJoints.php?article=258_Failure-Up-for-the-Challenge

www.orthop.washington.edu/shoulder_elbow



Frederick A. Matsen III, M.D. is one of the founding members of the American Shoulder and Elbow Surgeons. He is pictured here with the other founders: left to right, Lou Bigliani, Charles Rockwood, Charles Neer, Frederick Matsen, Bob Cofield, and Mel Post.

further information please contact Jodi Miner at her UWMedicine Endowment office (jominer@u.washington.edu, 206- 685-0177). In typically selfless fashion Dr. Matsen wishes this Chair to be tied to the position of the Residency Program Director to provide some support for the countless hours spent by the individual holding this office trying to advance our Orthopaedic Residency. We very much hope to be able to count upon your active support in this most meaningful endeavor in reflection of what the greatness of this man has brought for so many of us.

Jens R. Chapman, M.D., Professor and Acting Chair

Brodie Wood, M.D.
2010 Grateful Alumnus
University of Washington School of Medicine



From left, clockwise: Sophie, Chase, Cindi (Mom), Quinn, Hunter, Galen, and Logan Thatcher.

Born and raised in Seattle, Brodie Wood, M.D., first became interested in medicine at the age of 14, when his younger brother died at Harborview Medical Center after a tragic accident. After that day, Dr. Wood began volunteering at Harborview and at University of Washington Medical Center as often as he could and grew to be inspired by the surgeons he worked with. It was at Harborview that he first met Dr. Sigvard "Sig" Hansen who encouraged him to pursue orthopaedics saying "if you like medicine but prefer happy endings, choose orthopaedics". Dr. Wood attended the University of Washington where he received a Bachelor of Science in Biology, and attended medical school at the University of Pennsylvania. When he returned to the UW for his Orthopaedics Residency, Dr. Wood says he felt blessed and remembers his years as a resident as a hard, but wonderful time. Dr. Wood met his wife, Cindi, while in college and today they live in Olympia with their six children (ages 5-16).

Earlier this year, Dr. Wood contacted the department about making a substantial gift to support the Resident Education Discretionary Fund. He said that he wanted to give back because he remembered being the beneficiary of the generosity of the residents who gave before him and he wanted to pass it on. "Orthopaedics and medicine gave me my life back, gave me a purpose to live", he says, and this is why he feels it is so important to give back even more than he received. He hopes that today's residents have the same kind of experience he had while he was here.

Lyle Sorensen, M.D.
2010 Distinguished Alumnus
University of Washington School of Medicine



Dr. Lyle Sorensen first grew interested in orthopaedics working as an operating room assistant at Seattle's Virginia Mason Hospital. While studying for his BS in Microbiology and Immunology at the University of Washington, he continued his employment at Virginia Mason - now as a research technician in the Tumor Immunology Lab. When the time came to apply to medical school, the University of Washington was the obvious choice. He completed his residency at the University of Washington as well as a fellowship in Musculoskeletal Oncology and Tumor Surgery at Children's Hospital.

Dr. Sorensen is a highly valued member of our orthopaedic community. On the board of directors of the Washington State Orthopaedic Association (WSOA) since 2002, Dr. Sorensen has championed the profession of orthopaedic surgery and patient education. Recently, the WSOA received the 2009 award as the state association of the year from the American Academy of Orthopaedic Surgeons. He has served as Chairman of the University of Washington Orthopaedic Alumni since 1998.

Active nationally as well, Lyle has contributed to various committees for the American Academy of Orthopaedic Surgeons. He has worked with the American Orthopaedic Association Residents Conference where he was Chairman in 1993.

Lyle is the section head for Orthopaedic Surgery at Virginia Mason Medical Center.

We are proud to honor Lyle as our 2010 alumnus emeritus.

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Visiting Lecturers



Christopher Harner, M.D.
2010 LeCocq Lecturer

This year at our annual LeCocq lecture on February 11th and 12th, we were honored to have Dr. Christopher Harner as our 2010 LeCocq Lecturer.

Christopher D. Harner, M.D. is the Blue Cross of Western Pennsylvania Professor of Orthopaedic Surgery at the University of Pittsburgh School of Medicine. Dr. Harner is also Chief of the Division of Sports Medicine, Fellowship Director, and Medical Director at the UPMC Center for Sports Medicine.

Dr. Harner specializes in sports medicine, especially knee, ligament and cartilage injuries. His research focuses on healing such injuries, especially those of the anterior and posterior cruciate ligaments, through new surgical techniques.

Dr. Harner's leadership clinically and academically in Sports Medicine is evidenced by numerous grants, awards and dozens of published scientific articles in clinical and research journals. Awards for his research include the Cabaud Award (1999 & 2003) and the Excellence in Research Award (1994 & 2002) from the American Orthopaedic Society for Sports Medicine, the Hughston Best Paper Award by AJSM (2000), and the John Joyce Award (2001 and 2002) from ISAKOS (The International Society of Arthroscopy, Knee Surgery and Orthopedic Sports Medicine).

Dr. Harner's dedication to Orthopaedics and Sports Medicine is marked by his commitment to research and education. He is acknowledged as a Master Instructor by the Arthroscopy Association of North America and a reviewer for the Program Committee of the Orthopaedic Research Society. He was president of the Pennsylvania Orthopaedic Society (POS) from 1997 to 1998 and continues to serve on its board of directors. He serves on the education committees for both the American Orthopaedic Society for Sports Medicine and the Arthroscopy Association of North America, and on the executive committee of the University of Pittsburgh's Musculoskeletal Research Center.

Dr. Harner was appointed a 10 year term on the board of directors of the American Board of Orthopaedic Surgery 2000-2010 and is currently an Officer on the board of directors (2003-2004). Dr. Harner also is a member of the editorial review boards for three orthopaedic and sports medicine journals and is a reviewer for three additional scientific journals. Furthermore, Dr. Harner serves as a physician for many local sports teams including the University of Pittsburgh, Robert Morris University and Woodland Hills High School. He resides in the Fox Chapel area of Pittsburgh with his wife, Cindy and their three children.



Jeffrey N. Katz, M.D.
2010 OREF Hark Lecturer, Resident Research Day

This spring we were honored to have Dr. Jeffrey Katz as our OREF Hark Lecturer for Resident Research Day, June 25th.

Jeffrey Katz, M.D. is the Co-director of the Brigham Spine Center at the Brigham and Women's Hospital in Boston. He works in the Division of Rheumatology, Immunology and Allergy where is he an Associate Professor.

Dr. Katz graduated from Princeton University in 1980 with a degree in Biochemistry. At Yale Medical School in 1984, he completed his MD. He was a fellow in Rheumatology at Brigham and Women's Hospital from 1987 to 1990. Dr. Katz also completed a Kellogg Fellowship in Clinical Effectiveness at the Harvard School of Public Health in 1990.

Since 1990, he has been a Staff Rheumatologist at Brigham and Women's Hospital. He is also currently the Director of the Robert Brigham Arthritis and Musculoskeletal Clinical Research Center as well as the Director of the Orthopaedic and Arthritis Center for Outcomes Research at Brigham and Women's Hospital.

Dr. Katz has received many accolades such as the American College of Rheumatology Senior Rheumatology Fellow Award, the Arthritis Investigator Award, from the Arthritis Foundation, the Henry Kunkel Young Investigator Award, American College of Rheumatology, the Arthritis Hero Award from the National Arthritis Foundation, and the Clifford Barger Excellence in Mentoring Award from Harvard Medical School.

For his research, he is a physician investigator with extensive clinical experience in musculoskeletal disorders of all kinds including degenerative, traumatic and inflammatory. Dr. Katz has advanced training in clinical research methodology and has published extensively. His work has incorporated a range of designs including randomized trials, cohort and case control studies, qualitative research and quantitative literature synthesis.

University of Washington Medical Center

We are finishing a year of change at the University of Washington Medical Center and School of Medicine. Frederick A. Matsen, III, MD, our esteemed chairman for the past 23 years has stepped down as chairman of our department. Though losing Dr. Matsen's steady hand at the helm of our department, we are very excited that he will now be able to devote even more time to orthopaedic research, clinical care and resident education.

The University continues to remain an extremely busy center for tertiary orthopaedic care. There are projected

to be nearly 4,300 cases performed in fiscal year 2010. This represents a slight increase over the previous year and about a 15% increase from FY 2005. This increase in volume has occurred while the average length of an inpatient stay continues to decrease and is now under four days. In addition, our inpatient unit, 6 SE, under the management of Susan Theiler, RN, has seen a remarkable reduction in falls resulting in injury. During his time as Chief of Orthopaedics & Sports Medicine and Medical Director of 6SE, Seth S. Leopold, MD, worked closely with Ms. Theiler in developing this

program to decrease the number of falls by orthopaedic patients. Michael J. Lee, MD, one of our talented spine surgeons, is the newly appointed Medical Director for 6SE and looks forward to continuing patient safety programs developed by Dr. Leopold and Ms. Theiler and expanding on them with some new initiatives.

We continue to have very busy outpatient surgical practices at the Roosevelt Bone and Joint Center, the Sports Medicine Clinic, and the Eastside Specialty Center. Jerry Huang, MD is currently running the Hand Service and has a presence at both the Bone



Our Robotics Lab, operated by Peter R. Cavanagh, Ph.D. (pictured here center), opened on March 30, 2010.



UWMC is set to expand in Fall 2011.

and Joint Center and the Eastside Specialty Clinic. Dan Patzker, PAC and Magee Saewert, PAC assist Jerry in managing this busy service. Seth Leopold, MD continues to run the total joint service and maintains clinics at the BJC and the ESC. Paul Manner, MD, also a linchpin of the total joint service has just been promoted to Associate Professor in Orthopaedics and Sports Medicine while Howard Chansky has assumed the position of Acting Chief of Orthopaedics at the UWMC. Three physician assistants, Tim Coglon, Pete Hall, and Dan Stamper, round out the total joint service.

Dr. Matsen and Winston Warne constitute our shoulder and elbow service with the assistance of Alex Bertelsen, PAC. Our Spine Service



Our department owes a great deal of gratitude to Ken Karbowski, M.P.H., Director (right) and Patrick Green, M.B.A., Assistant Administrator (left).

remains in the capable hands of Michael Lee, MD, Jens Chapman, MD and Ted Wagner, MD. Sue Earls, PAC and Eching V. Bertelsen, PAC are critical members of the spine team. We were all excited over the recent birth of the very cute Alexander Jr. to Eching and Alex Bertelsen.

There are a wide variety of research interests at the University of Washington Medical Center and these are strongly reflected in the publication of this year's research report. We are very excited to announce the formal opening of the Orthopaedic Robotics Laboratory under the directorship of Peter R. Cavanagh, PhD. This laboratory is the first of its kind in our department and will permit Dr. Cavanagh and his team to continue their internationally renowned biomechanics research. The lab has already become a hub of activity as several faculty members and residents have started collaborative projects with Dr. Cavanagh. We are also pleased to announce that Dr. Cavanagh has accepted our first appointment as Vice Chair of Research for the Department of Orthopaedics and Sports Medicine.

We are very excited about our future at the University of Washington Medical Center. We anticipate a further increase in the number of inpatient procedures, as well as outpatient clinic visits. These endeavors should be aided with the recruitment of new faculty and the strengthening of our relationships with our family practitioners and rehabilitation medicine partners. We are embarking

on plans to further increase access to all of our clinics. In the process of enhancing access, we aim to realize stronger ties both to our orthopaedic colleagues in greater Seattle, as well as to our University of Washington family practice and rehabilitation physicians. We are pleased that Nelson Hager, MD, a member of the Department of Rehabilitation has joined Karin Holmberg, RN, Gary Barnett, RN and Dr Chansky in managing the Bone and Joint Clinic. Nelson brings a unique perspective gleaned from his experience building a busy practice in the private sector.

Under the leadership of our new acting chairman, Jens R. Chapman, MD, we are also looking to continue to develop the faculty at the University of Washington Medical Center. There are currently active recruitments for a foot and ankle surgeon, as well as a new orthopaedic oncologist to assist Ernest "Chappie" Conrad, MD, in managing his renowned tumor practice.

We are excited about the many developments underway on our service at UWMC and hope that many of the readers will join us in tour of our Research activities and educational activities planned around the year.

Howard A. Chansky, M.D.
Professor and Vice Chair

Sports Medicine

The University of Washington Sports Medicine Clinic has a proud history of treating athletic injuries not only in the Husky student athlete but athletically minded members of our community and local Region of the country as well. Started in 1975, The Sports Medicine Clinic continues to provide comprehensive care for injuries sustained at all levels of physical activity with a focus on the patient's current and future athletic goals.

Our clinical services include:

- Evaluation, prevention and treatment of sports or exercise-related injuries
- Surgical and specialty care of the shoulder, elbow, hip, back, knee, ankle and foot
- Arthroscopic and minimally-invasive surgery
- Exercise training programs and physical therapy/rehabilitation for returning to activity
- Brace-fitting, custom orthotics, splinting, casting and bike-fitting

Dr. John O'Kane has been named by Seattle magazine as one of the "Top Docs" in Sports Medicine. In 2008, Dr. O'Kane was also distinguished as being the first recipient of the Bob and Sally Behnke Endowed Chair for the Health of the Student Athlete.

Current research among our faculty includes examining injuries in female youth soccer players, examining Jones fractures in University of Washington football players, studying



Figure 2: The current location of the Sports Medicine Clinic resides within the backside of the Bank of America Arena and offers athletes and athletically inclined patients immediate proximity to high-level directed patient care.

the biomechanical properties of tibial anterior tendons and patellar tendon allograft, and studying the outcome of infected ACL reconstructions. Actively funded projects include collaborations with Smith + Nephew/Richards and DePuy/Mitek for the development and maintenance of the University of Washington Arthroscopy, Research and Training Laboratory (ART-lab). A pilot project looking at injuries in girls club gymnastics is also underway.

On the clinical side our practice has enjoyed robust growth with over 1,000 patient visits/month and over 100

surgical cases/month having become the norm.

Future goals for the Sports Medicine Clinic include the formation of an accredited Sports Medicine Fellowship, development of a premier full service sports practice for the Pacific Northwest, becoming a cornerstone for the development of the New Husky Stadium while continuing to provide the best possible care to our patients so they can lead an active lives.

John R. Green III, M.D. and Claudia Happe-Hartsell, R.N.

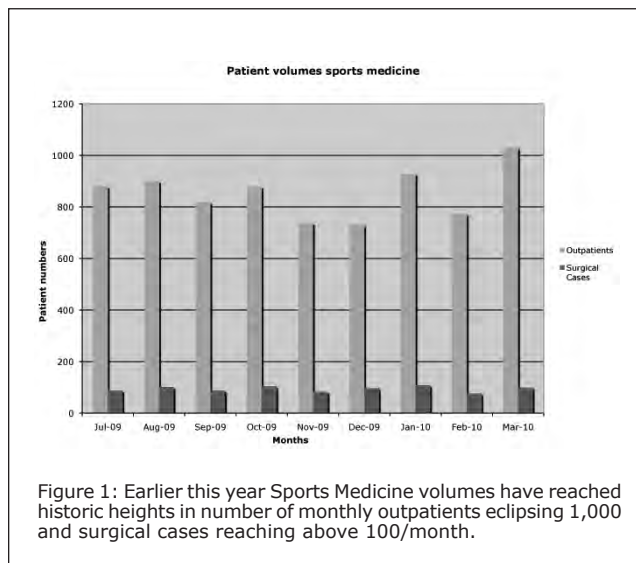


Figure 1: Earlier this year Sports Medicine volumes have reached historic heights in number of monthly outpatients eclipsing 1,000 and surgical cases reaching above 100/month.



Figure 3: Dr. John 'Trey' Green looking out over Husky stadium. Hopefully, a Husky Football stadium remodel will provide a new opportunity for colocation with Sports Medicine.



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If Not Why Not?

"Already in 1900 I had become interested in what I have called the End Result Idea, which was merely the common-sense notion that every hospital should follow every patient it treats, long enough to determine whether or not the treatment has been successful, and then to inquire 'if not, why not?'... We had found that this routine tracing of every case, interesting or uninteresting, had brought to our notice many things in which our knowledge, our technique, our organization, our own skill or wisdom, and perhaps even our care and our consciences, needed attention."

When he presented this idea in 1913 in the great hall of the Philadelphia Academy of Medicine, E. Amory Codman pointed out that answering these questions is of primary interest to the patient, the public, and those in the medical field. He then asked, "Who represents or acts for these interests?" and answered, "Strangely enough the answer is: No one." In his infamous cartoon of the "Back Bay Golden Goose Ostrich," he showed the bird producing golden eggs of profit while hiding her head in the sand so she could not see how much (or how little) the care was benefiting the patient. For his integrity, he was fired from the hospital (hmm).

Codman died 70 years ago and was buried in a nameless grave near his wife's family mausoleum. A century later we are struggling with the same issues.

If we are to have a valid assessment of the effectiveness of an operation, we

first need a method for determining the result in a reasonable statistical sample of patients having this procedure. As an example of the difficulty in achieving this objective, Hasan et al. showed that the great majority of shoulder arthroplasties in New York are done by surgeons who perform fewer than four per year. Because the preponderance of these cases are not included in the studies of outcomes (which emanate from academic centers), the surgical results data published in the peer-reviewed literature are not generally relevant to community orthopaedic practice, because they lack external validity—that is, they cannot be applied to the common surgical experience. We are surely a long way from complying with Codman's notion of following "every" patient. The issue, as he pointed out, is that no one is representing or acting in the interest of the average patient having the surgery.

As the expense of medicine becomes progressively unaffordable, the need for externally valid, generalizable analyses of surgical effectiveness will be pressed on us by the employers, who are responsible for the medical benefits of their employees, and by the government, which is responsible for the medical benefits of those without medical benefits from their employers. It is in their interest. The two key steps that will help us to obtain valid data on the common experience are (1) to define and apply routinely the most practical tool for measuring the result of treatment (such as a series of "yes or no" questions about

comfort and function that the patient can complete before and sequentially after the procedure) so that cost is not an obstacle to its use in every practice, and (2) to exert leadership at all levels for the broad collection and analysis of these data so we can see what is and what is not working across our specialty.

While I've been heavily criticized by those advocating "objective" measures, my inclination has been toward tools founded in patient self-assessment because such a tool can be practically applied in a consistent manner without worry about standardization of examiners in the documentation of range of motion and strength, because self-assessment is relatively immune from the bias of the examiner, because it is much less expensive to have the patient report on the patient than to hire someone else to do it, and, ultimately, because it is the patient's opinion that is most important regarding the comfort and function of their limbs and spine. To put a fine point on it, it seems a reachable goal to expect everyone doing shoulder procedures to have each of their patients report "yes" or "no" regarding 12 basic shoulder functions before and at a year after surgery; the same cannot be said for the more complex 'objective' instruments that require physical examination. If an evaluation method is impractical in community practice, it systematically and selectively excludes the largest and most important groups of patients and surgeons from the sample—those



From *The Shoulder*, by E. Amory Codman, 1934. Republished by R. E. Krieger 1984.

in general orthopaedic practices.

The benefit from a surgical procedure can only be determined if we assess the patient in the same way before and after the treatment. There is inconsistent use of the word "outcome" in our literature. Common sense indicates that "outcome" means what "comes out" of the treatment in terms of the chosen measurement tool applied at a reasonable time after surgery. In order to determine the effectiveness of the treatment, we need also to know what "goes into" the treatment or the "ingo." Thus, the benefit of the treatment is the difference between the outcome and the ingo as indicated by the same self-assessment applied before and after the procedure.

We recognize that the result of surgery is determined by three major factors: the patient, the surgeon, and the implant, if one is used. Let us consider these determinants in reverse order. The first factor is the implant. There are few data indicating that "improvements" in prosthetic design have a significant effect on the benefit of an arthroplasty to the patient. For example, two recent articles by Mileti et al. and Churchill et al. found no difference between "first" and "second"

generation humeral components. In this light, it is of concern that many tens of millions of dollars have been spent on trying to "improve" the humeral prostheses used in shoulder arthroplasty. For sure, the charges for implants are rising faster than either the established benefit to the patient from their use or the funds available in the health-care system to cover the increased charges. This is in contrast to the application of vascular stents, which both increased the quality of the result and reduced the cost of treating arterial occlusive disease. Were he alive today, Codman might ask, "In whose interest is the design of additional and more expensive varieties of orthopaedic prostheses?"

The second factor is the surgeon. It has been determined that patients cared for by surgeons who performed fewer than two shoulder arthroplasties per year were more likely to die postoperatively and had more surgical complications and longer lengths of stay than those managed by surgeons with a volume of five procedures or more per year. In one study, Jain et al. concluded that "patients who have a total shoulder arthroplasty or hemiarthroplasty performed by a high-volume surgeon or in a high-

volume hospital are more likely to have a better outcome." Hammond et al. found that "the patients of surgeons with higher average annual case-loads of total shoulder arthroplasties and hemiarthroplasties have decreased complication rates and hospital lengths of stay compared with the patients of surgeons who perform fewer of these procedures." "Who holds" the knife appears to have a strong effect on the result of a procedure, in the same way that "who holds" the fly rod, the paint brush, or the violin bow determines the result. The effects of intersurgeon differences extend beyond the surgical technique in the operating room. My late partner, Doug Harryman demonstrated that groups of patients with the same diagnosis in the practices of different surgeons were quite different from each other. Thus, the generalizability of the results obtained by a given surgeon treating his or her own patients may not be any more generalizable to all patients than the results obtained by a particular math professor in an elite university would be generalizable to all college students. As I like to say, "The surgeon is the method."

The third factor is the patient—the complex of the specific surgical



From Ernest Amory Codman, *The End Result of a Life in Medicine*, by Bill Mallon, W.B. Saunders, 2000.

problem and the human being who is affected by it. William Osler is credited with the statement: "It is more important to know what sort of patient has the disease than to know what sort of disease has the patient." Although it would seem intuitive that a patient's physical, emotional, and social welfare would all have a powerful effect on his or her ability to benefit from a surgical reconstruction, there has been little research on this important determinant of surgical effectiveness. Yet, as shown by Rozencwaig et al., the tools for this critical research, such as the Short Form-36 (SF-36) patient self-assessment, are at hand providing a compelling and practical approach for exploring the relationship of the patient's perceived physical and mental health to the result of orthopaedic procedures.

As we consider the validity of approaches to clinical research in orthopaedic surgery, we must ask, "What question are we trying to answer?" and "Will the answer we get from our study apply generally across our specialty, or only to a relatively few patients, practices, or surgeons?" If we are looking for a way to determine the answer to the question "Is prosthesis A or prosthesis B better in the hands of a surgeon who does nothing but this type of surgery?" we would want a sophisticated set of tools for controlling the variability in patients and their pathology as well as for documenting the function, mechanics,

and radiographic anatomy before and sequentially after surgery.

If we are asking, "Do community surgeons in general practice get the same results as surgeons with high volumes, special training, or memberships in specialty societies?" we need a method for including as many patients and as many surgeons as possible so that we have a statistically and externally valid sample. This will require the simplest and least taxing methodologies if it is to have a chance of succeeding. Finally, if we want to know which patients have the best results and which patients fail to benefit from a procedure, we need to capture data from the broadest possible sample of what is really happening. It is not a question of subjective versus objective measures; validity comes from matching the tool to the task.

In conclusion, I would respectfully suggest that, in Codman's parlance, each surgeon should act for the interest of her or his patients by using simple patient self assessments to practically "follow every patient ..., long enough to determine whether or not the treatment has been successful, and then to inquire 'if not, why not?'" Generals, football coaches, and NASA have more to learn from their failures than from their successes. As surgeons we can only learn from our failures if we strive to identify them.

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The Polymeric Collagen Phenotype of Cartilage Created from Human Bone Marrow Stem Cells

Abstract: Types II, IX and XI collagen exist in normal cartilage matrix as heterofibrillar polymeric assemblies. Verifying simply their expression or presence in the matrix may not be adequate to ensure the quality of engineered cartilage. Whether these molecules associate and cross-link correctly in the extracellular matrix is more important as a functional measure. Using newly developed methodology for screening collagen co-polymeric assembly, the quality of the collagenous matrix deposited by human bone marrow stem cells undergoing chondrogenesis was studied. The results provide new evidence that under suitable conditions human mesenchymal stem cells can differentiate into chondroblasts and synthesize type II collagen that forms a cross-linked heterofibrillar framework characteristic of developing cartilage.

Study Rationale

A continuous challenge in the field of cartilage tissue engineering has been to increase the collagen content of neo-cartilage to levels observed in native articular or developing cartilage. Since the collagen heteropolymer is a crucial template of the mature fibrillar architecture and for the ongoing stability of the mature tissue, we rationalize that a cross-linked template of type II/IX/XI collagen heterofibrils must assemble in the matrix of newly forming cartilage to allow type II collagen fibril growth, an increased collagen content and so achieve the biomechanical properties of functional cartilage.

Objective

This study investigated the ability of human bone marrow stem cells undergoing chondrogenesis to assemble a type II collagen-based cross-linked network characteristic of cartilage matrix *in vivo*.

Methods

Mesenchymal stem cell culture

and chondrogenic differentiation. Human bone marrow mesenchymal cells were isolated by adherence to tissue culture plastic and expanded in monolayer culture in MSC Growth Medium supplemented with FGF2 [1]. Cells were detached with trypsin and transferred to serum-free chondrogenic medium containing TGF β 3, dexamethasone, ascorbic acid 2-phosphate, sodium pyruvate, proline and ITS +1 as described in [1]. Aliquots of cells were centrifuged in Corning Transwell™ filter units. Cultures were maintained at 37°C, 5% CO $_2$ for 3, 7, 14, 28 days and media changed every two days. Neo-cartilage samples were frozen for future biochemical analysis.

Total Collagen Analysis. Samples were thawed, drained of excess liquid and weighed. They were hydrolyzed in 6M HCl at 110°C for 24 hrs. An aliquot of the hydrolysate was colorimetrically assayed for hydroxyproline [2]. Collagen content was expressed as % collagen/wet weight. Human fetal cartilage (15 week) was used as control.

Collagen cross-link analysis.

Samples were acid hydrolyzed as above. Pyridinoline cross-links were quantified by C-18 reverse-phase HPLC and fluorometry [2] and expressed as moles per mole of collagen. Human fetal cartilage was used as a control.

Mass Spectrometry. Following SDS-PAGE and Coomassie blue staining, in-gel trypsin digests of collagen chains from hMSCs engineered cartilage were analyzed to establish their identity.

Collagen Heteropolymer Detection. The collagen network laid down by hMSCs undergoing chondrogenesis was depolymerized and extracted using pepsin. The various collagen chains and chain fragments were resolved by Laemmli SDS-PAGE. The collagen chains were transferred to PVDF and probed with monoclonal antibody (mAb) 10F2, which recognizes a cleavage site (neo-epitope) in a sequence in the C-telopeptide cross-linking domain of type II collagen. When necessary the blots were then probed with mAb 1C10 which recognizes type II collagen chains [3]. A colorimetric or luminescence detection system was used. A pepsin extract of fetal cartilage

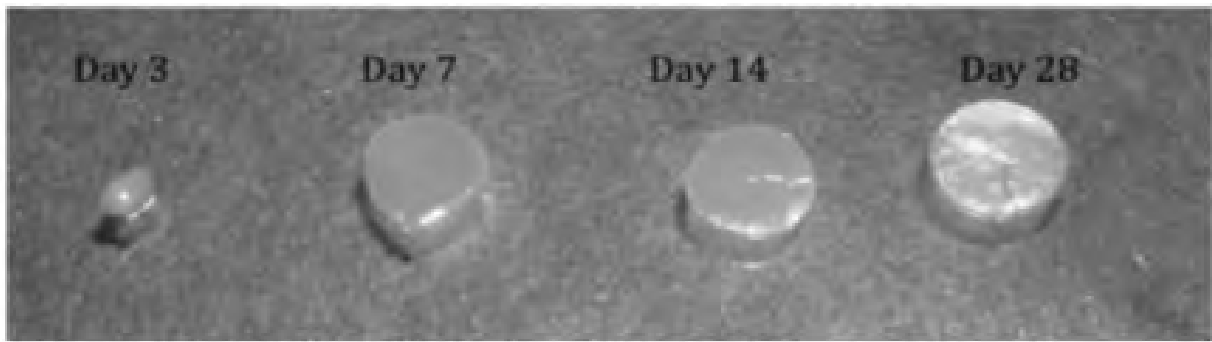


Figure 1: Macroscopic view of scaffold-free human mesenchymal stem cell derived tissue-engineered cartilage showing growth and differentiation into a cartilage-like disc.

containing type II collagen was used as a standard.

Results

Mass spectrometry of in-gel trypsin digested collagen chains, showed that type II collagen and type XI collagen are synthesized and deposited in the extracellular matrix as early as day 7 in culture.

Figure 1 shows the gross appearance of glossy, cartilaginous tissue after 14 days in transwell scaffold-free culture. Histochemical (Safranin-O) and immunohistochemical (type II collagen) analysis of the tissue showed intense, uniform staining of a type II collagen and proteoglycan containing extracellular matrix [1]. A firm consistency was noted by day 14. By day 28 the rigid disc has a consistency like cartilage.

A progressive increase in collagen content from week 1 to week 4 in chondrogenic culture was observed (Table 1). The collagen content (1% of wet wt.) by week 4 compares well with human fetal cartilage (3% of wet wt. at 15 weeks *in utero*).

High levels of hydroxylysyl-pyridinoline (HP) cross-links are a characteristic of cartilage collagen.

At 1 wk HP cross-links were barely detectable (Table 1). At 2 weeks the HP content of the neo-cartilage approached that of human fetal cartilage and was maintained over the next 14 days.

The high concentration of proteoglycans [1] in the samples affected the migration pattern of the collagen chains on electrophoresis (Figure 2). However it was clear that the antibody 10F2 reacted with the $\alpha 1(\text{II})$ chain on western blots as expected for a cross-linked type II collagen polymer, (10F2 recognizes the C-telopeptide of type II collagen cross-linked to $\alpha 1(\text{II})$ collagen chains) indicating that a cross-linked collagen network had assembled in the neocartilage within a week. A pepsin extract of normal cartilage revealed a similar pattern. The antibody also reacted with $\alpha 1(\text{XI})$ collagen chains as we previously described [3], (seen here migrating slightly slower than the $\alpha 1(\text{II})$ chains on days 14 and 28) implying this chain was cross-linked to the C-telopeptide of type II collagen and that type XI collagen was copolymerized and cross-linked to C-telopeptides of type II collagen. A heteropolymer of type II and XI collagen had formed in the

neocartilage. The same cross-linking sites occur in normal articular and epiphyseal cartilages.

Discussion

The cartilage formed in transwell cultures had a relatively mature cross-linked collagen network by day 14 in culture. This is reflected in the original characterization of the transwell culture system by Murdoch et al., [1]. They observed only a modest gain in total wet weight between days 14 and 28 despite of a 95% increase in proteoglycan content. The heteropolymeric cross-linked collagen framework restricted proteoglycan swelling in the neo-cartilage matrix, which can explain the limited gain in wet weight.

Conclusion

The results indicate that under culture conditions first reported by Murdoch et al., [1], human mesenchymal stem cells *in vitro* can differentiate into chondroblasts and synthesize type II and type XI collagen that form a heteropolymeric cross-linked fibrillar framework characteristic of developing cartilage. Whether the formation of this framework translates

	Day 7	Day 14	Day 28	Human Fetal Cartilage (15 weeks)
% collagen wet weight	0.42	0.56	0.90	2.98
HP (moles/molecollagen)	0.05	0.23	0.22	0.23

Table 1: Increase in collagen and pyridinoline cross-link contents of cartilage discs with time in culture.

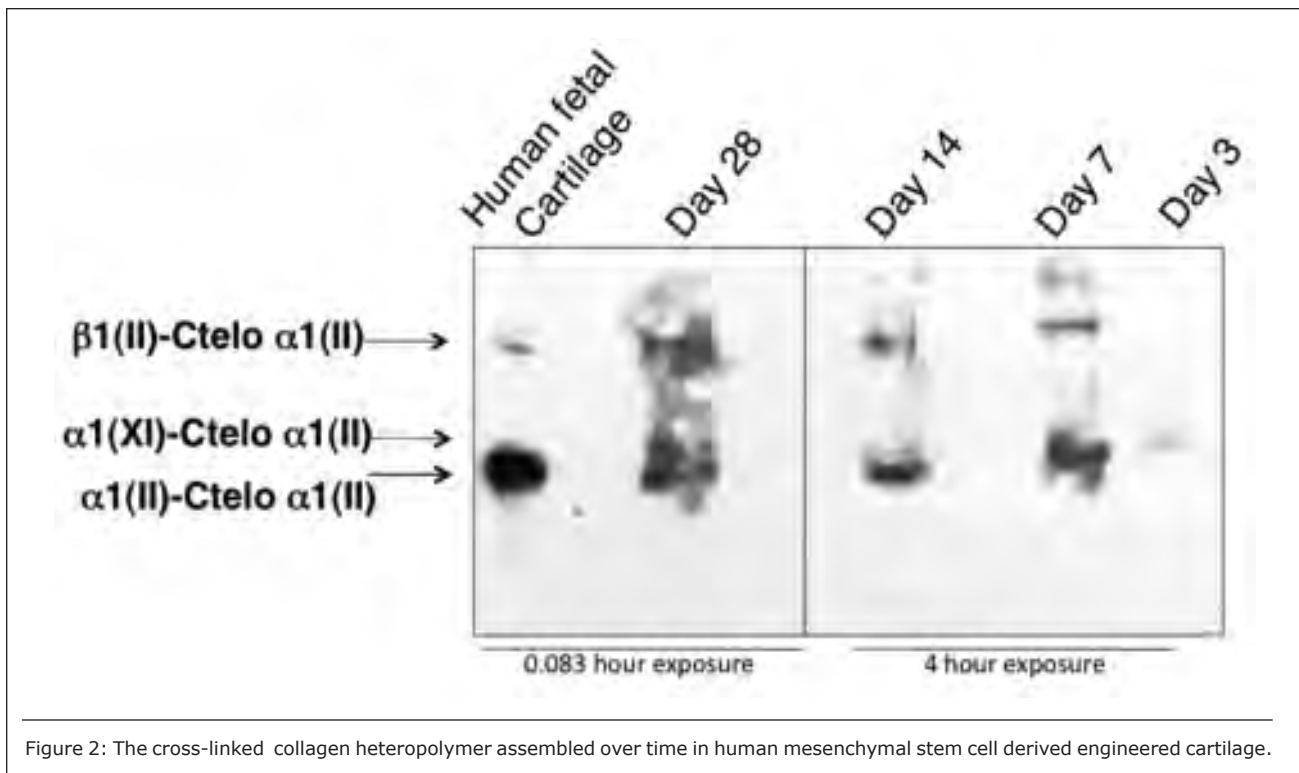


Figure 2: The cross-linked collagen heteropolymer assembled over time in human mesenchymal stem cell derived engineered cartilage.

to a more functional neocartilage is important to determine and is now being investigated.

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Soccer Injuries in Female Youth Players: Comparison of Injury Surveillance by Certified Athletic Trainers and Email

Abstract: In this prospective cohort study we sought to determine whether utilization of certified athletic trainers vs. parent internet-based survey would be comparable for identifying soccer injuries in 12-14 year old female players participating in Seattle, WA. We found acute injury rates of 3.0/1000AE, 3.9/1000AE, and 4.7/1000AE and overuse injury rates of 1.0/1000AE, 2.9/1000AE, and 2.9/1000AE for ATC only, internet-based survey only, and either system, respectively. The injury rate based on the weekly parent internet-based survey was similar to the rate based on the ATC reporting and had comparable classification of injured body region and laterality of injury.

Study Rationale and Content

Soccer is one of the most popular sports in the world and is increasing in popularity in the US especially amongst girls. As more girls play, physicians are seeing more injuries but little data exists regarding the rate and type of injuries sustained by young teenagers and no large studies have prospectively assessed injury risk factors in this age group. These studies are needed but appropriate methodology for collecting injury data in this age group is not well defined.

Clinical Question

This pilot study was performed to determine if a parent internet-based survey could identify injuries as accurately and effectively as certified athletic trainers (ATC) assigned to each team to collect injury data.

Methods

Study design: Prospective Cohort Study (IRB approved)

Study population: 92 female youth soccer players ages 12 to 14 years from four elite and four recreational soccer teams from the Seattle Youth Soccer Association.

Injury surveillance systems compared:

Parent internet-based survey: Parents were provided definition of overuse and acute injury. Parents completed an internet based weekly report of soccer practice hours and any injuries sustained. Incomplete injury forms received follow-up phone calls for additional information and parents were called if the weekly form was not completed.

Certified athletic trainers: ATC attended weekly practice to identify any injuries sustained and complete the questionnaire that matched the internet based questionnaire.

Injury definition:

Acute injury: New, sudden onset injury resulting from participation in club soccer that resulted in missing a subsequent game or practice.

Overuse injury: Development of new onset of pain in a specific body region resulting from soccer participation persisting for two weeks or more not resulting from an acute event.

Athletic exposure time assessment: Practice time was recorded by the

parents in the weekly questionnaire. Game time was kept by a volunteer parent or manager.

Statistical analysis: Baseline demographic and soccer data among the uninjured and injured subjects were compared using Fisher's exact test for categorical variables, and ordinal variables were compared using Wilcoxon rank sum test. Among the total of injuries reported by one or both of the ATC and internet-based systems we calculated the proportion captured by each system, the proportion captured uniquely by each system and the proportion of injuries captured in common.

Results

Acutely injured players were more likely to play forward, more likely to have had a prior injury and more likely to use a personal trainer during the soccer season. Players with overuse injuries were more likely to be younger, play at the elite level and to play forward (Table 1).

22 subjects experienced 27 acute injuries which were reported by one or both surveillance methods. Among the 27, 85% (23/27) were reported by



of injury rates in youth soccer.

Playing forward, a history of a prior injury, and working with a personal trainer (for reasons that are unclear) increase the risk of acute injury.

Younger elite players were more likely to have overuse injuries and playing forward was also a risk factor.

The internet based system identified a greater percentage of total injuries and performed comparably to the ATC model regarding body region injured.

Summary and Conclusions

Parents are feasible as collectors of basic injury data for their children.

Internet-based injury surveillance systems that use parent reporting should be considered for future studies of sports injuries in youth populations where athletic trainers are not available, such as at the middle school level and non-school-based sports clubs.

internet-based survey, 63% (17/27) were reported by ATC.

The acute injury incidence rate was 4.7/1000 AE hours using reporting from either the internet-based or ATC system, 3.9/1000 AE hours using reporting from the internet-based system, and 3.0/1000AE hours using reporting from the ATC system.

The most common acutely injured body regions were the ankle (43%), the knee (11%), and the hip (11%).

17 subjects experienced 17 overuse injuries with 100% (17/17) reported by the internet-based survey, 35% (6/17) reported by ATC

The overuse injury incidence rate was 2.9/1000 AE hours using reporting from either the internet-based survey or ATC system, 2.9/1000 AE hours using reporting from the internet-based survey system, and 1.0/1000AE hours using reporting from the ATC system.

The most common body regions for overuse injuries were the knee (32%) and lower leg (29%).

For all injuries, the Kappa statistic indicated the agreement was very good for body region injured and laterality of injury.

Discussion

The rate of injury in this population (2.9/1000 AE overuse and 4.7/1000 AE acute) is consistent with other studies



	Players with acute injuries (N=22) %	Players with overuse injuries (N=17) %	Uninjured players (N=49) %
Age (years)		b	
11	9	6	4
12	36	47	22
13	23	35	29
14	32	12	45
Menarchal	77	47	73
Length of soccer career (years)			
1-4	9	0	10
5-6	18	6	14
7-8	46	71	43
9+	27	23	33
Play on school team	36	35	43
Position	a	b	
Defender	18	35	31
Forward	50	53	18
Midfielder	27	12	47
Goalie	5	0	4
Level of play	a	b	
Elite	77	82	53
Recreational	23	18	47
Number of other sports played			
1	32	29	29
2	27	29	29
3	23	20	20
4+	18	22	22
Ever injured	77 ^a	53	43
Using a personal trainer	32 ^a	24	10
Participating in injury prevention program	9	6	12

Table 1: Demographic and Soccer Information among Female Youth Soccer Players 12-14 Years of Age, Seattle, Washington, 2006.
a Comparing acutely injured to uninjured players p<0.05
b Comparing overuse injured to uninjured players p<0.05

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Funding:

This publication was made possible by grant # R21AR053371 from the

National Institute of Arthritis and Musculoskeletal and Skin Diseases, Bethesda. MD.

Study was approved by the University of Washington Institutional Review Board.

Reproduced in condensed format with permission for the Journal of Athletic Training. Full article citation: MA Schiff, CD Mack, NL Polissar, MR Levy, SP Dow, and JW O'Kane. J Athl Train, May 1, 2010; 45(3): 238-42.

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Lateral Tibial Plateau Length and Radial Convexity as Anterior Cruciate Ligament Injury Risk Factors: Is it Gender or Geometry?

Abstract: The articular surface geometry of the tibial plateau and its relationship to the femoral surface may predispose individuals to anterior cruciate ligament (ACL) injury[2-4]. We retrospectively evaluated MRIs performed in 185 age- and activity-matched uninjured and non-contact unilateral (uACL)-, bilateral (bACL)-, and revision (rACL)-injured persons to evaluate geometric differences in the lateral tibial plateau distal femur to ascertain factors that could be associated with ACL injury or reinjury. We found that all females (uninjured or injured) demonstrate a relatively shorter tibial plateau to distal femoral bearing surface and a comparatively steeper lateral plateau convexity compared to uninjured males. In females, there is little variation in this geometry regardless of whether they have or have not suffered an ACL injury. In contrast, males who suffered ACL injuries or reinjuries demonstrated a tibial plateau geometry that closely approximated that of the female knee. In addition, in males a shorter and more convex plateau geometry correlated with a greater propensity for bilateral or recurrent injuries. These data suggest that the predilection for ACL injury is in part related as much to the shape of the lateral knee bearing surfaces rather than gender. The data also indicate a potential explanation for the mechanism of ACL injury.

Study Rationale And Context:

Anterior Cruciate Ligament (ACL) injuries are among the most commonly occurring and disabling of athletic injuries. They affect approximately 80,000 persons annually at a cost of one billion dollars[1]. Females are a greater risk of ACL injury than males, with a 4- to 6-fold greater injury risk to female athletes compared to same-sport male athletes[4,5]. The reasons for this are controversial. Contrary to popular opinion, the majority of ACL injuries are the result of non-contact mechanisms; resulting from rapid deceleration and/or 'cutting' without physical collision with another participant. Certain individuals, male and female, appear to be at risk for recurrent tears (re-tearing a previously reconstructed ACL) or bilateral tears (tearing the opposite-leg ACL) with continued participation. To prevent ACL injuries, it is necessary to better

identify factors that put individuals at greater risk for ACL injury, re-injury, or bilateral injuries, and to understand more completely the mechanisms of an ACL tear.

Clinical Question

Is the shape of the lateral knee articulating surface (proximal tibial plateau and distal femur) different in persons who suffer ACL injuries, and do gender differences in this shape help to explain the female predisposition for anterior cruciate ligament injury in an age- and activity-matched population? We hypothesized that the females would have a relatively shorter tibial plateau and smaller radius of curvature than males, and that patients who were 'at risk' (suffered bilateral or recurrent ACL tears) would demonstrate more pronounced geometric differences.

Methods

MRI images in 185 age- and activity-matched uninjured and ACL-injured patients presenting to the University of Washington Sports Medicine Clinic were evaluated. These were divided into the following groups for comparison:

- Uninjured (25F/36M): no history of ACL injury or knee instability
- Unilateral ACL (uACL; 26F/43M): persons who were treated for a single non-contact ACL injury and have not had a reinjury or other-sided injury
- Bilateral ACL (bACL; 22F/23M): persons who've sustained non-contact ACL injuries in both knees (separate injuries)
- Revision ACL (rACL; 9F/4M): persons who sustained a non-contact ACL and subsequently re-tore their reconstructed graft via a non-contact mechanism

After the collection of injury data and the assignment of the MRI's to

GENDER/ INJURY GROUP	FAP (cm)	TPAP (cm)	FAP:TPAP (length ratio)	FAP:TPAP p value (uninj vs injury group)	FAP:TPAP p value (female vs male)
F uninjured	6.49	2.97	2.21		
F uni ACL	6.41	2.83	2.21	0.8	
F biat ACL	5.50	2.87	2.23	NS	
F reivs ACL	6.29	2.91	2.18	NS	
M uninjured	7.21	3.55	2.05		0.0008
M uni ACL	7.13	3.31	2.19	0.001	0.61
M biat ACL	7.08	3.28	2.21	0.006	0.69
M reivs ACL	7.38	3.62	2.12	0.458	0.50

Table 1: Length relationships in the lateral tibiofemoral compartment in uninjured and ACL-injured males and females. FAP = Femoral A-P Length, TPAP = Tibial Plateau A-P Length, FAP:TPAP = ratio of femoral to tibial length.

GENDER/ INJURY GROUP	TPr (cm)	Fr (cm)	TPr:Fr (radius ratio)	p value (uninj vs injury group)	p value (female vs male)
F Uninjured	3.32	2.38	0.73		
F uni ACL	3.19	2.24	0.72	0.719	
F biat ACL	3.12	2.30	0.77	0.201	
F reivs ACL	2.99	2.17	0.78	0.741	
M Uninjured	4.11	2.67	0.68		0.089
M uni ACL	3.60	2.56	0.74	0.019	0.41
M biat ACL	3.45	2.52	0.78	0.018	0.85
M reivs ACL	3.27	2.68	0.83	0.016	0.24

Table 2: Radius of curvature relationships in the lateral tibiofemoral compartment in uninjured and ACL-injured males and females. TPr = Tibial Plateau Radius of Curvature, Fr = Femoral/Fibonacci Radius of Curvature, TPr:Fr = ratio of tibial plateau and femoral radii of curvature.

groups, 3 separate observers, blinded to group and gender analyzed images of the middle weight-bearing sagittal plane of the joint using specialized software (OsiriX v3.6.1) for the following variables (Figure 1):

- Tibial Plateau Radius of Curvature

(TPr): The radius of a perfect circle circumscribed on the weight-bearing articular surface of the tibial plateau.

- Distal Femoral Radius of Curvature (Fr): The radius of a logarithmic curve (Fibonacci series) that maps the shape of the lateral femoral condyle articular

surface taken at the point of contact with the tibial plateau.

- Lateral Tibial Plateau Anterior-to-Posterior Length (TPAP): the length of the joint surface of the distal femur.
- Distal Femoral Anterior-to-Posterior Length (FAP): the length of the joint surface of the proximal tibia.
- To eliminate bias due to individual variations in size, the ratios of Fr:TPAP and FAP:TPAP were utilized.

Data from 3 blinded observers was averaged and statistical analysis was performed using Student's T-Test. Additional statistical analysis, power analysis, and assessment of odds ratio will be available in the published version of this manuscript.

Results:

Tibial Plateau/Distal Femur Length (Table 1)

- Significant differences in the relative length of the tibial plateau and distal femur between males and females.
- Uninjured females demonstrated a relatively shorter plateau compared to femur length (higher FAP:TPAP ratio) than uninjured males.
- The plateau length relative to femoral length was not significantly different between ACL-injured males

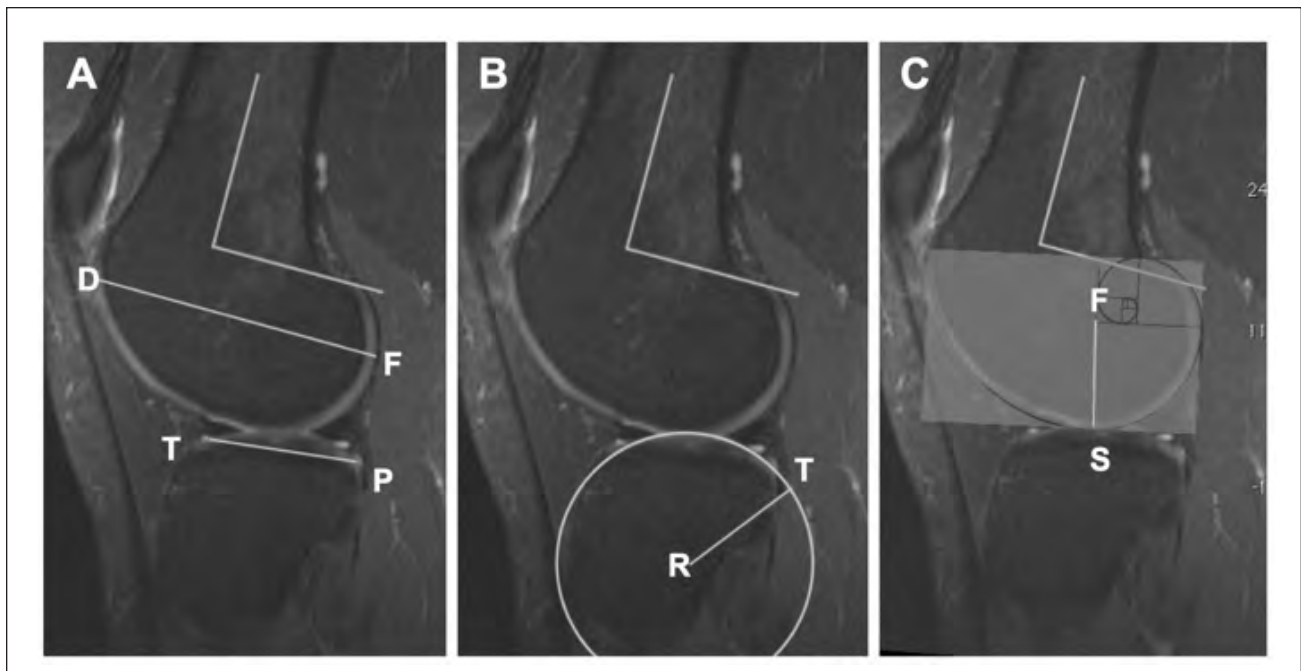


Figure 1: Mid-weight bearing sagittal plane measurements of the lateral tibial femoral compartment. (A) Line D-F represents the Femoral Antero-Posterior length (FAP). Line T-P represents the Tibial Plateau Antero-posterior length (TPAP). (B) A circle is circumscribed to follow the articular cartilage surface of the tibial plateau. The radius of this circle (R-T) represents the Tibial Plateau Radius of Curvature (TPr). (C) The Fibonacci series template is circumscribed over the distal femoral articular surface. A measurement is made of the radius of the Fibonacci series that best corresponds to the weight-bearing region of the knee in flexion. This radius line (F-S) represents the Femoral/Fibonacci radius of curvature (Fr).

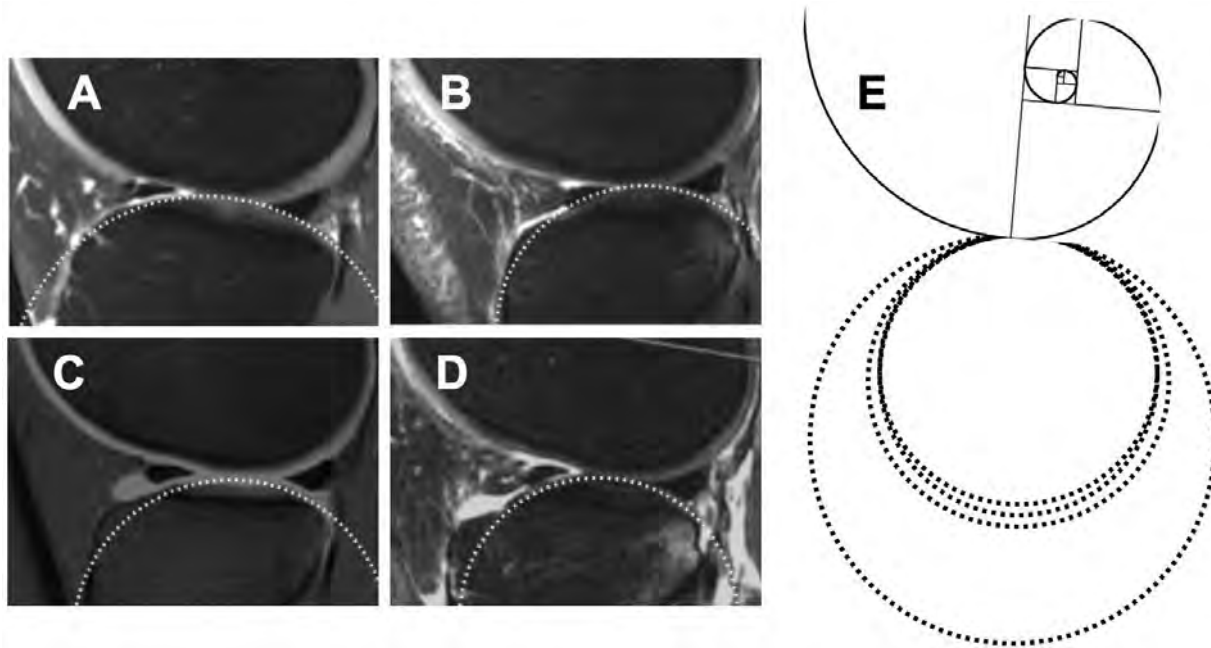


Figure 2: (Left) Comparison of tibial plateau geometric curvature (dashed white line) in a typical uninjured male (A), ACL-injured male (B), uninjured female (C), and ACL-injured female (D). In images A-D, individual size differences can be negated by standardizing the distal femoral anterior to posterior length to a uniform Fibonacci logarithmic curve (E). (Right) The Fibonacci curve sits atop the 4 superimposed plateau curvatures. Note that the largest curvature (representing the uninjured male) is remarkably different than the curves of the uninjured female, ACL-injured female, and ACL-injured male.

and uninjured females.

- No significant differences existed between injury-matched (uACL, bACL, or rACL) males and injury-matched females.

- Females, uninjured or injured, demonstrated very little variability in the relative length of the tibial plateau.

- Conversely, uninjured males had a significantly longer relative tibial plateau length (smaller FAP:TPAP ratio) than uACL- and bACL-injured males.

Tibial and Femoral Radius of Curvature (Table 2)

- Comparison of TPr:Fr ratios indicated that the convexity of the lateral tibial plateau was significantly steeper (small radius of curvature relative to the femur) in uninjured or unilateral-ACL-injured females compared to their male counterparts.

- No significant gender differences in the relative plateau radius (TPr:Fr) were observed in persons who suffered bilateral ACL injuries or recurrent ACL injuries.

- The relative plateau radius of curvature fell within a very narrow range in females regardless of whether they were uninjured or injured (uACL, bACL, rACL).

- Conversely, uninjured males had statistically-significantly smaller TPr:Fr ratios (a relatively larger lateral tibial

plateau compared to the femur) than injured males (uACL, bACL, rACL).

- When comparing injury-matched females and males, there were no statistically-significant differences in convexity of the tibial plateau relative to the femur.

Discussion

- Our results indicate that there is a characteristic geometry that may be a relative risk factor for non-contact ACL injury, bilateral injury, and recurrent injury.

- This geometry is more commonly found in persons of the female gender, and thus could at least partially explain the higher female predilection for ACL injuries (Figure 2).

- Males who suffer ACL injuries demonstrate tibial geometry characterized by a shorter tibial plateau relative to the distal femur with steep convexity (small radius of curvature) when compared to uninjured males. Therefore, this geometry may represent an identifiable risk factor for ACL injury in males.

- Strengths: We have identified a novel means of measurement and characterization of the tibial plateau (mid-sagittal radius of curvature) and distal femur (Fibonacci radius of curvature) and studied it in an age- and

activity-matched cohort of subjects (Figure 1).

- Limitations: This is a retrospective study. The power of the study is limited in the revision (rACL) population due to low numbers.

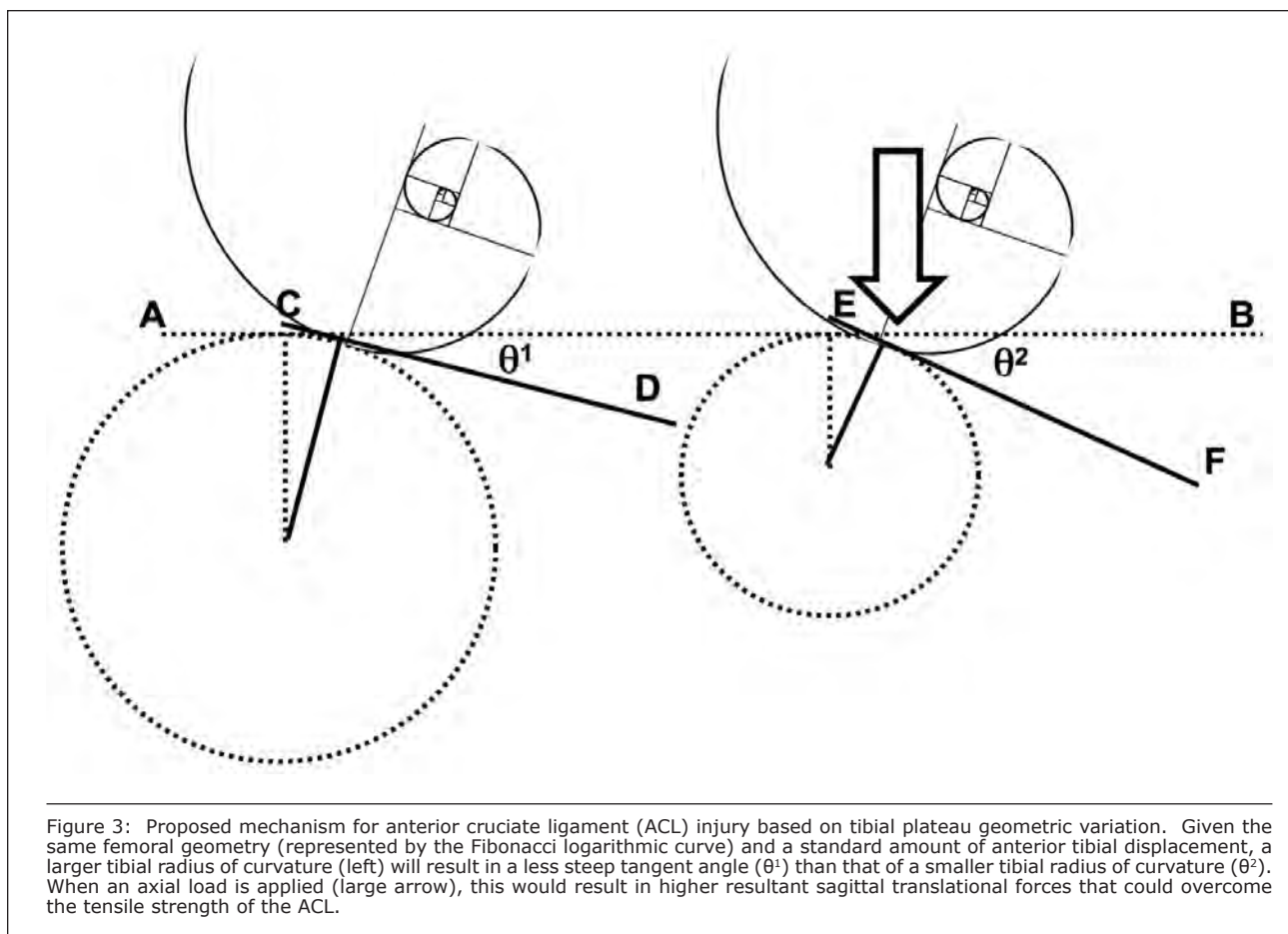
- A lateral knee architecture with a shorter, more convex tibial bearing surface may be inherently less stable to translational and rotational forces. In theory, axial loading of a translated, internally rotated joint with this geometry could lead to conditions that exceed the ACL tensile strength, and represents a potential mechanism for non-contact ACL tears (Figure 3).

- Prospective clinical evaluation and cadaveric biomechanical evaluation are planned to further evaluate the role of lateral tibial/femoral geometry and the risk of ACL injuries.

Summary And Conclusion

- Persons who suffer non-contact anterior cruciate ligament (ACL) injuries or re-injuries appear to share a common tibial geometry that may put them at risk

- The female predilection for ACL injuries may be partially explained by the fact that this geometry may be more common in all females, but uncommon in uninjured males.



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Adult Reconstructive Surgery Service

Osteoarthritis affects more people than any other joint disease and is the most common cause of long-term disability in most populations over the age of 65 years. A report from the Third National Health and Nutrition Examination Survey estimated that 37.4% of adults in the United States who are 60 years of age or older have radiographic evidence of the condition. Although osteoarthritis is not a life-threatening disease, the morbidity associated with this condition is considerable; 80% of patients with osteoarthritis have limitation of movement, and 25% have difficulty performing major activities of daily living. The economic burden of osteoarthritis may exceed \$60 billion per year in the United States.

Although osteoarthritis is most commonly managed without surgery, some patients have severe pain and limitations of their daily activities; for these patients, joint replacement surgery is often the intervention of choice. The knee and hip are the large joints that are most commonly affected by arthritis; according to 2009 statistics from the National Institute of Arthritis and Musculoskeletal and Skin Diseases, nearly three-quarters of a million people will get a knee or hip replacement each year in the United States.

The Joint Replacement faculty at the University of Washington Medical Center are internationally known for their contributions to the science of surgery for arthritis, and their discoveries continue to shape the field. Their clinical practices cover the waterfront in terms of services related to patients with arthritis, post-traumatic joint conditions, failed joint replacements, and bone tumors. The two full-time UWMC joint replacement surgeons (Paul A. Manner, MD and Seth S. Leopold, MD) have particular interest and expertise in minimally-invasive surgical techniques for hip replacement and knee replacement.

Howard A. Chansky, MD (Professor) is engaged in an ongoing research program investigating clinical outcomes of hip fracture surgery in a large population of US veterans. Dr. Chansky also has both research and clinical



Paul A. Manner, M.D. was promoted to Associate Professor.

interest in the treatment of long-bone fractures around joint replacements.

Ernest U. Conrad, III, MD (Professor) comes at the specialty from his background as a musculoskeletal tumor surgeon; his research focuses on the durability of and surgical alternatives to the special kinds of implants required by patients who have lost large segments of bone to malignant tumors. Most recently, Dr. Conrad has published a series comparing condyle-sparing allograft surgery to large-segment joint replacements in patients who have malignant tumors about the knee; the results of this approach to using bone grafts appear very promising and truly represent a limb-sparing approach to a very desperate problem.

Seth S. Leopold, MD (Professor) focuses his research and clinical interests on minimally-invasive total knee arthroplasty. He also engages in editorial work for a number of national and international journals, and for the last 10 years has maintained a research program on unusual sources of bias in the peer-reviewed literature. Dr. Leopold was the principal investigator on a project about treating infected hip replacements.

Paul A. Manner, MD (Associate Professor) has a national reputation for both his clinical work and his research related to minimally-invasive surgery for hip replacements. His research on

this subject pertains both to the clinical outcomes and medical-economic benefits associated with this kind of surgery. In addition to his ongoing studies in both of those areas, Dr. Manner was a co-investigator on a study that used a very patient-centered approach to surgical decision-making. He also maintains a basic science laboratory on the subject of cartilage biology.

Seth S. Leopold, MD
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ESET Histone Methyltransferase is Essential for Chondrogenic Differentiation

Abstract: The ESET protein, a histone methyltransferase, is expressed in early hypertrophic chondrocytes during embryo development. To investigate the effects of ESET on Sox9 protein during chondrogenesis, we established a doxycycline-inducible siRNA system to achieve sustained ESET knockdown in chondroprogenitor cells. While down-regulation of ESET did not affect expression of Sox9 at the protein level, these cells no longer possessed the ability to undergo chondrogenic differentiation in response to growth factor treatment. In addition, we observed that Sox9 target genes such as Col2 were down-regulated together with ESET knockdown. Through chromatin immunoprecipitation assay, we found that in cells with ESET knockdown, Sox9 was unable to gain access to Col2 enhancer region. Taken together, these findings suggest that ESET histone methyltransferase is required for binding of Sox9 to its target sequence and is essential for differentiation of chondrogenic cells.

Introduction

The process of chondrocyte differentiation and cartilage formation is controlled by important transcription factors such as Sox9 [1]. Even though transcription factors such as Sox9 are known to be critical to the activation of chondrogenic genes, a fundamental question in cartilage biology is how these transcription factors gain access to their target genes within specific chromatin regions. Chromatin is the complex combination of DNA and proteins that makes up chromosomes. Chromatin accessibility can vary during development, regulates gene expression and is determined by enzymatic modifications of histone proteins. To investigate how histone modifications regulate differentiation of chondrogenic cells, we have focused on a histone methyltransferase discovered by our laboratory and named ESET. ESET methylates lysine 9 residue within histone H3 [2]. Here we show that ESET is transiently up-regulated during chondrogenesis in mouse embryos. To investigate the

effects of ESET on Sox9 protein during chondrogenesis, we established a doxycycline-inducible siRNA system to achieve sustained ESET knockdown in chondrogenic cells.

Methods

Inducible ESET siRNA knockdown: Inducible siRNA knockdown of ESET was achieved using the pSLIK (single lentivector for inducible knockdown) platform. In this system, the ESET microRNA-like short hairpin is inserted downstream of the green fluorescence protein (GFP) to allow concomitant expression of a heterologous mRNA during tetracycline-dependent siRNA knockdown.

Chromatin immunoprecipitation (CHIP) assay: Cross-linked chromatin from 1×10^7 ATDC5 cells were collected and subjected to sonication to shear DNA into 500-1000 base pairs. Antibody binding was carried out overnight with 200 μ g of chromatin, 6 μ g of rabbit anti-Sox9 antibody, 1 μ g of mouse anti-RNA polymerase II or normal mouse IgG, and 60 μ l of pre-blocked protein

G-agarose beads. After extensive washes with buffers from the EZ Chip™ kit (Millipore), bound DNA was eluted from the beads, cross-linking was reversed by incubation at 65°C overnight, DNA was purified using the spin column and finally collected in 50 μ l elution buffer for PCR amplification with specific primers.

Results

Immunohistostaining of mouse embryos revealed that ESET protein is most abundant in pre- and early-hypertrophic chondrocytes found in developing vertebrae, growth plates of long bones and digits (Figure 1). High levels of ESET protein were also detected in newly formed bones and in the skins of mouse embryos.

We used a lentiviral vector to achieve doxycycline-induced siRNA knockdown of ESET in ATDCs chondroprogenitor cells. Doxycycline led to a significant and specific reduction of ESET protein in cells harboring specific siRNAs but Sox9 protein was not affected (Figure 2A). This efficient siRNA knockdown

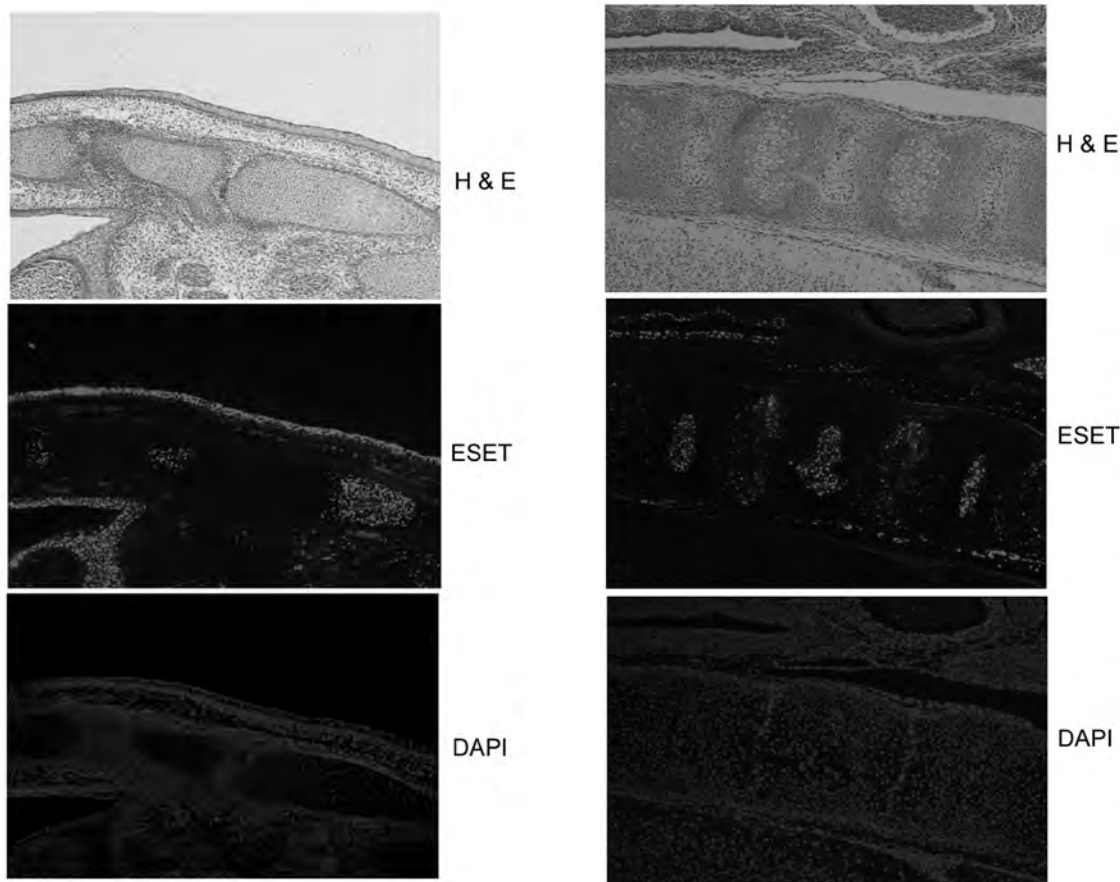


Figure 1 A: Expression of ESET histone methyltransferase in early hypertrophic cells. Growth plates of digits from an E16.5 mouse embryo were stained with hematoxylin–eosin (H &E) to show cell morphology (top panel), with an anti-ESET antibody to show ESET expression (middle panel), or with DAPI to show nuclei (bottom panel).

Figure 1 B: Expression of ESET histone methyltransferase in early hypertrophic cells. Vertebrae from an E16.5 mouse embryo were stained with hematoxylin–eosin (H &E) (top panel), with an anti-ESET antibody (middle panel), or with DAPI (bottom panel).

of ESET could be sustained for as long as doxycycline was present in the medium. Using RT-PCR, we found that siRNA knockdown of ESET resulted in down-regulation of chondrocyte specific genes such as Col2 (Figure 2B). After 35 days of culture in insulin, Alcian blue staining revealed a cartilage-like extracellular matrix by cells expressing normal levels of ESET but not by those with doxycycline-induced ESET knockdown.

ESET knockdown decreased expression of the Col2 gene without affecting Sox9 protein levels. To investigate whether transactivation of Col2 by Sox9 normally requires ESET protein in chondrocytes, we developed a system using ATDC5 cells in which Sox9-induced activation of the mouse Col2 promoter-enhancer is indicated by expression of easily detectable luciferase. In cells with normal levels

of ESET protein, co-expression of Sox9 increased the luciferase activity by more than 100x fold. In cells with doxycycline-induced ESET knockdown, the transactivating ability of Sox9 was decreased by as much as 75%. This result prompted us to carry out an *in vivo* study referred to as a ChIP assay to assess the ability of Sox9 protein to bind to its natural target sequence within the enhancer region of the Col2 gene. While Sox9 binds directly to Col2 enhancer element in ATDC5 cells with normal levels of ESET, Sox9 binding to the Col2 enhancer element is significantly diminished in cells with lower levels of ESET protein. To confirm that these findings are not limited to ATDC5 cells, we also carried out the experiments in mesenchymal stem cells and obtained similar results.

Discussion

Epigenetic regulation of gene expression plays an increasingly recognized role in the control of differentiation and development. As a histone methyltransferase known to be associated with euchromatic regions, a normal level of ESET protein appears to be required for the maintenance of chromatin structure that permits access to Sox9 protein. ESET expression is most abundant in pre- and early-hypertrophic chondrocytes and partly overlaps with expression of HDAC4, a histone modification enzyme that is involved in chondrocyte hypertrophy [3]. Since ESET is known to interact with a variety of DNA and histone modification enzymes including several HDACs [4], it will be interesting to examine whether HDAC4 functionally interacts with ESET to ensure an orderly transition

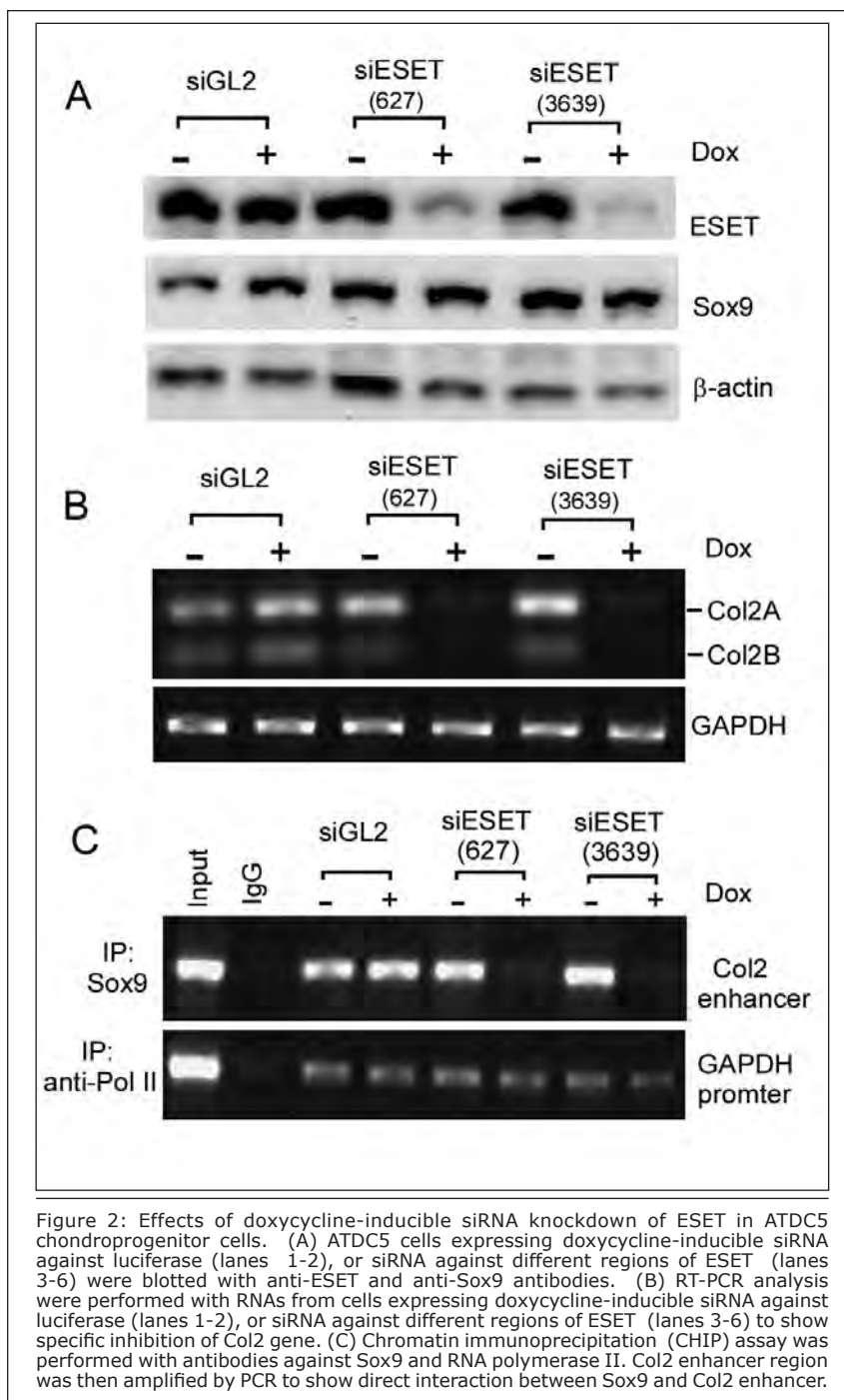


Figure 2: Effects of doxycycline-inducible siRNA knockdown of ESET in ATDC5 chondroprogenitor cells. (A) ATDC5 cells expressing doxycycline-inducible siRNA against luciferase (lanes 1-2), or siRNA against different regions of ESET (lanes 3-6) were blotted with anti-ESET and anti-Sox9 antibodies. (B) RT-PCR analysis were performed with RNAs from cells expressing doxycycline-inducible siRNA against luciferase (lanes 1-2), or siRNA against different regions of ESET (lanes 3-6) to show specific inhibition of Col2 gene. (C) Chromatin immunoprecipitation (ChIP) assay was performed with antibodies against Sox9 and RNA polymerase II. Col2 enhancer region was then amplified by PCR to show direct interaction between Sox9 and Col2 enhancer.

from pre-hypertrophic chondrocytes to hypertrophic chondrocytes during skeletal development. Ultimately, using tissue regeneration technology to treat diseases such as arthritis will require detailed understanding of molecular pathways of natural tissue development. We believe that ESET is an important component of these pathways.

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Two-Incision Minimally Invasive THA Reduces Costs and Length of Stay Without Increased Complications

Abstract: 50 consecutive patients undergoing two-incision total hip arthroplasty were matched by age, gender, BMI, and comorbidity to patients undergoing a standard lateral approach. Hospital costs and charges were compared, along with length of stay, component position, and complication rates. Component position and complication rates were identical for the two groups; however, hospital costs and charges were significantly lower for the two-incision group, as was length of stay.

Study Rationale and Context:

Minimally invasive techniques for total joint arthroplasty have been widely publicized and criticized with little data to support or refute their use. While anecdotal evidence suggests that length of stay (LOS) and hospital costs can be reduced with minimally invasive techniques, few studies have been published. Frequent criticism of these studies centers on preferential selection of optimal patients, who would do well with any technique.

Objective/aim (or clinical question):

We hypothesized that the apparent savings in cost and reduced LOS, attributed to use of minimally invasive techniques, result purely from patient selection.

Material and Methods:

Medical records, hospital charges and costs for consecutive patients undergoing two-incision minimally invasive total hip arthroplasty (MIS) between September 2006 and September 2008 were obtained. Records and hospital charges and costs for patients undergoing THA via a standard approach (STD) in the same time period were reviewed to

find patients who matched the two-incision patients for age, gender, BMI and medical comorbidity. Patients for whom a match could not be made were excluded.

Results:

Mean LOS for MIS pts was 2.42 days compared to 3.64 days for STD. All MIS patients were discharged home; only 43 of 50 STD patients were discharged home.

Total, direct and indirect, OR, and therapy costs were all significantly lower for MIS than for STD approaches. For lab, materials management, and pharmacy, MIS and STD procedures had equal costs. The only cost center where STD procedures were less costly was imaging. Complication rates and component position were no different.

Discussion:

- Our initial hypothesis that matching of patients by age, gender, BMI and comorbidity would eliminate any difference in cost and length of stay between patient groups was not proved.

- We found strong support for a significant difference, in keeping with our alternate hypothesis that MIS procedures would be less costly than

traditional procedures.

- In every instance, with the exception of imaging, costs associated with MIS procedures were equal or lower than the costs associated with traditional procedures.

- Analysis showed that total costs, direct costs, indirect costs, OR costs, and therapy costs were lower for MIS procedures than for traditional or standard approaches.

- For laboratory, materials management, and pharmacy, MIS and traditional procedures had equal costs.

- The only cost center where traditional procedures were less costly was imaging, since the MIS procedures required fluoroscopic imaging in the OR.

Summary and Conclusion:

Not every patient is a candidate for minimally invasive arthroplasty, and not every surgeon should perform these procedures. However, hospital costs and length of stay can be significantly reduced in appropriately selected patients in the proper setting.

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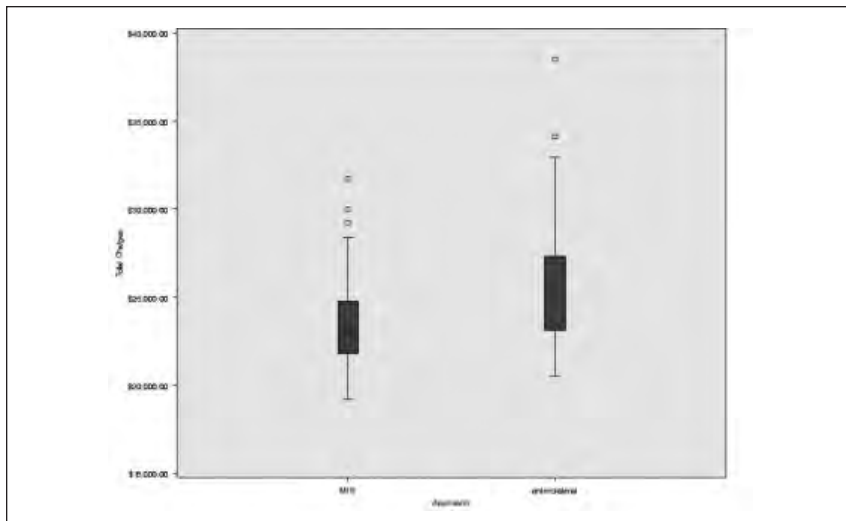


Figure 1: Total charges.

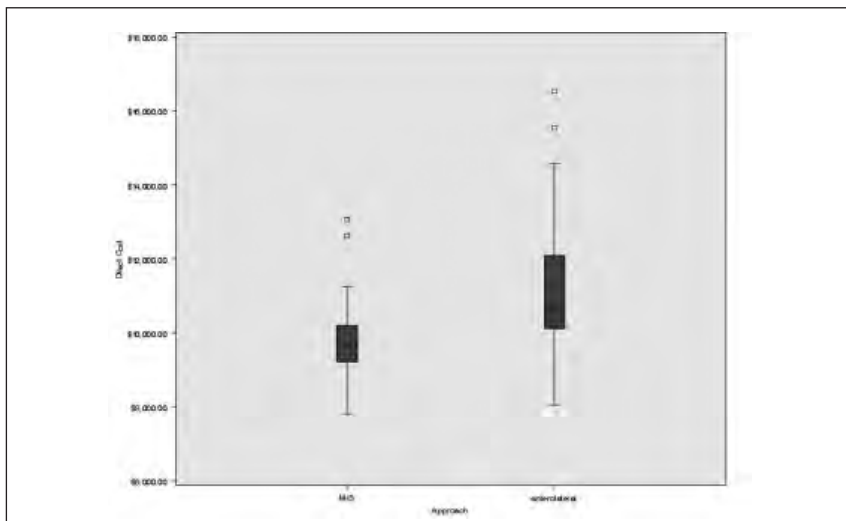


Figure 2: Direct costs.

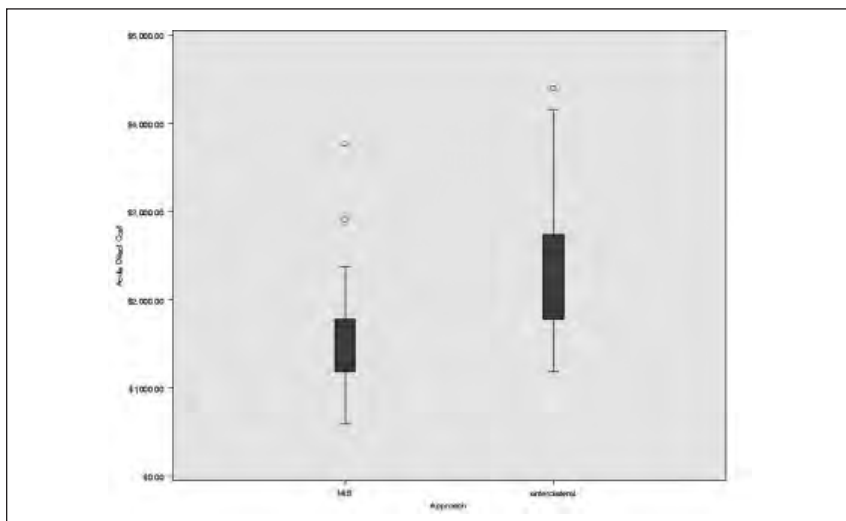


Figure 3: Acute care costs.

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Comparison of One vs Two-Stage Revision for the Infected Total Hip Arthroplasty: A Markov Expected-Utility Decision Analysis

Abstract: Two-stage revisions for infected total hip arthroplasty (THA) have lower re-infection rates than single-stage direct exchange revisions; however, the two-stage approach may result in increased, but poorly quantified, surgical morbidity. Using a decision analysis we compared the single-stage, direct-exchange to the two-stage revision for treating the infected THA by examining the health states experienced by patients treated with each approach, as well as utility values reported for those health states. The Markov model favored direct-exchange revision over the two-stage approach.

Study Rationale and Context:

Although the rate of infection after primary THA is under one percent, the volume of THAs performed in this country still results in many patients whose hip replacements become infected. Optimal treatment of these infections would restore a patient's health and function rapidly with as little risk as possible.

Objective/aim (or clinical question):

The present study compares the direct-exchange treatment of the infected THA with the two-stage revision using a technique called expected-utility decision analysis. We tested the hypothesis that the two-stage revision is the superior treatment for the infected THA.

Material and Methods:

The approach taken in decision analysis is to have patients assign utility values to possible outcomes (the health states that can arise in the course of treatment of the infected THA), to use a systematic review of the literature to determine the relative likelihoods of each of those outcomes occurring, and then to calculate the overall "merit" of a treatment.

The utility values for the health states represented in the model were attained from a previously published analysis of patient- and surgeon-derived responses. In brief, the utility paper involved designing surveys for both outpatients and orthopedic surgeons eliciting preference measures based on trade-offs between impaired health versus full health with shortened life, as well as between two impaired temporary health states. In this study, we found that patients are significantly less willing to trade length of life for quality of life than are surgeons.

The states presented in this model as well as the probabilities of each state were derived from the available medical literature. We reviewed 4048 articles, and found eleven appropriate articles involving a two-stage protocol and eight involving a direct-exchange protocol.

A Markov model was completed with the patient-derived utility values and then again using the surgeon-derived utility values to compare the merit of each treatment.

Results:

For the two-stage arm probabilities were calculated as follows: success (0.782), re-infection (0.065),

mechanical complication (0.093), death (0.025), second stage not completed (0.034). In contrast, direct-exchange arm probabilities were found to be: success (0.719), re-infection (0.123), mechanical complication (0.153), death (0.0052), second stage not completed (0.034). The analysis determined the direct-exchange protocol to be the dominant strategy regardless of whether patient- or surgeon-derived utilities were applied, and regardless of whether a one- or ten-year horizon was considered. Final payoffs favored the direct-exchange over the two-stage model for both the one year model and the ten year model. In order to achieve equivalence between the approaches by varying the death rates, the probability of death had to double in the direct-exchange approach. Equivalence on the basis of re-infection occurred only when infection rates in the direct-exchange were five times higher than reported.

Discussion:

- Infection after THA is rare but causes tremendous morbidity and high cost.
- Optimal treatment of the infected THA is unclear, recommendations differs across the developed world.

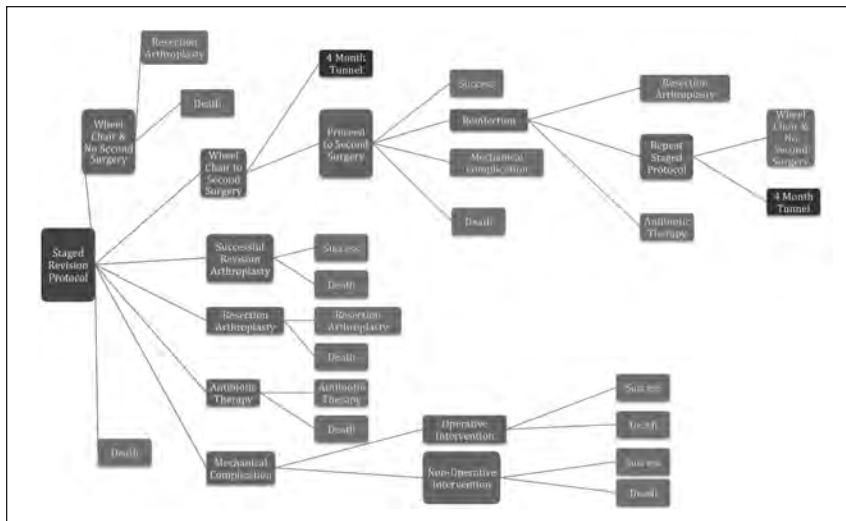


Figure 1: Example of decision tree for the staged revision arm. It is fairly complex as we attempted to approximate real clinical practice as closely as possible.

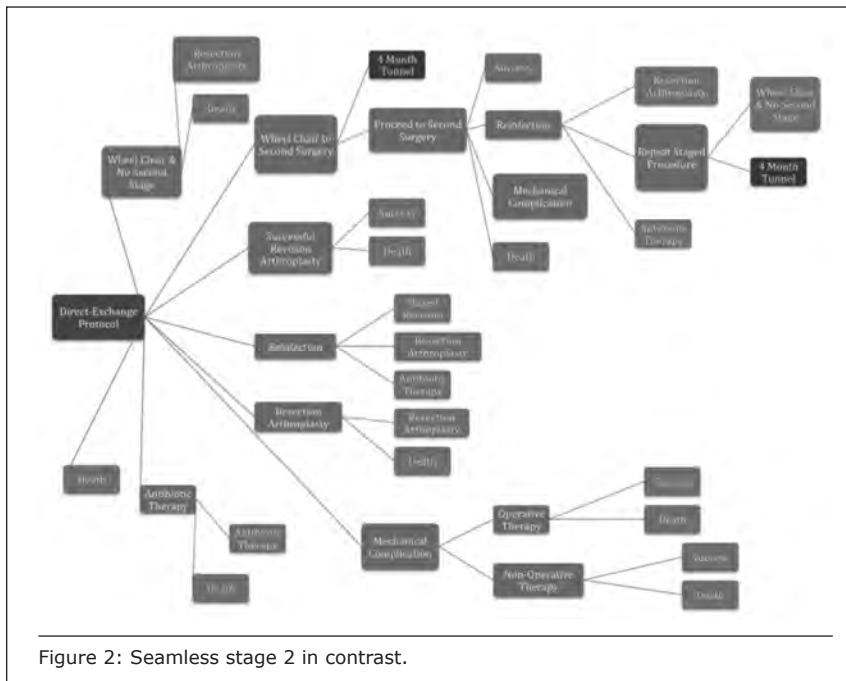


Figure 2: Seamless stage 2 in contrast.

There has been a widespread reluctance to perform a single step exchange surgery of an infected hip arthroplasty due to the fear of not being able to clear infectious tissues out of the body adequately. Therefore a two-stage approach – consisting of removal of the implant, resection of infected tissues, placement of antibiotic carriers such as Antibiotic beads, and then eventually replacement of the joint arthroplasty - after some time period - has been widely recommended. However the transition time is one of significant down time for affected patients – who are usually unable to bear weight on their affected limb. The ventual

revision surgery can be quite complex due to extensive scarring. Hence, the single stage exchange surgery with adequate surgical debridement and placement of a new implant has found some proponents as well.

- This study used a time-trade-off technique, the 'gold standard,' to assess utility value for both patients and surgeons.

- Limitations include the lack of randomized controlled trials in the existing literature on which to base decision-making, the inconsistency of the existing literature in reporting complications, and the inherent limitations in applying a model to the

real world.

- We were surprised by the strength of dominance of the direct-exchange approach, as this has not been our clinical practice.

- The treatment selected – whether single-stage direct exchange or two-stage revision THA – must therefore find a safe and an appropriate balance between outcome and overall risk, not just the risk of persistent infection.

- Further research should emphasize the use of decision analysis to allow clinicians to make informed choices, and provide realistic assessment of risks and benefits.

Summary and Conclusion:

Decision analysis was used to evaluate the risks of two different approaches to treatment of infected total hip arthroplasty, comparing single-stage direct exchange to a staged procedure. Although we expected that the staged approach would be superior, our analysis showed that the single-stage procedure resulted in less morbidity, at the cost of a higher infection rate.

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Ewing's Sarcoma: Tissue-Specific Expression of EWS-Fli1 in Transgenic Mice

Abstract: Ewing's sarcoma is a potentially fatal cancer of bone that primarily affects children and young adults. The genetic mutation that causes Ewing's sarcoma has been known for many years but this knowledge has not yet resulted in more effective treatments. Our laboratory has been active in understanding how the mutation actually functions and in developing molecular strategies to treat Ewing's sarcoma by inhibiting the causative mutation. In this report we describe our early attempts to develop an animal model that accurately models the development of Ewing's sarcoma in humans. Ideally this will permit us to study different treatment strategies.

Study Rationale

While the EWS-Fli1 chimeric fusion protein is the hallmark of Ewing's family tumors, it has been difficult to recapitulate the tumor phenotype in vitro by forced expression of the EWS-Fli1. Our laboratory pioneered an in vitro approach using RNA interference to study Ewing's sarcoma cell lines in which EWS-Fli1 expression was knocked down. This permitted us to study EWS/Fli1 in actual Ewing's cells as opposed to in surrogate non-Ewing's cells with forced expression of the fusion protein. However, ideally Ewing's sarcoma must be studied in an animal as opposed to an in vitro model.

To study the functions of EWS-Fli1 in vivo, we initially focused on xenografts of Ewing's sarcoma in immune-deficient mice. As the xenograft experiment was in progress, we also explored other possibilities of expressing EWS-Fli1 in transgenic mice with the goal of developing a more realistic model of tumor development. It has been known for some time that EWS-Fli1 is toxic to most primary mouse cells and thus lethal in embryonic mice. We reasoned that in order to express EWS-Fli1 in transgenic mice, the fusion

gene has to be silenced until after embryonic development. The approach we chose uses conditional expression of the EWS-Fli1 allele with the LoxP-Cre system. In this system EWS-Fli1 expression is normally silenced in transgenic mice thus permitting normal development. Mating the transgenic mice with Cre mice activates EWS-Fli1 expression. The Cre-expressing mouse strain will specify the tissue or cell type in which the EWS-Fli1 transgene is expressed.

We have chosen the type II fusion for our study since there is evidence that Ewing's sarcoma patients with this fusion subtype have a worse clinical outcome than those with the type I fusion (Logan et al., 2002). In addition, two previous transgenic studies have used the type I EWS-Fli1 fusion gene and both have failed to generate sarcoma when expressing the fusion gene alone (Lin et al., 2008; Torchia et al., 2007). We hypothesize that expression of type II EWS-Fli1 fusion gene in transgenic mice may result in a more overt tumor phenotype.

Methods:

Generation of mice for cell type- or

tissue-specific expression of type II EWS-Fli1:

We RT-PCR amplified type II EWS-Fli1 transcript from SK-ES cells and sub-cloned the cDNA into the pCLE2 vector (Lin et al., 2008) to generate pCLE2-EWS-Fli1 (Figure 1A). Even though the GFP gene and the EWS-Fli1 fusion gene can be transcribed as a single mRNA by the chicken β -actin promoter in this construct, only GFP protein is expressed since the translation will end at the stop codon before the EWS-Fli1 sequence.

Results:

To confirm activation of EWS-Fli1 after Cre-mediated deletion of the GFP gene, we co-transfected pCLE2-EWS-Fli1 and pEF1 α -Cre into 293T cells. Western blotting indicated that the EWS-Fli1 fusion protein was indeed only detectable with co-expression of the Cre recombinase (Figure 1B). When the transgene DNA cassette from pCLE2-EWS-Fli1 was used for pronuclear microinjection to generate transgenic animals, we obtained 11 founders that were confirmed by genotyping to carry the transgene cassette. Offspring from these founders are developmentally

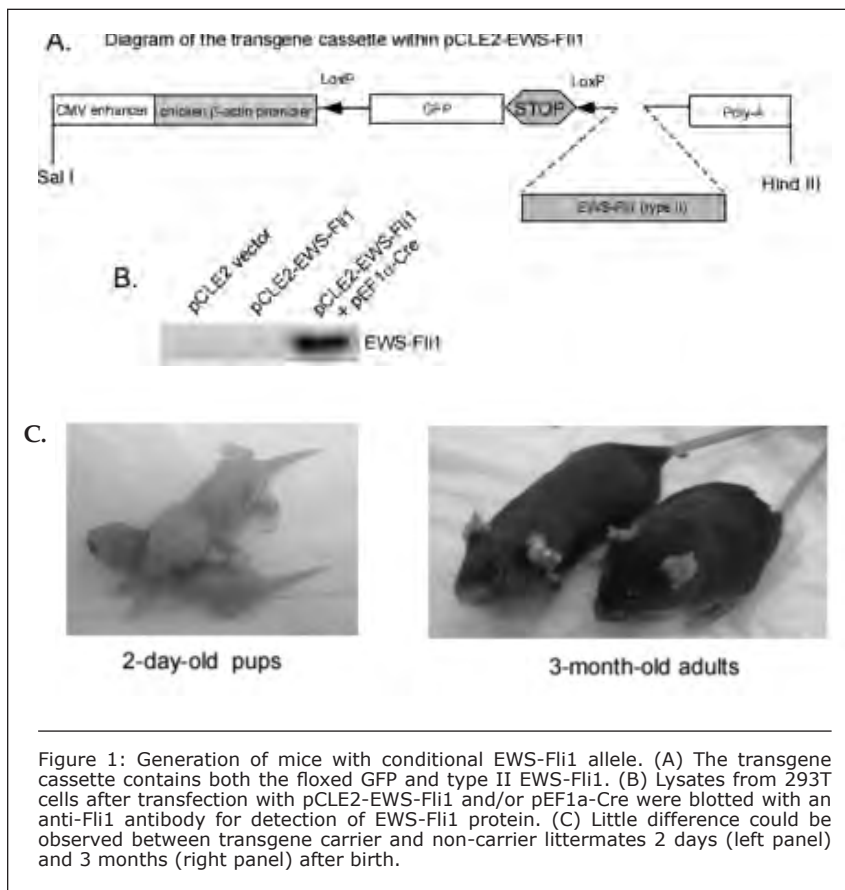


Figure 1: Generation of mice with conditional EWS-Fli1 allele. (A) The transgene cassette contains both the floxed GFP and type II EWS-Fli1. (B) Lysates from 293T cells after transfection with pCLE2-EWS-Fli1 and/or pEF1a-Cre were blotted with an anti-Fli1 antibody for detection of EWS-Fli1 protein. (C) Little difference could be observed between transgene carrier and non-carrier littermates 2 days (left panel) and 3 months (right panel) after birth.

normal, fertile, and not prone to tumor formation (Figure 1C). Thus, the conditional EWS-Fli1 allele is inactive in these transgenic animals and will be activated in a cell type- or tissue-specific manner in offspring after mating with various Cre mice.

Discussion and Future Plans:

Since there is substantial evidence that Ewing's sarcoma originates from cells of mesenchymal origin, in our initial experiment we plan to mate the Prrx1-Cre strain with EWS-Fli1 transgenic mice. Prrx1-Cre mice express Cre recombinase under the control of the paired related homeobox 1 (Prrx1) enhancer. When crossed with a strain containing a loxP site-flanked sequence of interest, Cre-mediated recombination in the offspring results in deletion of the flanked sequence in early limb bud mesenchyme and craniofacial mesenchyme while sparing the central vital organs. This Cre mouse strain therefore represents an effective tool for specifically expressing a "floxed" EWS/Fli1 transgene specifically in mesenchymal stem cells.

The preponderance of evidence suggests that Ewing's sarcoma

arises from mesenchymal cells but there is also evidence that Ewing's sarcoma might arise from neural cells. This contention is supported by observations that Ewing's sarcoma cells can be forced in vitro to undergo neuronal differentiation, and that EWS-Fli1 can regulate critical genes in neural crest development. In addition, Ewing's cells stain positive for neuron-specific enolase (NSE), a gene that is expressed in neuronal tissues. Mice with Cre expression driven by the NSE promoter are commercially available. Mice hemizygous for this NSE-Cre transgene are viable, fertile, and do not display any gross physical or behavioral abnormalities. These NSE-Cre mice harbor a transgenic insert consisting of the Cre recombinase gene under the control of the promoter region of the rat neuron specific enolase gene. As such, Cre recombinase activity is directed specifically to neuronal cells. After confirmation of Cre-mediated activation of type II EWS-Fli1 in double-positive fetuses, we will investigate whether expression of neuron-specific EWS-Fli1 can lead to tumorigenesis.

Summary and Conclusions:

Transgenic mice with conditional and tissue specific expression of EWS/Fli1 may yield key insights into the molecular pathways that determine development of Ewing's sarcoma. They may also be the best available model to study new therapies for Ewing's sarcoma.

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Trauma

Though it is one of the two primary teaching hospitals of the UW School of Medicine, Harborview began its tenure as a 6-bed medical facility in 1877 as part of the county poor farm. The current campus was built in 1931-33. It is owned by King County but managed by the University of Washington and staffed by full time physician faculty of the UW School of Medicine. It has evolved as an internationally recognized center for patient care, research and teaching in trauma care. Orthopaedics has been a key part of that process from the beginning. Orthopaedics has made a transition from the place where indigent patients receive general orthopedic care to a specialty program covering the orthopedic problems that require special expertise in internal fixation; trauma, spine, hand and foot and ankle. The physical plant expanded again in 2008 with 6 additional ORs and a new inpatient and outpatient facility to alleviate years of overcrowding.

Clinical care

In spite of the enormity of the economic collapse in Washington, the Harborview division is down only slightly in total work performed. While the trauma and hand services have reduced volume paralleling the decrease in the ER volume, the Foot service has held its ground and the spine service has grown. However a combination of a 3% drop in commercial sponsorship and an equal increase in unsponsored care has contributed to a challenging economic environment.

Teaching/research

The faculty and trainees remain committed to academic productivity with a very high profile at the recent annual meeting of the American Academy of Orthopedic Surgery. In addition to primary scientific papers, the HMC faculty staffed Instructional Course Lectures and Symposia in trauma, spine, hand and foot. HMC faculty have published numerous papers in peer reviewed orthopedic journals this academic year including the Journal of Bone and Joint Surgery,



Harborview Medical Center has expanded its specialty services and is continuing its mission through the new Ninth & Jefferson Building (NJB), a 14-story building located across the street from the main medical center. Positioned on the eastern crest of the hill along Ninth Avenue, the building is bordered by Terry, James and Jefferson streets and serves as a new gateway to the Harborview campus. NJB houses expanded specialty services such as, the Eye Institute, Global Health, Institute for Simulation and Interprofessional Studies (ISIS), Neurosciences, Otolaryngology, Orthopaedics, UW Medicine Sports and Spine Center and the Sleep Institute.

Injury, Journal of Neurosurgery and Spine, Spine, Journal of Trauma Journal of Applied Biomechanics, Foot Ankle International, The Journal of Hand surgery, Orthopedics and Clinical Orthopedics and Related Research.

Academic funding

Harborview Medical Center will serve as one of 12 core clinical centers in a newly established Extremity Trauma Clinical Research Consortium. Funded by the Orthopaedic Extremity Trauma Research Program (OETRP) of the Department of Defense for \$18.4 million over 5 years, the Consortium will work closely with several major military treatment centers and the U.S. Army Institute of Surgical Research (USAISR) to conduct multi-center clinical research studies relevant to the treatment and outcomes of severe orthopaedic trauma sustained on the

battlefield. These studies will help establish treatment guidelines and facilitate the translation of new and emerging technologies into clinical practice.

In addition HMC is one of five centers funded by the Department of Veterans affairs to study the comparative effectiveness of ankle arthrodesis and ankle arthroplasty. The other centers are in Michigan, Oregon, Colorado and New Zealand.

Due to the efforts of David Barei, M.D., Associate Professor of Orthopaedics and Sports Medicine, HMC received funding the trauma ACE (Advanced Clinical Experience) Program from OREF Clinician Development Program Trauma Fellowship Grant, The Center for Orthopaedic Trauma Advancement and the OMeGA grant. The grants offset the cost of education and training of orthopedics surgeons seeking advanced training in management of challenging fractures.

National Leadership

M. Brad Henley, M.D., Professor of Orthopedics and Sports Medicine, was appointed as a director of the American Academy of Orthopaedic Surgeons, its political association and as Chair of the Board of Specialty Societies.

Bruce J. Sangeorzan, M.D.



DAVID P. BAREI, M.D.

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MICHAEL J. GARDNER, M.D., SEAN E. NORK, M.D.,
AND STEPHEN K. BENIRSCHKE, M.D.

Complications of Provisionally Stabilized Tibial Pilon Fractures Referred from Outside Institutions

Abstract: The purpose of this retrospective clinical review was to evaluate the treatment course of tibial pilon fractures provisionally stabilized at outside institutions and subsequently transferred, focusing on the incidence and reasons for revision procedures, and subsequent complication rates. Our institutional trauma database demonstrated that of the 758 pilon fractures treated at Harborview Medical Center between January 2000 and September 2007, 39 patients with 42 fractures had a temporizing surgical procedure prior to referral. Almost 95% of patients required revision of their pre-transfer fixation and ultimately incurred a substantially higher complication rate than recent contemporary controls, prompting us to conclude that, when possible, the initial and definitive management of these injuries be performed at the accepting institution.

Study Rationale and Context

Tibial pilon fractures demonstrate significant soft tissue injury, and two-staged protocols promoting soft tissue recovery prior to definitive fixation are favored [1,2]. Using internal fibular fixation and temporary tibial external fixation, the first stage should restore anatomic tibial length, alignment, and rotation. If not, revision procedures may be required, potentially resulting in increased complications.

Clinical Question

Do patients with tibial pilon fractures treated with provisional stabilization at outside facilities and subsequently transferred to our institution for definitive treatment, require revision of their provisional fixation and do they have a higher complication rate than contemporary published controls and those within the same institution?

Methods

Study Design: Retrospective clinical study (IRB approved)

Inclusion Criteria:

All patients sustaining a tibial pilon fracture between January 2000 and September 2007, treated with a temporizing surgical procedure (fibular and/or tibial internal or external fixation), at an outside facility prior to transfer to our institution.

Exclusion Criteria:

Distal tibial pilon fractures treated definitively at outside institutions and referred secondary to complications.

Patient Population and Interventions Compared:

- Thirty-nine consecutive patients with 42 tibial pilon fractures had a temporizing surgical procedure performed at an outside facility prior to transfer.

- During the study, tibial pilon fractures were managed using staged open reduction and internal fixation (ORIF) following these principles:

- Initial Stage:
 - Anatomic fibular ORIF using a posterolateral approach and ankle

joint spanning tibiocalcaneal external fixation.

- Avoidance of Schanz pins within areas of anticipated surgical incisions and definitive implants.

◦ Definitive Stage:

- After soft tissue recovery, anteromedial or anterolateral approach with conventional screw/plate implants to secure anatomic articular reduction, and tibial alignment.

Outcomes and Analysis

- Primary outcome: frequency and rationale for revision of initial stabilization.

- Secondary outcome: deep septic complications.

- Standard techniques were used to compare demographic and injury characteristics, and complication rates between the study and eligible populations.

Results

- Forty of 42 (95%) fractures required revision of the pre-transfer fixation prior to definitive fixation

Reason for Revision	Total Fractures = 42
Tibial Malreduction	33 fractures (83%)
Fibular Malreduction	4 fractures (10%)
Tibial Pins Within Anticipated ORIF Zone	5 fractures (13%)
Loose Tibial Pins	3 fractures (8%)
Foot Pins Requiring Revision*	24 (71%)

Table 1: Reason for Revision and Total Fractures. * pin malposition, talar neck placement, loose, extraosseous placement

	Study Group (n=42)	Institutional Control (n=758)	p-Value
Age	41 years	42 years	p=0.31
C-type Injury	36 (90%)	459 (61%)	p=0011
Open Fracture	22 (52%)	192 (25%)	p=0.00025
Deep Infection	10 (24%)	63 (8%)	p=0.0029

Table 2: Study Group, Institutional Control, and p-value, vs Age, C-type Injury, Open Fracture, and Deep Infection.

Study	Study Population n=total fractures (percent open)	Deep Wound Sepsis Rate
Grose, JOT 2007(3)	44 (41%)	2 (4.5%)
Sirkin, JOT 1999(2)	56 (39%)	3 (5.3%)
Patterson, JOT 1999(1)	22 (27%)	0 (0%)
Chen, JOT 2007(4)	65 (14%)	5 (8%)
Boraiah, JBJS 2010(5)	59 (100%)	2 (3%)

Table 3: Study Population and Deep Wound Sepsis Rate.

(Table 1).

- Late complications occurred in fourteen fractures (33%), which included deep infection in ten (24%), nonunion in three (7%), and a delayed

ischemic foot that was deemed non-revascularizable. Twenty-three patients (55%) underwent additional procedures following definitive fixation, including nine soft tissue coverage

procedures and three amputations.

- Compared with our institutional controls, the referred pilons demonstrated a statistically significantly higher deep sepsis rate. While the referred pilon group also demonstrated a significantly higher proportion of C-type injuries and open fractures as compared with the institutional control group, neither of these variables was independently associated with the occurrence of a deep wound infection (Table 2).

- Compared with contemporary published literature using staged protocols for tibial pilon ORIF however the deep infection rate of the study group was substantially higher (Table 3).

Discussion

- While staged protocols for the management of tibial pilon fractures are well accepted, the effect of provisional (stage 1) fixation prior to transfer to an institution that will provide definitive fixation has never been evaluated.

- Our results show that a high percentage of those patients referred after surgical attempt at provisional fixation require revision of the fixation, with tibial malreduction and external fixation errors being the most common presentation.

- When compared with our own institutional control and recent published literature, a higher than expected percentage of these patients developed deep wound complications and required a number of secondary procedures. The causation of these complications cannot be interpreted with certainty because of the higher proportion of C-type and open injuries present in the study population.

- Future studies may be able to more precisely determine a causative factor(s) associated with our findings. Additionally, the information in this manuscript may facilitate educational curricula that may ameliorate this problem.

Summary and Conclusion

- The majority of pilon fractures treated with provisional stabilization followed by referral to our institution, required revision prior to definitive fixation. This resulted in avoidable additional procedures, and higher complication rates than recent published literature.



Figure 1: This 27 year-old female was involved in a high speed motor vehicle collision and sustained an open comminuted right distal tibial pilon fracture. She was initially treated at an outside facility with operative debridement, fibular fixation, and spanning external fixation. She was transferred to Harborview Medical Center for definitive treatment. Anteroposterior (A) and (B) lateral plain radiographs upon presentation to Harborview demonstrate several technical shortcomings. The lateral view identifies an extension malreduction of the fibula resulting in anterior translation of the talus from beneath the anatomic axis of the tibia. Because of the fibular malreduction, the distal tibia is obligatorily extended and shortened. The anteroposterior view demonstrates lateral to medial tibial Schanz pin placement that resulted in a substantial amount of soft tissue compression, necrosis, and drainage from the pin sites. Additionally, the pin sites are located within the anticipated zone of definitive operative exposures and implants, potentially increasing the risk of infection. The talus remains translated lateral relative to the mechanical axis of the tibia, and the lack of medial external fixator support allows the talus to lie in a malreduced varus alignment. The provisional stabilization was revised upon presentation. Mortise (C) and lateral (D) plain radiographs now demonstrate appropriate medial to lateral Schanz pin placement well out of the anticipated area of definitive implants and exposures. The fibula has been revised to anatomic length, alignment, and rotation. The talus now lies in an improved position relative to the anatomic axis of the tibia, and adequate tibial length is now restored. All of these changes greatly facilitate subsequent definitive tibial ORIF. Several weeks after her injury, the soft tissue envelope was amenable to definitive tibial ORIF. Six months after her final procedure, anteroposterior (E) and lateral (F) plain radiographs demonstrate union with excellent restoration of axial alignment and articular congruency.



Figure 2: Three representative examples of tibial malreductions in three separate patients.
 (A) Substantial residual cephalad displacement of the talus is evident.
 (B) Marked shortening through the tibial diaphysis is appreciated once the residual fibular displacement is noted. The lateral malleolus is identified by the white arrow.
 (C) Near 100% translational malreduction can be identified on the lateral view.



Figure 3: Fibular malreduction can be identified on this lateral radiograph after provisional fibular reduction and fixation, followed by tibiotalar spanning external fixation. The 15° fibular extension deformity affects reduction of the tibial articular surface. Additionally, the talus is malreduced anterior to the mid-diaphyseal line of the tibia.

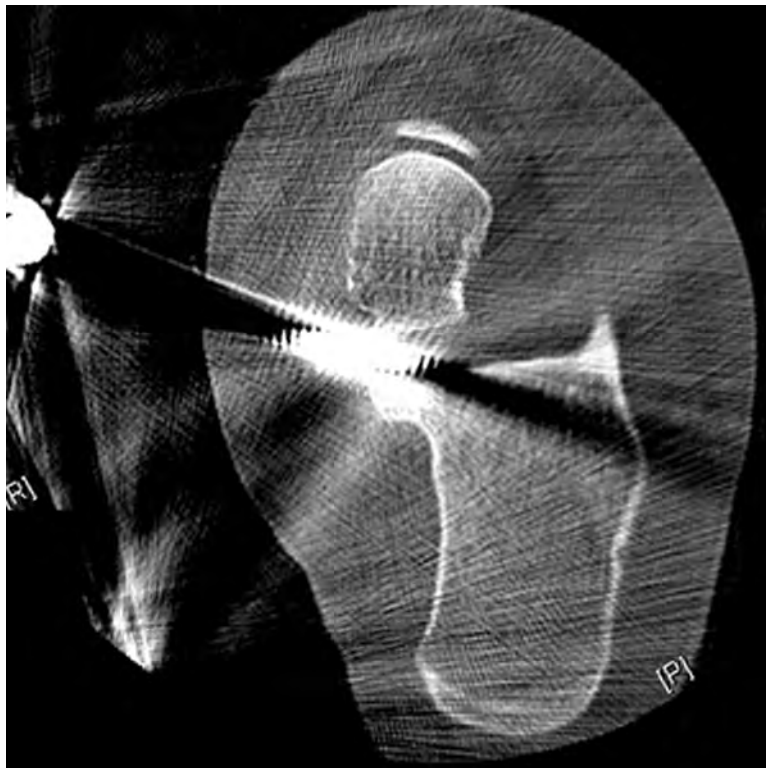


Figure 4: Axial CT scan of a tibial plafond fracture treated with open reduction and fixation of the associated fibula fracture and spanning external fixation of the tibial fracture component. Prior to revision, an external fixation Schanz pin is identified erroneously traversing the middle facet of the subtalar joint.

- The authors recommend that, when possible, the initial and definitive management of these injuries be performed at the accepting institution.

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Fluoroscopically-Guided Hip Capsulotomy: Effective or Not? A Cadaveric Study

Abstract: Ten paired cadaveric hips were utilized for a fluoroscopically-guided capsulotomy study to assess the efficacy and the safety of percutaneous hip capsulotomy. In all specimens, the intra-capsular pressures were significantly decreased and no major structures were injured. We conclude that fluoroscopically-guided hip capsulotomy is a safe procedure resulting in decreased intra-capsular pressures.

Study Rationale:

Clinical research has shown that femoral neck fractures can disrupt retinacular arteries, generating an intra-capsular hematoma that, if left untreated, may contribute to avascular necrosis (AVN) of the femoral head by compromising flow to the femoral head. Surgeons have recommended an open capsulotomy to relieve intraarticular fluid pressure in addition to open reduction and internal fixation. This however adds surgical morbidity by necessitating further surgical dissection in an already compromised area. More recently, fluoroscopically-guided hip capsulotomy following operative fixation of even minimally-displaced femoral neck fracture has been recommended to allow for decompression of the hematoma. Questions have been raised regarding the effectiveness and safety of such a procedure.

Objective:

The purpose of this study was to examine the efficacy of a fluoroscopically-guided hip capsulotomy through a small lateral incision and to better understand its anatomic relationship to nearby neurovascular structures. Our hypothesis was that this procedure would reliably decrease intra-articular

pressure while maintaining a safe distance from critical structures.

Methods:

Ten fresh-frozen paired cadaveric hips were injected under fluoroscopic guidance with saline sufficient to generate an intra-articular pressure greater than 58 mm Hg. The pressure was monitored continuously using a percutaneous transducer (Figure 1). A limited lateral approach to the proximal femur was performed by one of two senior orthopaedic trauma surgeons. Using a scalpel placed under fluoroscopic guidance, each surgeon made one attempt at an anterior capsulotomy (Figure 2). Changes in intra-articular pressure were monitored and recorded throughout the procedure. The specimens were then dissected to measure the extent of each capsulotomy as well as the distance from capsulotomy to nearby neurovascular structures (Figure 3).

Results:

On attempted capsulotomy, a rapid and substantial decrease in intra-articular pressure was seen in all hips. The mean intra-articular pressure post-capsulotomy was 8.4 mm Hg. In nine hips the final pressure was less than 10 mm Hg. In the remaining specimen

the pressure stabilized at 40 mm Hg, but successful capsulotomy was verified through direct visualization during subsequent dissection. The capsulotomies averaged 15.1 mm in length (range 3-35 mm). None of the attempts at capsulotomy lasted longer than 90 seconds. The average distance between capsulotomy and the lateral-most branch of the femoral nerve was 19.5 mm (range 15-30 mm). The femoral artery was on average 40.3 mm (range 36-52 mm) from the site of capsulotomy. There was no correlation between the side on which capsulotomy was performed and its extent or proximity to neurovascular structures.

Discussion:

Minimally-displaced fractures may not disrupt retinacular vessels, but can result in AVN of the femoral head. The significance of the intracapsular hematoma continues to be debated. Crawford et al. measured the intra-articular pressures in patients with minimally displaced femoral neck fractures[1]. The average pressure was 66.4 mm Hg. Beck et al. monitored femoral head perfusion in patients as saline was injected into the hip capsule[2]. Cessation of pulsatile blood flow to the femoral head occurred at

Specimen	Side	Gender	Starting pressure (mm Hg)	Post-capsulotomy pressure (mm Hg)	Decrease in pressure (mm Hg)
1	R	Male	58	7	51 (87.9%)
1	L	Male	107	10	97 (90.7%)
2	R	Female	112	7	105 (93.8%)
2	L	Female	60	0	60 (100%)
3	R	Male	115	0	115 (100%)
3	L	Male	65	0	65 (100%)
4	R	Male	60	40	20 (33.3%)
4	L	Male	58	8	50 (86.2%)
5	R	Female	100	2	98 (98%)
5	L	Female	100	10	90 (90%)

Table 1: Specimen results re pressure.

Specimen	Side	Gender	Capsulotomy length (mm)	Distance from capsulotomy to femoral artery (mm)	Distance from capsulotomy to femoral nerve (mm)
1	R	Male	5	52	30
1	L	Male	3	48	20
2	R	Female	35	41	17
2	L	Female	10	39	18
3	R	Male	25	36	15
3	L	Male	15	41	16
4	R	Male	23	50	15
4	L	Male	12	45	16
5	R	Female	8	51	22
5	L	Female	15	49	26

Table 2: Specimen results re distance.



Figure 1: Cadaver hip after dye injected and pressure monitor in place.

a mean pressure of 58 mm Hg; well below the average intra-articular pressure seen by Crawford.

Several studies have shown that intra-capsular pressures can be decreased and blood flow to the femoral head can be improved with decompression of the intra-capsular hematoma, making a strong argument for capsular decompression in femoral neck fractures treated with closed reduction and percutaneous fixation[3,4]. Although aspiration of an intra-capsular hematoma may reduce intra-articular pressure and improve femoral head perfusion, the benefits may be transient. As the hematoma re-accumulates, blood flow to the femoral head is again compromised. Thus, some surgeons choose to perform a capsulotomy, which is more likely to result in lasting decompression of the intra-capsular space[5,6].

Conclusions:

Fluoroscopically-guided hip capsulotomy through a small lateral incision is a safe, effective and expedient method by which to substantially reduce intra-articular pressure following minimally-displaced femoral neck fractures.

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Figure 2: Flourosopic assisted capsulotomy being performed with scalpel.



Figure 3: Anterior hip dissection following capsulotomy with wire indicating path. Distance from neurovascular structures measured.



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Tibial Tubercle Fractures Associated with Bicondylar Tibial Plateau Fractures: Incidence, Treatment and Complications

Abstract: In this retrospective review, we present the first known report on the incidence and complications seen in the setting of tibial tubercle fractures/extensor mechanism disruptions (TTFs) associated with high energy bicondylar tibial plateau fractures. TTFs were seen in greater than 20% (85/392) of all bicondylar tibial plateau fractures treated between 2003 and 2008, with high-energy mechanisms predominating. Though complications rates are high, stabilization remained durable, with no loss of fixation.

Study Rationale and Context

TTFs may occur in association with high-energy bicondylar tibial plateau fractures, though the actual incidence of this associated pattern remains unreported (Figures 1a and 1b)[1]. The addition of a tibial tubercle fracture, which disrupts the knee extensor mechanism, complicates both the treatment and the aftercare of a tibial plateau fracture.

Objective/Clinical Question

The aim for this project was to determine how often patients with bicondylar tibial plateau fractures had an associated TTF, to describe our treatment strategy and to assess the incidence of complications seen in this combined injury pattern.

Materials & Methods

- Retrospective review of a prospectively obtained trauma database at Harborview Medical Center a regional level one trauma center.

- 392 consecutively treated AO/OTA 41-C, bicondylar tibial plateau fractures in 382 patients (10 bilateral injuries) between January 2003 and December 2008.

- All radiographs reviewed by authors (MRM, RPD) to determine presence of a TTF.

- Inclusion Criteria: All patients with both bicondylar tibial plateau fractures & tibial tubercle fractures/extensor mechanism disruptions treated between January 2003 and December 2008. Exclusionary criteria included failure to meet inclusionary criteria.

- All patients underwent initial knee spanning uniplanar external fixation as the first part of their treatment.

- All patients underwent definitive fixation of their bicondylar tibial plateau fracture with plate/screw constructs once soft tissue conditions permitted. The TTF component of the fracture stabilized with a one-third or one-quarter tubular plate and screw buttress construct or stabilization with two or three independent 2.7 or 3.5 mm lag screws (Figures 2a, 2b & 2c).

- Outcomes
 - Mechanisms of injury
 - Percent open fractures
 - Incidence of compartment syndrome
 - Incidence of associated injuries
 - Rates of complications including:

- Loss of fixation
- Infection
- Nonunion
- Failure to regain range of motion

Results

- 85 TTFs (21.7%) in 392 bicondylar tibial plateau fractures.

- High-energy mechanisms of injury predominated, with motorcycle collisions most common (47% of cases), followed by pedestrian struck by motor vehicles (15%) and automobile collisions (14%).

- 50/85 (58.8%) of fractures were 41C3 injuries, while 34/85 (40%) were 41C3.3 type, the most highly comminuted category of the AO/OTA classification[2].

- 24/85 (28.2%) of TTFs were open fractures[3].

- Type III injuries represented 22/24 (91.6%) of the open fractures

- Type IIIA was the most common type, accounting for 50% (12/24) of the open injuries

- Type IIIB injuries were seen in seven patients (8.2%), all of whom required soft tissue flap coverage.

- Type IIIC injuries were seen in two patients (2.4%), both of whom



Figures 1a & 1b: Injury anteroposterior and lateral radiographs of comminuted tibial plateau fracture with associated tibial tubercle fracture after high speed motorcycle injury.

required vascular repair.

- Twelve of 85 (14.1%) patients developed leg compartment syndrome which required fasciotomies.

- 24/85 (28.2%) patients had a meniscal injury noted at the time of operative fixation.

- 48/84 patients (57%) with this injury combination had other orthopaedic injuries requiring fixation.

Complications

- 15.3% (13/85) patients developed a deep infection.

- Ten patients (11.8%) had nonunions at the level of the metadiaphysis. Seven of these had been after open fractures. All ten required revision surgery.

- There were no nonunions of the tibial tubercle component of the fractures and all were healed by six months post-operatively.

- 21.1% of patients did not regain full extension, though all but one had lost <10 degrees of extension.

- 7.7% did not obtain >100° of flexion.

- Only four patients (7.7%) had symptomatic tibial tubercle hardware.

Discussion

- Extremely little has been reported on this combined injury pattern[1]. But Barei et al. described complications in high energy bicondylar plateau fractures[4].

- In the Barei paper, 13% of fractures were open, while in our group, open fractures were twice as common (28.2%).

- The incidence of compartment syndrome seen by Barei (14.5%) is similar to that noted in this study (14.4%).

- The rate of infections in this group (15.3%) is higher than that reported in the Barei study (8.2%), but may



Figures 2a, 2b & 2c: Treatment of tibial tubercle fracture with 1/3 tubular plate (2a), 1/4 tubular plate (2b) and independent 3.5 mm lag screws (2c).

correlate with the higher rate of open injuries and 41C3.3 fractures.

- Strengths of this study include the first report of a large number of these high energy injuries treated by a single group of experienced fellowship-trained orthopaedic traumatologists

- Weaknesses of this study include the inherent limitations of a retrospective study and the use of historical controls rather than a direct comparison group.

- From a clinical perspective, surgeons should realize that TTFs occur not infrequently in association with high-energy tibial plateau fractures.

- The high-energy nature of these injuries is likely the driver for the high rate of complications seen.

- Remaining questions: Does the TTF fracture itself or its treatment contribute to a higher metaphyseal nonunion rate and rate of infection? Can immediate active extension exercises be initiated?

Summary and Conclusions

- TTFs are telltales of a high-energy mechanism in bicondylar tibial plateau fractures.

- TTFs can be successfully treated with standard implants applied through the same incision typically utilized for tibial plateau fixation.

- Complication rates including infection, limited range of motion and nonunion are common, though they likely related more to the high energy mechanism than to the presence of the TTF itself.

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Biomechanical Comparison of Less Invasive Stabilization System for Mechanically Unstable Fractures of the Distal Femur: Fixation with Titanium versus Stainless Steel and Bicortical versus Unicortical Fixation

Abstract: In this biomechanical study, our purpose was to test the effect of 1) titanium (Ti) versus stainless steel (SS) metal and 2) locked unicortical versus bicortical shaft fixation on stiffness of Less Invasive Stabilization System (LISS) constructs in a mechanically unstable distal femur fracture model. No difference was found in stiffness in axial loading or plastic and total deformation between Ti unicortical LISS fixation, SS unicortical LISS fixation, and bicortical SS LISS fixation with only a small decrease in stiffness in torsional loading in the titanium group compared to the stainless steel groups ($p < 0.0001$) and a small increase in stiffness in torsional loading with bicortical versus unicortical proximal fixation ($p = 0.04$). While there are numerous considerations when selecting implants for these fractures, our results indicate that stiffness is not a significant factor in choosing between the constructs tested.

Study Rationale

SS metal and bicortical locking screws in LISS constructs may have important implications for bone healing. While relative instability in large effective fracture gaps present in mechanically unstable distal femur fractures are desirable [1], the impact of increased rigidity with SS metal and bicortical locked fixation of the shaft are unknown.

Research Question

Is there a difference in titanium versus stainless steel metal and locked unicortical versus bicortical shaft fixation on stiffness of LISS constructs in a mechanically unstable distal femur fracture model?

Methods

Study design: Biomechanical benchtop experiment

Fracture Model

- 24 4th-generation femoral

synthetic composite sawbones

- Nine-hole LISS plates (Figure 1)
- Group 1: Ti plates with unicortical locking screws (Figure 2)
- Group 2: SS plates with unicortical locking screws (Figure 3)
- Group 3: SS steel plates with bicortical locking screws (Figure 4)

• Unicortical distal screws per manufacturer recommendations [2]

- AO/OTA 33-A3 fracture

Mechanical Testing [3]

- Servohydraulic materials testing machine
- Axial Loading (Figure 5)
 - o Compression at 10mm/min. Stopped at 500 N.

- Torsional Loading (Figure 6)
 - o Torqued to maximum 20 Nm at 20 degrees/min.

- Cyclic Axial Loading
 - o Increments of 10 cycles starting with 300 N. Load increased by 100 N, to maximum load of 1000

N. Displacement control mode at 0.75mm/sec.

Data Recording

• Load-displacement curve plotted for each construct

• Stiffness calculated as slope of initial region of curve.

• Plastic deformation = displacement present after the final cycle - amount of displacement present at the start of the first cycle (300N).

• Total deformation recorded after last testing cycle.

Statistical Analysis

• One way analysis of variance with a Tukey post-hoc test

- Significance defined at $p < 0.05$.

Results

• See Table 1.

• None of the constructs failed during mechanical testing.

• No difference in stiffness in axial loading between the groups regardless



Figure 1: Titanium and stainless steel LISS plates.



Figure 2: Ti plates with unicortical locking screws.



Figure 3: SS plates with unicortical locking screws.

of presence of unicortical or bicortical locking screws ($p = 0.51$).

- No difference in total deformation ($p=0.41$) and plastic deformation ($p = 0.11$) between the groups.

- There was a difference in torsional stiffness between the groups ($p<0.001$).

- o There was decreased torsional stiffness in the titanium group compared to the stainless steel unicortical group ($p<0.0001$) and the stainless steel bicortical group ($p<0.0001$). There was increased torsional stiffness when comparing bicortical to unicortical proximal fixation in the stainless steel group ($p = 0.04$).

Discussion

- This biomechanical study of unstable distal femur fractures treated with the LISS comparing stainless steel to titanium and unicortical to

bicortical fixation showed comparable stiffness in all constructs tested in axial loading. Only torsional rigidity differed significantly between the titanium and stainless steel groups and the unicortical and bicortical proximal locking configuration.

- The effects of small differences in torsional stiffness on bone healing are presently unknown and likely of limited clinical significance.

- There are several advantages of stainless steel over titanium LISS implants including easier removal of stainless steel implants, easier intraoperative fluoroscopy due to greater radiodensity of stainless steel, and the ability to easily place bicortical locked screws in the stainless steel plate [4].

- Strengths: Well established testing protocol with improved test set-up from previous studies.

- Limitations: Sawbones model only mimics young bone and results may not extrapolate to osteopenic bone [5].

Conclusions

- There was no difference in axial stiffness, total or plastic deformation between Ti and SS LISS plates and unicortical and bicortical locking screws in SS constructs. Numerous considerations exist when selecting implants but our results indicate that stiffness is not a significant factor in choosing between the constructs tested.

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	Axial Load (N/mm)	Total Deformation (mm)	Plastic Deformation (mm)	Torsion (Nm/degree)
Titanium	1335.8 ± 280.6	1.20 ± 0.25	0.39 ± 0.10	2.27 ± 0.19
Stainless Steel Unicortical	1226.1 ± 177.6	1.36 ± 0.25	0.53 ± 0.18	3.43 ± 0.19
Stainless Steel Bicortical	1194.1 ± 275.9	1.32 ± 0.21	0.52 ± 0.14	3.77 ± 0.36

Table 1: Results of Biomechanical Testing.



Figure 4: SS steel plates with bicortical locking screws.



Figure 5: Set-up for axial loading. Distal segment mounted on platform with ball bearings to eliminate torque during loading.



Figure 6: Set-up for torsional loading. Distal segment clamped into vice to introduce torque.

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Funding Source: Synthes U.S.A.

Acknowledgements: Julie Agel, Phillippe Huber, Ted Gross



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Clinical Analysis Of Less Invasive Stabilization System For Mechanically Unstable Fractures Of The Distal Femur: A Comparison Of Reoperation, Union And Implant Failure Rates Between Stainless Steel And Titanium Implants

Abstract: In this retrospective study, we compared clinical outcomes for subjects treated with stainless steel versus titanium versions of the Less Invasive Stabilization System (LISS) (Synthes U.S.A., Paoli, PA) in adult patients treated for OTA 33A and 33C at a single academic level 1 trauma center with a mean follow-up of 10.7 months. There was no difference in non-unions between titanium and stainless steel implants and in a multivariable analysis, open fracture was an independent risk factor for reoperation, and metal type was not associated with any outcome assessed. We did not find a difference in union rates of distal femoral fractures attributable to metal composition of the lateral locked plate but further prospective trials will be required to substantiate these findings and study the relative importance of other technical factors such as plate length and screw configuration.

Study Rationale

The LISS was originally developed using titanium alloy[1,2]. In North America, many surgeons question the theoretical benefits of less stress-shielding and increased biocompatibility and prefer stainless steel[3,4]. Stainless LISS plates are used exclusively at our institution but no studies exist that examine differences in clinical outcome due to metal composition (Figure 1).

Clinical Question

Is there a difference in union rates and implant failure in patients with unstable distal femur fractures treated with titanium (Ti) versus stainless steel (SS) LISS plates?

Methods

Study design: Prospective cohort study (IRB approved).

Inclusion criteria: Greater than 16 years with extra-articular (OTA 33A)

and complete articular (OTA 33C) distal femoral fractures treated either the Ti or stainless SS LISS between January 1, 2003 and June 30, 2008.

Exclusion criteria: Follow-up less than six months. Non-LISS distal femoral locked implants.

Patient population and interventions compared:

- 338 adults with OTA 33A and 33C fractures were treated at our institution.
- 146 were treated with the LISS
- 104 met inclusion criteria of which 80 were treated with the titanium LISS and 24 were treated with the stainless steel LISS

Implants

• LISS fixators were implanted per manufacturer's technical specifications and SS or Ti was chosen at surgeon's discretion

- If there was radiographic evidence of healing patients were gradually advanced to full weight bearing by 10-

12 weeks post-operation.

Statistical Analysis

• Means of patient and surgical variables were compared between treatment groups (SS versus Ti) using appropriate non-parametric tests of significance.

• Unadjusted differences in the incidence of primary and secondary outcomes were tested using Fisher's Exact test.

• Multivariable logistic regression analysis was performed with significant defined at $p < 0.05$

Results

• Patients in the treatment groups were similar in age, gender and rates of obesity (Table 1).

• 32 patients in the Ti cohort and 5 patients in the SS cohort required additional surgeries (Table 2). A large proportion of these procedures were planned bone grafting for segmental bone loss as the result of a severe

Variable	Ti (n=80)	SS (n=24)	P-value
Age	50	53	0.48
Gender	58% male	63% male	0.81
Obese	25%	42%	0.13
Diabetes	5%	21%	0.03
Smoker	34%	25%	0.47
Follow-up(mo)	13	8	0.01
Mechanism of Injury	MVC	MVC	0.11
OTA Class	33C2	33C2	0.19
Open Fracture	59%	33%	0.04

Table 1: Patient and injury characteristics.

Procedure	Ti (n=80)	SS (n=24)	Total
Bone Graft (Planned)	12	2	14
Bone Graft (Unplanned)	2	1	3
I&D (Infection)	1	2	3
Knee Manipulation	8	0	8
Nonunion Repair / Hardware Removal	4	0	4
Hardware removal for pain	4	0	4
Other	1	0	1
Total	32	5	37

Table 2: Additional Surgeries.

open injury.

- Unadjusted comparison demonstrated no significant differences in need for additional surgery, union, or implant failure between groups (Table 3)

- Open fracture was an independent risk factor for need for further surgery

- All implant failures (n=7) occurred in Ti group: 3 failures of proximal fixation in patients who healed without further intervention. There were 3 failures of proximal and 1 failure of distal fixation in patients who developed non-union and required further procedures.

Discussion

- We found no significant difference in nonunion or implant failure between subjects treated with the SS or Ti LISS for unstable distal femur fractures.

- Strengths: We used the "natural experiment" that occurred at our institution with the exchange of Ti for SS to make our treatment groups similar and controlled for remaining confounding bias in our analysis. This is the only clinical study that has been able to so closely isolate metal composition differences in assessing outcomes of this fracture.

- Limitations: Drawbacks include unknown or unmeasured confounding, potential for measurement bias, and differences in follow-up. While

duration of follow-up was controlled for in the multivariable analysis, there is no way to assure that this did not introduce selection bias, the direction of which cannot be determined [5].

- A larger SS cohort with longer follow-up may change the outcomes noted and we will continue to follow these patients prospectively.

Summary and Conclusions

- This observational study of locked distal femoral plating with SS versus Ti LISS found no significant difference in need for further surgery, union, or implant failure.

- The previously described risk of open fracture was found to be associated with outcome in multivariable regression analysis.

Outcome	Ti (n=80)	SS (n=24)	P-value	P-value*
Additional Surgery	40%	21%	0.10	0.25
Non-union	10%	13%	0.71	1.0
Implant Failure	9%	0%	0.2	0.19

Table 3: Crude Estimates (*patients with planned bone grafting excluded from analysis).

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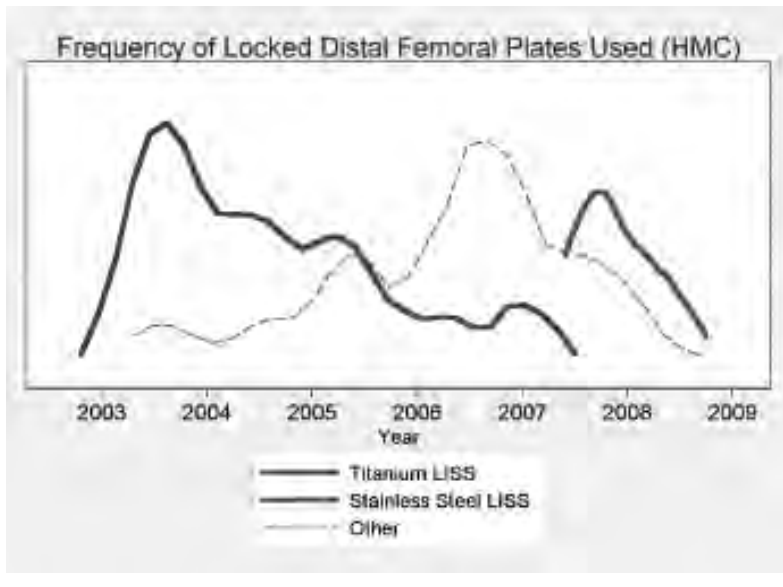


Figure 1: Frequency of Locked Distal Femoral Plates Used (HMC).

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Figure 2: Radiographs of a supracondylar intercondylar distal femur fracture (a, b). CT scan further delineates fracture pattern (c, d). The fracture was treated with a stainless steel LISS plate and went on to heal (e, f, g, h).



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Senior Patients with Acetabular Fractures: Epidemiology and Risk

Abstract: In this retrospective clinical review, we focused on patients aged 65 years and older with acetabular fractures. Our trauma database identified 156 patients treated from 2004 through 2009. Similar to younger patients with acetabular fractures 72% were males, but different from younger patients 71% of our senior acetabular fractures were caused by low energy traumatic events such as falls from standing. Two specific fracture patterns dominated these senior acetabular fractures as 70% were either associated both column or anterior column-associated posterior hemitransverse (AC/PHT) patterns. Not surprisingly, 82% of our patients had diagnosed and relevant medical comorbidities. Operative treatment was selected in only 36.5% of the patients. Overall mortality rate for these patients was 33% within one year after injury, and 75% of those patients died within 3 months after injury. The one-year mortality rate for those treated without surgery was 44% while those undergoing operative care had a 12% one-year mortality rate.

Study Rational and Context

Acetabular fractures in senior patients are poorly understood. Details such as incidence, associated injuries, co-morbidity, and mortality rate are but a few of the clinical unknowns for this patient population. These senior patients perhaps have increased overall clinical risks due to such issues as medical conditions, bone quality, and others.

Clinical Question

What is the epidemiology and mortality rate for senior patients with acetabular fractures?

Methods

Study design: Retrospective clinical review (IRB approved)

Inclusion criteria: All patients aged 65 years and older admitted to Harborview Medical Center from 2004 through 2009 with acetabular fractures.

Exclusion criteria: None

Patient population and interventions:

- 156 consecutive patients that had either operative or non-operative treatment for their acetabular fractures were identified and evaluated for demographic data, mechanism of injury, pre-injury status, fracture type, treatment details, and survival at one year post-injury.

- Operative details were recorded for patients that had undergone open reduction and internal fixation (ORIF).

- Patient mortality was confirmed in three ways: direct knowledge of patient death by the authors, medical chart data indicating patient death, and the Social Security Death Index. If there was no indication of patient death by any one of the three methods above, the patient was presumed to be living.

Radiographs were reviewed from the date of injury and most recent follow-up. Data points were analyzed utilizing SPSS 17.0 (SPSS Inc., Chicago, IL). Our institutional review board approved this study. No outside

sources of funding were used for this study.

- The average age of the study population was 77.5 years (65 – 97). The average ages of patients treated operatively was 75.5 (\pm 8), and 78.6 (\pm 7.4) for those treated nonoperatively ($p = 0.018$).

- There were 113 male and 43 female patients.

- Pre-injury status demonstrated an active population with 80% being community ambulators. For those patients treated with ORIF and/or exam-under-anesthesia (EUA), there was an average delay of 3.8 days (range 1 to 20 days).

- The average hospital stay was 13.8 days (\pm 9.7) for patients that underwent surgical intervention and 11.1 (\pm 10.1) for those that had non-operative management ($P = 0.11$).

- Post-hospital disposition showed that 16% were discharged to home and 77% were discharged to a skilled nursing facility.

- Patient comorbidities were



Figure 1A: This 81 years old female patient with multiple medical comorbid conditions including significant Parkinson's disease lost her balance and fell while walking in her home. She complained of right sided hip pain and was referred to our institution after being seen at her local emergency room. Her plain pelvic anteroposterior injury radiograph demonstrates prior surgical procedures, poor bone quality, and a displaced associated both column acetabular fracture.



Figure 1B: Three days after injury her medical condition was optimized and she underwent operative repair using the lateral iliac and middle vascular wound intervals of an ilioinguinal exposure. The fracture reduction was stabilized with a pelvic brim plate and supporting columnar screws. Her son and daughter helped her recover at home uneventfully. Her hip is without complaint and she ambulates as before but now with a "balance stabilizing" walker.

common with 82% of the group having an average of 2 medical comorbidities (range from 0 to 8). The most common comorbidities were hypertension (32%) and diabetes (26%). In the operative group, 76% of the patients had comorbidities with an average of 1.6 comorbidities (± 1.3) per patient.

In the nonoperative group, 86% of the patients had comorbidities ($P > 0.05$) with an average of 2.2 (± 1.6) comorbidities per patient ($P = 0.02$).

- Mechanisms of injury included 70.5% falls, 23.1% motor vehicle crashes (MVC), 2.6% bicycle accidents, 1.3% pedestrians struck by cars,

and 2.4% from others mechanisms. Simple falls usually at home and from a standing height were causative in 48 patients (31%). Related traumatic injuries in these patients were common occurring in 35% of the cohort. Interestingly, approximately 15% of the falls were from ladders with an average height of 11 feet and included a few patients that fell from their house roofs.

- Fracture types were variable but consisted predominantly of OTA/AO 62B (45%) and 62C (37%) or Letournel and Judet Associated Anterior Column/Posterior Hemitransverse and Both Column patterns.

- Treatment for these patients included 41.7% nonoperative without exam under anesthesia (EUA), 20.5% that underwent EUA and were ultimately treated non-operatively, and 36.5% that underwent ORIF. In the nonoperative patient group, 77.6% were treated with protected weight bearing only (weight of leg only) and 16.4% were treated with traction for 4-6 weeks.

- Standard protocols at our institution for all acetabular fractures patients consist of 6 weeks protected "weight of limb" bearing followed by a 4 to 6 week partial progressive weight bearing regimen. All patients are typically full weight bearing by three months post-injury.

- Average operative time was 206 minutes (range 110 to 464 minutes). Three main approaches were utilized for the 56 patients that underwent ORIF: the ilioinguinal approach with Stoppa interval (24 patients), the ilioinguinal approach with only the lateral and middle windows developed (13 patients), and the Kocher-Langenbeck incision (16 patients). Two patients had a Smith-Petersen approach and one patient had combined approaches. No extended iliofemoral approaches were used. It is our routine to develop the Stoppa interval instead of the medial window of the ilioinguinal exposure. Estimated intraoperative blood loss amounts were 595 milliliters (range 50 - 1900 milliliters). Intraoperative blood collection with a cell-saving device was used in all acetabular cases. In addition to autologous blood return, 30% of patients received intraoperative blood administration averaging 2.15 units (range 1-5 units).

- Fixation constructs were

predictably constant across the study. With the two primary fracture patterns noted, (AO/OTA 62B3 and 62C), the constructs consisted predominantly of pelvic brim plates with posterior column stabilization using long screws placed both through the brim plate and independent from the plate. The brim plate was supplemented with an intrapelvic plate in those patients with significant intrusion of the quadrilateral surface. Average plate length was 6 to 9 holes for the brim plate and 10 holes for the intrapelvic plate. Standard malleable pelvic 3.5 millimeter (mm) reconstruction plates were used in all patients. Most often, transverse patterns (62B1 and B2) were treated with a Kocher-Langenbeck approach and one or two posterior column plates. The anterior column was stabilized most often with 4.5 mm medullary screws inserted either retrograde or antegrade depending on the fracture details and normal osteology. Two medullary screws were used whenever possible.

- Patient mortality at one-year post-injury was 32.7 % with 78.4% of these patients expiring within 75 days from injury. In patients treated non-operatively, one-year mortality was 44%. In the operative group, one-year mortality was 12%. It is interesting to note that one-year mortality and 90 day mortality were 79% and 47% respectively for patient treated with traction alone. The mortality data was stratified by age and our data demonstrated a relatively even distribution among 5-year groups. Utilizing a chi-square analysis, there were no significant differences among the groups with 30-day, 90-day, or one-year mortality.

Discussion

- As our population ages and the number of geriatric group fractures increase, evidence-based treatment regimens are relevant to managements as we strive for cost-containment and optimal treatments.

- Interestingly, males comprised 72% of the patients in this study. This gender distribution is similar to younger patients with acetabular fractures caused by high energy traumatic events. Almost all of our senior patients were injured in low energy events.

- The fracture patterns identified

in our study demonstrate that 70% of senior patients with acetabular fractures will sustain associated patterns according to Letournel: either associated both-column fractures or anterior column/posterior hemitransverse (AC/PHT).

- We also noted, different from the younger trauma patient population where associated injuries are common, that less than 50% of these senior patients had associated traumatic injuries. This is very likely due to the low-energy nature of injury mechanisms sustained in the senior population. These were most often ground-level falls or falls from ladders at low heights, highlighting environmental safety concerns for senior patients.

- Management depended on numerous factors including the appropriate and timely evaluation and treatment of medical comorbidities such as hypertension and diabetes (the most common in our series). Only 36.5% of our 156 patients underwent ORIF. We utilized routine implants as well as predictable and reliable fixation constructs. We adjusted our incisions as necessary based upon previous surgeries the patients had undergone (i.e. hysterectomy, caesarean section, etc.). Despite our concerns regarding poor bone quality at operation, no special surgical equipment or implants were needed for successful reduction and stable fixation in senior acetabular operative care.

- Among patients that died during the study period, we intervened surgically in only 16% of the cases. In the group that survived throughout the study period, we operated on 91% of those patients. These data indicate one of two things that are difficult to interpret with our study design; namely, we are accurately selecting those patients which we are confident will benefit from surgical intervention, or conversely, we are under-operating on a large number of patients. After age-stratifying the data set, we found no significant differences in any one group (65-69, 70-74, etc to 90 and greater) in regards to higher mortality rates at any time period.

Summary and Conclusions

- Acetabular fractures in the senior population are not uncommon and occur predominantly in male due to

low energy traumatic events.

- These patients are difficult to manage successfully not necessarily due their fracture, but rather due to their overall medical-clinical complexity.

- The two most common fracture patterns were the associated both column and AC/PHT making their operative technical repairs predictable.

- It is very common for this patient population to present with medical comorbidities and the utilization of a multidisciplinary team may be beneficial in their care.

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Closed Subtrochanteric Femur Fractures Treated with Open Reduction and Reamed Antegrade Intramedullary Nailing: Technique and Complications

Abstract: The purpose of this retrospective clinical review was to evaluate the complications and successes in a consecutive series of patients with closed subtrochanteric femur fractures treated with an open reduction combined with reamed antegrade statically locked intramedullary nailing. Our institutional trauma database demonstrated that of the 154 subtrochanteric fractures treated with an antegrade nail at Harborview Medical Center between January 2000 and July 2008, 56 patients could not be reduced with closed methods and required an open reduction prior to nail placement. This procedure included direct visualization, manipulation, reduction and provisional stabilization of the fracture fragments prior to nailing. Of the 56 fractures, 91% demonstrated some healing at their first follow-up visit and all healed by an average 121 days. There were no deep infections or wound complications associated with the open approach. The postoperative alignment matched the final alignment indicating no loss of fixation. A final deformity of <5 degrees was observed in 98% with only one malreduction of 7 degrees of varus. In conclusion, a careful open reduction combined with intramedullary nailing of complex subtrochanteric femur fractures was associated with an accurate reduction, a high rate of union, and rare complications.

Study Rationale and Context

The treatment of subtrochanteric femur fractures has been a source of difficulty for surgeons and a challenge for implant manufacturers, especially given the high compressive, tensile, and torsional forces in the region. Plates and nails have been used with some success in the past. However, malreduction in this region frequently leads to malunion or nonunion. An open approach to intramedullary nailing is initially counterintuitive as it appears to run opposite the philosophy of soft tissue preservation with closed nailing. However, because the accurate reduction of these fractures is so important for maximizing the surgical success, an open reduction can potentially be combined with intramedullary nailing.

Clinical Question

In patients with subtrochanteric femur fractures whose injuries cannot be successfully reduced with closed or percutaneous methods and require an open reduction prior to nailing, is there an acceptable rate of complications and predictable fracture healing in good alignment?

Methods

Study Design: Retrospective clinical study (IRB approved)

Inclusion Criteria:

All patients sustaining a subtrochanteric femur fracture between January 2000 and July 2008, treated with an open reduction followed by reamed antegrade nailing. This patient group was selected as a subset

of all subtrochanteric femur fractures treated. Included were closed injuries, skeletally mature patients over the age of 16, and ambulatory patients.

Exclusion Criteria:

Subtrochanteric femur fractures treated with plates.

Subtrochanteric femur fractures successfully treated with closed reduction or percutaneous methods prior to intramedullary nailing. While these patients were excluded from the study population, they were similarly followed to union to confirm that an open reduction did produce an unacceptable nonunion or complication rate.

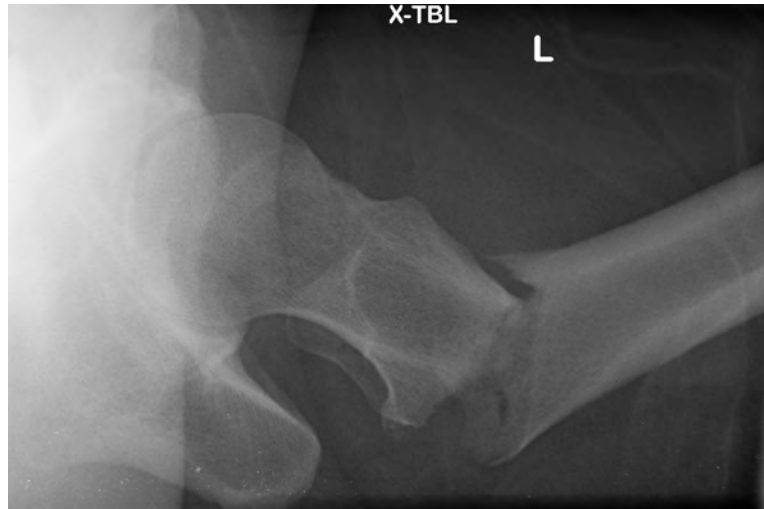


Figure 1: This is a typical but simple subtrochanteric femur fracture in the AP (A) and Lateral (B) planes. Closed reduction with percutaneous measuraw was unsuccessful in allowing for placement of an intramedullary device.

Patient Population and Interventions Compared:

- Of 154 patients with a subtrochanteric femur fracture treated with an antegrade nail, 96 had follow-up to union.
 - Of these, 40 were successfully reduced and nailed in a closed fashion, with or without percutaneous reduction tools.
 - The remaining 56 fractures required an open approach for direct visualization, manipulation, reduction, and provisional stabilization prior to nailing. All fractures were treated under the supervision of a fellowship trained orthopaedic trauma surgeon.
 - These were predominately high energy injuries with 20 motor vehicle crashes, 12 falls from height, 9 falls from standing, 3 motorcycle accidents, 3 pedestrians struck, and a variety of other mechanisms in the remainder.
 - There were 30 males and 26 females with an average age of 50 years (the 9 patients who were injured in a fall were 77 years of age).
 - Of the fractures, 22 were completely located below the lesser trochanter and 34 had fracture extensions proximally.
 - Operative Technique: Patients were positioned supine, a generous lateral surgical approach was used, and additional muscular dissection was minimized. Extraperiosteal exposure of the minimum amount of the fracture necessary for reduction was performed and soft tissue friendly

clamps were used. Reamed nailing was performed with a trochanteric or piriformis cephalomedullary nail in the vast majority (51 of 56).

Outcomes and Analysis

- Primary outcome: fracture union
- Secondary outcomes: complications including alignment, wound healing, deep infection, secondary operative procedures.
 - Standard techniques were used to compare demographic and injury characteristics, and complication rates between the study population (open reduction) and those patients managed with closed techniques.

Results

- All 56 fractures that were treated with an open approach united.
- Some fracture callus (signifying progressive healing) was observed radiographically in 91% at their first radiological follow-up.
 - The average time to union (healing on three of four cortices) was 161 days (range, 12 to 56 weeks).
 - There were no deep infection nor wound complications associated with the open approach for reduction.
 - One patient had screw loosening of the cephalad of the two proximal screws. This was treated with bolt exchange and healing progressed without complication.
 - Five additional patients required removal of symptomatic hardware.
 - The final alignment was within 5

degrees in 98%. One patient had a 7 degree varus deformity.

- In the 40 patients that did not require an open approach for reduction, 19 were successfully reduced with a closed manipulation and 21 required percutaneous manipulation prior to nailing. There was one nonunion. Healing was uneventful in the remaining 39 patients with an average time to healing of 152 to 158 days.

Discussion

- Both lateral plate constructs and intramedullary nails have been used with some success in the treatment of these difficult subtrochanteric femur fractures. Early weight bearing may not be possible with plates, and their eccentric location may make them biomechanically inferior. Nails have a biomechanical advantage, allow early weight bearing, but are often associated with malreduction of the fracture when closed methods are used. An open reduction of a fracture treated with an intramedullary nail is disrupts the fracture hematoma and may contribute to complications such as infection or nonunion. However, the improved reduction may assist with maintenance of reduction.
 - Our results show that all fracture healed despite an open approach. Further, the vast majority (98%) healed with excellent alignment (defined as less than 5 degrees of deformity). Only one patient healed with a malreduction

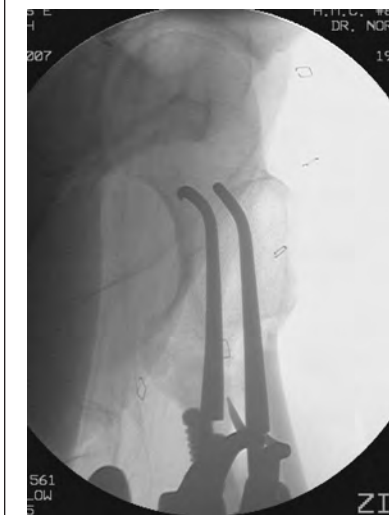


Figure 2: An open reduction through a direct lateral incision with a careful subvastus approach was performed. Strategic clamp placements allowed for reduction as well as manipulation of the femur to allow for identification of the nail entry site (A, B).



Figure 3: The fracture was maintained in a reduced position during reaming and nail placement to ensure an accurate reduction (A, B).



Figure 4: The final implant placement and reduction (A, B).

which was 7 degrees of varus. Wound complications were not observed.

- When compared with our own institutional control (patients treated with a closed reduction) and recent published literature, an open reduction was associated with excellent results.

- Cephalomedullary nails with fixation into the femoral head were used in the majority of instances with good hardware placement.

Summary and Conclusion

- The use of an open reduction for the treatment of complex subtrochanteric femur fractures that do not respond to closed and percutaneous

reduction methods is associated with high success rates. This includes high rates of fracture union, good maintenance of alignment, no wound or deep infections, and few secondary procedures. Cephalomedullary nails appear to be a good choice for the treatment of these fractures.

- The authors suggest that an open reduction combined with placement of a reamed antegrade cephalomedullary nail is an appropriate treatment

strategy for subtrochanteric femur fractures. This study supports the supposition that the reduction is an integral part of fracture healing in this high-stress region.

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Septic Complications of ORIF in Comminuted Bicondylar Tibial Plateau Fractures with Compartmental Syndrome: The Association with Surgical Sequencing

Abstract: The purpose of this retrospective clinical review was to evaluate the effect of surgical sequencing on septic complications associated with open reduction and internal fixation (ORIF) of high-energy comminuted bicondylar tibial plateau fractures presenting with compartmental syndrome. Over a 10-year period, our institutional trauma database identified 51 patients that sustained 51 comminuted bicondylar tibial plateau fractures presenting with compartmental syndrome that were treated with four-compartment fasciotomy and knee spanning external fixation followed by definitive ORIF. Eight patients (16%) developed deep septic wound complications, all of which occurred in fractures managed with definitive fasciotomy wound closure followed by delayed ORIF, suggesting that infection rates for this complex injury pattern may be minimized by early definitive fracture stabilization, followed by subsequent fasciotomy coverage or closure.

Study Rationale and Context

Current treatment strategies for high-energy tibial plateau fractures utilize a brief period of spanning external fixation to allow resolution of soft tissue injury prior to definitive ORIF [1, 2]. An associated compartmental syndrome however, mandates an emergent surgical intervention through the injured soft tissue envelope. In this setting, the timing of ORIF relative to soft tissue recovery remains unclear.

Clinical Question

Does the timing of fasciotomy wound closure relative to definitive ORIF have an effect on deep wound sepsis rates in the setting of comminuted bicondylar tibial plateau fractures presenting with compartmental syndrome treated with fasciotomy?

Methods

Study Design: Retrospective clinical study (IRB approved)

Inclusion Criteria:

Between January 1996 and December 2005 inclusive, we identified 387 adults with 389 comminuted bicondylar tibial plateau fractures treated with ORIF. Of these, 75 patients with 76 fractures had clinical and/or manometric evidence of compartmental syndrome treated with a four-compartment fasciotomy.

Exclusion Criteria:

- (1) Fasciotomy performed at an outside facility (n=3 patients).
- (2) Non-salvageable limb treated with amputation during the initial hospitalization (n=6 patients).
- (3) Fracture treated entirely with external fixation (n=4 patients).
- (4) Clinical follow-up less than 24 weeks unless a septic wound complication occurred (n=11 patients).

Patient Population and Interventions Compared:

- Fifty-one patients sustaining

51 comminuted bicondylar tibial plateau fractures with an associated compartmental syndrome were treated with an emergent four-compartment fasciotomy and temporary knee spanning external fixation, followed by delayed ORIF.

- Fasciotomies were managed with repeated debridements, and closure with skin grafting or delayed primary closure.

- All fractures were stabilized using plate and screw implants. Lateral plates were applied via an anterolateral exposure, and medial implants were applied via posteromedial surgical exposures.

- Patients that received definitive wound closure followed by definitive ORIF were compared with patients that received definitive ORIF followed by definitive wound closure.

Outcomes and Analysis

- A deep septic wound complication was defined as: (1)

Patient	Bacteria
1	<i>Enterobacter cloacae</i>
2	<i>Pseudomonas aeruginosa</i> , <i>Enterobacter cloacae</i>
3	Methicillin-resistant <i>Staphylococcus aureus</i>
4	<i>Enterobacter cloacae</i>
5	Methicillin-resistant <i>Staphylococcus aureus</i>
6	<i>Enterobacter cloacae</i>
7	<i>Staphylococcus aureus</i>
8	<i>Enterococcus species</i>

Table 1: Infections

a surgical site requiring operative debridement, (2) bacterial growth from intraoperative cultures and (3), antibiotic administration directed by the Infectious Disease service.

- A multivariate analysis determined the effect of predetermined variables on the incidence of infection.

Results

- Eight of the 51 cases (15.7%) were complicated by infection (Table 1).

- Using variables determined a priori, multivariate analysis identified significant associations with infection (Table 2).

- Because time to ORIF was strongly associated with an infection ($p=0.001$), this variable was more closely investigated. The 51 patients were therefore grouped on the sequence of definitive ORIF and wound closure.

- All were initially treated with fasciotomy and knee spanning external fixation. Subsequently, 30 fractures underwent fasciotomy closure (delayed primary closure and/or skin grafting), followed by definitive ORIF. The remaining 21 fractures underwent

definitive ORIF at the time of definitive fasciotomy closure or before. A group T-test demonstrated a significant association with deep infection in those managed with definitive fasciotomy closure followed by ORIF compared with those treated with definitive ORIF followed by definitive fasciotomy closure ($p=0.006$). In fact, all eight infections occurred in patients managed with definitive fasciotomy closure followed by definitive fracture fixation (Table 3).

Discussion

- Staged protocols for the management of high-energy bicondylar tibial plateau fractures are well accepted. However, in the setting of an associated compartmental syndrome, treatment decisions become additionally complex. While previous studies have indicated that this injury constellation may be at an increased risk for surgical wound infection, an assessment of factors that may be responsible for this has not been examined[1, 3].

- The findings of this study are strengthened by the identification

of a substantial number of patients incurring an otherwise unusual injury constellation treated in uniform fashion, other than that related to wound closure.

- Because of the retrospective nature of the study, other variables that may be in part responsible for our findings may have been unappreciated, particularly those related to wide variances in the degree of soft tissue injury despite a lack of difference in the Injury Severity Scores, rates of open fractures, and rates of vascular injuries.

- A larger prospective analysis of a group of these injuries treated prioritizing definitive fixation and avoiding operating near or through immature skin grafts would help to substantiate the findings of this retrospective review[4].

Summary and Conclusion

- Similar to the treatment of open fractures[5], infection rates for bicondylar fractures treated with four compartment fasciotomies are minimized by early definitive ORIF, followed by early soft tissue coverage or closure. Surgeons, when faced with a deep infection in this clinical setting should consider empiric antibiotic treatment appropriate for methicillin-resistant staphylococcus species and gram negative bacteria, while awaiting definitive organism identification.

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	Fractures without infection	Fractures with infection	
Fractures (<i>n</i>)	43	8	<i>n</i> =51
Time ED-OR (hours)	11.8 (13.5)	4.8 (1.1)	0.002*
Time to Fixation (days)	2.6 (11.1)	12.8 (5.2)	0.001*
Age (years)	44.4 (11.1)	37.1 (6.9)	0.028*

Table 2: Variables with statistically significant differences- all 51 fractures. *statistical significance (2- tailed) equal variances not assumed. ED=Emergency Department; OR=Operating Room; parentheses indicate standard deviation. No differences were observed for: time from injury to fasciotomy, single versus two-incision four-compartment fasciotomy, split thickness skin graft versus delayed primary closure, size of split thickness skin graft in cubic centimeters, type of internal fixation used for fracture stabilization, open versus closed fracture, gender, Injury Severity Score, or if the patient was initially seen at another hospital and transferred for definitive care.

	Definitive Closure <i>then</i> Definitive Fixation	Definitive Fixation <i>followed by</i> Definitive Closure	
Fractures (<i>n</i>)	30	21	<i>n</i> =51
Delay to fixation (days from the time of definitive closure)	11.33 (5.5)	-6.00 (8.5)	0*
Infection	8	0	0.006*

Table 3: Definitive Closure First versus Definitive Fixation First. *statistical significance (2-tailed) equal variances not assumed. Parentheses indicate standard deviation.

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Foot and Ankle

Our Foot and Ankle group works out of the Sigvard T. Hansen Foot & Ankle Institute, which has relocated into the new Ninth and James Building over the past year in order to improve access for our patients. Our group of practitioners continues to consist of the following faculty:

- o Stephen K. Benirschke
- o Sigvard T. Hansen
- o Bruce Sangeorzan
- o Doug Smith

We also continue to educate 3 postresidency Clinical Instructors per year and deliver a wide range of foot and ankle surgery for patients with traumatic, degenerative and dysplastic conditions.

Our main challenge will consist of the transition of one of our icons, Dr. Hansen into a semi-retired status at the end of this year.

Sigvard "Ted" Hansen has been an icon in orthopaedics for over 40 years. Initially his focus was on the management of polytraumatized patients. Leading the other faculty at Harborview, he proposed and implemented a method for treating multiple trauma patients, utilizing the emergency transport facilities developed in King County for cardiac victims.

After establishing a stable faculty to deliver unparalleled trauma care to patients from the WWAMI (Washington, Wyoming, Alaska, Montana, Idaho) region, he turned his full attention the foot and ankle.

His training provided a natural segue to this practice, utilizing techniques managing patients with neuromuscular disease. The foot and ankle practice developed from managing complex foot reconstruction problems such as residual club foot deformities, cavus feet, and a host of neurologic problems including Charcot and idiopathic arthropathy, to an ongoing in-depth study of the comprehensive management of ankle arthrosis. After recognizing that the classic management of ankle arthrosis often led to host of additional problems within the foot, he popularized total ankle arthroplasty as a treatment alternative in selected patients, utilizing

a prosthesis developed by another UW orthopaedic alumnus, **Frank Alvine**, UW Res '74.

The reconstruction algorithm for ankle arthrosis is now much more sophisticated, ranging from ankle cheilectomy to primary arthroplasty, and arthrodesis take-down for arthroplasty to revision arthroplasty, all in an effort to maintain motion in the essential hindfoot joints. While arthrodesis is an appropriate treatment for the young, active patient, Dr. Hansen has stressed the importance of anatomical realignment of the ankle in this endeavor, and has identified the necessity of a plantigrade foot beneath any ankle reconstruction.

Dr. Hansen's practice continually reaffirms the natural history of gastrocnemius equinus and its sequelae, and the importance of recognizing this entity as the primary pathognomonic feature in nearly all foot pathology. His legacy is a host of trainees working as his disciples, delivering their interpretation of his

teachings, in academic and clinical centers all over the world.

We look forward to having him continue along side-by-side with us for many years to come as Professor Emeritus.

Stephen K. Benirschke, M.D.



Two pioneers standing side-by-side: Dr. Sigvard "Ted" Hansen UW Resident '69 (left) and Bob Winquist UW Resident '74 have greatly influenced trauma care during their years at Harborview and have continued to play major roles in elective Orthopaedic subspecialties.



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KRISTEN L. HORNER, B.S., MICHAEL J. FASSBIND, M.S.,
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Ankle Arthritis Occurs in Ankles with Altered Morphology

Abstract: Osteoarthritis occurs approximately nine times less frequently in the ankle than at the knee and hip in spite of a small surface and frequent injury. In the absence of injury or deformity, degenerative arthritis in the ankle is uncommon. We studied surface anatomy of the ankle joint to better understand the nature of the disease. **Methods:** Three-dimensional Computer models were created of the ankle surfaces from CT scans in patients with and without ankle arthritis to allow morphologic comparisons. In the non-arthritis group we included patients with high arch (cavus), low arch (planus- both symptomatic and non symptomatic) and patients with neutral feet as true controls. We measured the radius of articular surface of the tibia and talus, and fit the joint surfaces to a cylinder. We calculated the orientation of these curved surfaces relative to one another. We calculated tibial coverage of the talus, defined as the angle between two planes sharing the axis of the talar cylinder and touching the anterior and posterior margins of the tibial joint surface. **Results:** Mean tibial and talar radii were significantly higher and mean coverage angle was significantly lower in OA feet than in all other foot categories and the OA subjects were also older ($p < .05$). In addition the OA ankle had increased misalignment between the tibia and talus in the transverse plane (rotation) **Conclusions:** Findings included less congruence, a larger radius (flatter surface) and less coverage in the group of patients with OA. These parameters are all consistent with less containment and more potential shear in the sagittal plane.

Introduction:

Osteoarthritis (OA) is the most common joint disease and is the leading cause of chronic disability in the United States [1,2]. It is known to frequently affect weight-bearing joints, but symptomatic ankle OA occurs approximately nine times less than at the knee and hip [1]. This disparity is not completely understood considering the ankle joint bears more pressure and is the most commonly injured joint in the human body [1]. The motivation for the study was the clinical observation that ankle arthritis is commonly associated with anterior subluxation and with recurrent instability. We postulated an analogous anatomic situation as the reduced center-edge angle of Wiberg in the

pediatric dysplastic hip.

In this study we analyzed computer tomography (CT) scans of patients with ankle OA patients with no previous trauma to determine the effect of foot shape in the development of ankle OA. We used pes cavus (high arch), neutrally aligned (normal arch), pes planus (flat arch) as a reference group. We hypothesized that measurable characteristics of the tibial plafond and the talar dome, along with the alignment of the two joint surfaces, would be different in patients with ankle OA versus those without AO. A secondary purpose was to determine if pes planus and pes cavus feet had a different tibial and talar joint surface morphometry and alignment than neutral feet, such that these feet might

be predisposed to develop ankle OA.

Methods:

Subjects were recruited from the University of Washington and the VA Puget Sound Health Care System with Institutional Review Board approval. All subjects gave informed consent. Inclusion criteria were self-ambulation, between the ages of 18 and 75, and having either non-traumatic ankle OA or one of the following foot types free of other lower extremity pathology: pes cavus, neutrally aligned, or pes planus. The pes planus feet were subdivided into asymptomatic (non-painful) and symptomatic (painful) feet. Exclusion criteria were a partial foot amputation or prior foot surgery that could have changed bone shape.



Figure 1A and 1B: The joint surface was mapped on the talus and tibial plafond using 2D CT images. The surfaces from the 2D images were then appended onto the 3D model. The 3D model includes the tibia, the talus, and the joint surface.



Figure 2: The joint surfaces were fitted to cylinders that provided a radius of curvature. The radius of the tibia is greater than that of the talus in this image.

CT images were collected of each foot and processed into three-dimensional (3D) computer models using specialized software. The tibia and talus were segmented from the CT data in Multi-Rigid, a custom developed

program. ITK-SNAP (an open source segmentation application) was then used to select out the tibio-talar joint surface. Output from Multi-Rigid and ITK-SNAP were then aligned in Blender (an open source 3D graphics program) so that the joint surface selected in ITK-SNAP could be transferred onto the surface of the bones segmented in Multi-Rigid. The result was a 3D replica of the original ankle scan including the tibia, the tibial joint surface, the talus and the talar joint surface visibly delineated and anatomically scaled. Joint surfaces were exported into MATLAB for data fitting and analysis.

We calculated the radius of the tibia and talus, determined using a least squares method (Gauss-Newton algorithm) to fit the Blender joint surfaces to a cylinder. We also calculated the skew angle between the two cylinders, using the dot product

of the tibial and talar cylinder axes including the projected frontal and transverse skew angles. We then created a coverage angle for the talus similar to the Center-Edge angle of Wiberg for the hip joint. The coverage angle is the tibial coverage of the talus defined as the angle between two planes sharing the axis of the talar cylinder and touching the anterior and posterior margins of the tibial joint surface (Figure 1).

Linear mixed effects regression was used to determine if there were differences in mean plafond anatomy measures by foot type, with foot as the elementary unit of analysis (n=108) and subject modeled as a random effect. All models included age, gender and BMI as adjustment covariates. The significant level was $p < .05$.

Results:

Overall differences in mean measures by foot type group were found for age, tibial and talar radius, frontal skew and coverage angle ($p < .01$), as well as BMI ($p = .01$) with borderline differences for transverse skew ($p = .049$) (Table 1). Mean tibial and talar radii were significantly higher (a less curved joint) and mean coverage angle was significantly lower in OA feet than in all other foot categories. The OA subjects were also older ($p < .05$). Mean frontal skew in OA feet was significantly higher than in neutral feet or either flat foot group. Comparisons with neutral feet yielded significantly lower mean transverse skews and significantly higher mean frontal skew for pes cavus feet. No significant differences in foot anatomy measures for neutral vs. flatfeet were found.

Discussion:

This study confirms that ankles that develop arthritis in the absence of trauma, have less coverage of the talus than do non arthritic ankles, a situation analogous to the hip in dysplasia. The ankle joints with arthritis were in older patients, had a larger radius and less coverage of the talus by the tibia in the group of patients with OA. These parameters are all consistent with less containment and more potential shear in the sagittal plane. This study is one of the first to explore the complex 3D surface topography of the ankle joint and its relationship to the development

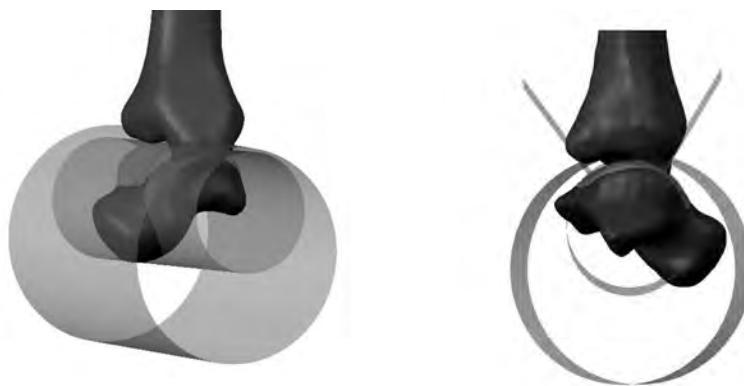


Figure 3: Ankle joint with fitted cylinders (left, antero-medial view) and coverage angle planes (right, lateral view). The coverage angle (shown on the right) was an angle formed by the center of the talar cylinder and the anterior and posterior margins of the tibial plafond. The greater the angle the more the tibia covered the talus.

foot type (n)	sex (M:F)	age*	BMI (kg/m ²)*	tibial rd. (mm)*	talar rd. (mm)*
ankle OA (13)	8:5	65.15 (8.97) a	28.15 (4.37) c	39.10 (8.68) a	27.93 (4.75) a
pes cavus (23)	14:9	43.78 (10.85)	28.37 (4.94)	30.23 (5.51)	21.36 (3.08)
neutrally aligned (29)	14:15	50.17 (6.39)	24.72 (2.85)	30.39 (4.23)	20.30 (1.72)
asympt. pes planus (22)	13:9	49.64 (7.97)	28.82 (6.60)	29.49 (5.55)	20.88 (3.13)
symp. pes planus (21)	11:10	54.43 (12.40)	29.67 (6.19)	29.11 (5.54)	21.15 (3.39)
	tibia/talus	cylin. skew (!)	frontal skew (!)*	trans. skew (!)*	cover. (!)*
ankle OA (13)	1.42 (0.31)	10.92 (8.89)	5.53 (4.99) b,d	9.03 (8.35) b	69.98 (8.57) a
pes cavus (23)	1.42 (0.24)	4.79 (3.83)	3.51 (3.70)	3.26 (2.67)	76.22 (7.01)
neutrally aligned (29)	1.50 (0.21)	6.06 (2.95)	1.01 (0.89)	5.85 (3.09)	75.27 (3.94)
asympt. pes planus (22)	1.41 (0.18)	5.95 (3.36)	0.99 (0.84)	5.79 (3.43)	75.66 (6.27)
symp. pes planus (21)	1.38 (0.15)	6.56 (3.44)	1.49 (1.03)	6.30 (3.49)	75.76 (5.36)

*overall significant difference (sig. diff.)
a = sig. diff. btwn OA and neutral, cavus, asympt. planus and symp. planus
b = sig. diff. between neutral and cavus
c = sig. diff. between neutral and cavus, asympt. planus and symp. planus
d = sig. diff. between OA and neutral, asympt. planus and symp. planus
rad. = radius, asympt. = asymptomatic, symp. = symptomatic, cylin. = cylinder, trans. = transverse, cover. = coverage

Table 1: Demographics, ankle morphology and alignment [mean (SD)]

of osteoarthritis in patients. A larger tibial and/or talar radius, which indicates a flatter bone, could affect the stability, depth and containment of the joint. Larger skew angles reflect less joint alignment. These parameters contribute to an unstable joint and are significantly correlated with primary osteoarthritis and could be considered intrinsic risk factors of developing ankle OA. However, our study did not address whether these characteristics developed before or after the ankle OA. Also, we found minimal relationships between foot types and these parameters, but this study was cross sectional, not longitudinal.

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Acknowledgements:

VA RR&D grant A4843C and the University of Washington MSRTP



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Treatment Of Gastrocnemius Equinus: Stretching Works

Abstract: Pre- and post-stretching ankle range of motion was measured in 62 patients (107 feet) who presented to our clinic with chronic foot and/or ankle pain in 2005. Ankle dorsiflexion (measured with the knee straight) increased on average 8° after 6 weeks of stretching and 68% of patients had sufficient relief from their pain to require no additional intervention, while 32% went on to gastrocnemius release. Targeted, consistent stretching should be the first course of treatment in patients with chronic foot and/or ankle pain because significant increases in ankle dorsiflexion are possible.

Study Rationale And Context

In order to determine an appropriate treatment protocol for patient with chronic foot and ankle pain and limited ankle dorsiflexion, we conducted a retrospective review of the clinical notes of patients who presented to our foot and ankle clinic. Stretching is associated with a reduction in symptoms [1] and we wondered if it was also associated with an increase in ankle dorsiflexion.

Clinical Questions

- Does stretching increase ankle dorsiflexion?
- In those patients whose symptoms do not resolved after conservative treatment, does gastrocnemius recession increase ankle dorsiflexion?

Methods

Study Design: Retrospective review of clinical records (IRB approved)

Inclusion/exclusion criteria:

- Our patient database for was searched for patients who presented in 2005 to the foot and ankle clinic for treatment of chronic foot and/or ankle pain.
- Inclusion criteria for this study include those patients who had a pre-

stretching and post-stretching ankle dorsiflexion assessment by the same physical therapist and whose pain was not associated with a traumatic injury.

- This yielded 62 individuals with data on 107 ankles (52 right, 55 left).

Measurements:

- Ankle range of motion (dorsiflexion and plantar flexion) was assessed with the knee extended and flexed $> 60^{\circ}$ by a single observer during the initial clinical visit and after 3 months of stretching.

Intervention:

- Patients with gastrocnemius equinus are instructed in two types of gastrocnemius stretches performed while shod. One is similar to the standard towel type stretch and the other involves standing with the midfoot on the edge of a stair and lowering the heel with the fulcrum near talonavicular joint. A critical element in both stretches is to reduce torsional stress in the midfoot by maintaining the subtalar joint in a neutral position. Patients complete two 30 second repetitions per day.
- Patients for whom stretching does not produce increase in ankle range of motion are considered for surgical

“lengthening” of the muscle complex, a gastrocnemius recession (also known as a Strayer procedure or “gastroc slide”), that releases the tendon that connects the gastrocnemius to the Achilles tendon, allowing the gastrocnemius to slide proximally across the underlying soleus fascia.

Results

- After stretching for an average of 49 days, the average ankle dorsiflexion value with an extended knee increased 8° from -12.4° to -4.3° (Table 1 and Figure 1).
- Ankle dorsiflexion with an extended knee was significantly lower than dorsiflexion with a flexed knee ($p < 0.0001$) during the initial clinic visit in all individuals, indicating the presence of gastrocnemius equinus.
- Dorsiflexion and plantar flexion values were not different between the left and right ankles ($p > 0.09$). No patient admitted to non-adherence to the stretching regime at the initial follow-up.
- For 20 patients (18 right and 15 left feet) of the 62 patients (32%), stretching was unsuccessful and did not resolve their pain and they required a gastrocnemius recession.
- Three of the patients who had

Variable	Time	All patients	Non-recession	Recession
# patients (feet)		62 (107)	42 (74)	20 (33)
Dorsiflexion, Extended knee (°)*	Initial	-12.4	-11.5	-14.3
	Stretching	-4.3	-2.2	-8.9
	Recession	---	---	5.6
Dorsiflexion, Flexed knee (°)*	Initial	6.1	7.2	3.3
	Stretching	8.5	9.6	5.4
	Recession	---	---	10.8
Plantar flexion, Extended knee (°)	Initial	53.6	54.3	43.7
	Stretching	52.0	53.6	42.2
	Recession	---	---	41.4

Table 1: Average ankle range of motion values.

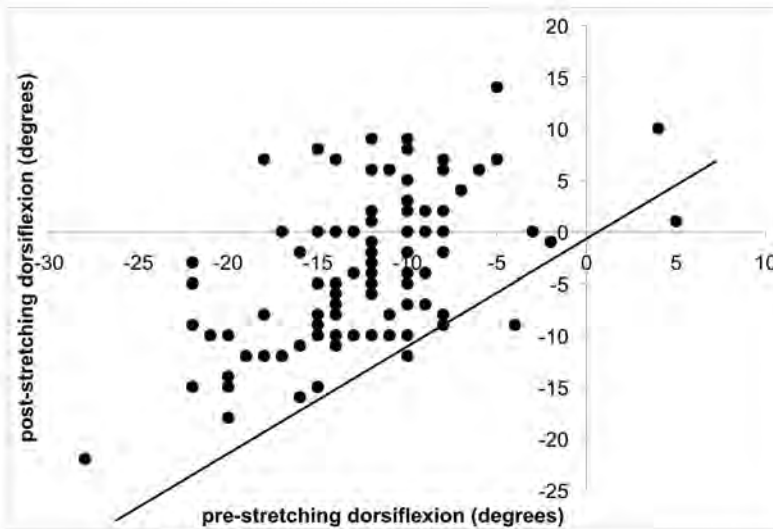


Figure 1: Ankle dorsiflexion in 107 feet measured pre- and post-stretching. Values above and to the left of the line indicate increases in dorsiflexion.

recessions also had additional surgical procedures, including cheilectomies and/or midfoot reconstruction.

- No complications occurred in the surgical patients.

Discussion

- Gastrocnemius recession has been reported to increase ankle dorsiflexion by approximately 20° and to allow extended knee dorsiflexion to equal bent knee dorsiflexion in short-term follow-up [1]. We obtained similar increases in ankle range of motion (-14.2° to +5.6°).

- Conservative treatment that

includes stretching appears to be an effective treatment in people with chronic foot and/or ankle pain, with many patients receiving enough relieve from their symptoms to not seek further medical care. In those patients who do not obtain relief from their symptoms with conservative treatment, gastrocnemius recession does significantly increase ankle dorsiflexion.

- We recommend this two-tier approach: conservative treatment that includes the stretching regime described herein for all patients, followed by gastrocnemius recession

These anteroposterior and lateral standing radiographs demonstrate a middle aged female with significant forefoot pain. The lateral standing image shows the heel to be off level ground and the ankle joint to be in plantar contracted position 10 degrees short of neutral. The forefoot has splayed slightly in response to the abnormal resultant loading. Heel cord stretching as described in this paper helped alleviate the patient's symptoms without further surgery.

for those for whom conservative treatment fails to allay their symptoms.

Conclusions

- Targeted, consistent stretching should be the first course of treatment in patients with chronic foot and/or ankle pain because significant increases in ankle dorsiflexion are possible.

- Patients that do not obtain substantial improvement in ankle dorsiflexion with stretching should be considered for gastrocnemius recession.

References

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Spine

Our UWMedicine Spine Service is comprised of a multidisciplinary effort to provide the best possible evidence based care for the full range of spinal disorders affecting patients of all ages. We provide services at Harborview Medical Center, the University of Washington Medical Center, Seattle Childrens Hospital and the Eastside Specialty Center.

Our core service line has 6 surgeons with primary Orthopaedic appointments, 4 with primary Neurosurgical appointments and 8 colleagues with primary appointments in the Department of Rehabilitation Medicine. We also enjoy a close working relationship with our colleagues in the UW Pain Center and are privileged to have consultation resources that encompass all medical and surgical specialties within UWMedicine.

Our Postresidency program offers 3 post-residency training (ACE) positions for Orthopaedic and 2 positions for Neurosurgical colleagues. In addition, we have become one of the more popular rotations among the 5 total residents who rotate on the Spine service from both Orthopaedics and

Neurosurgery.

We provide a regular in-house didactic and peer review process through weekly pre-operative indications conferences, weekly radiology case discussions, monthly quality improvement conferences and a monthly Spine Grand Rounds. A special meeting highlight are our monthly Spine Journal Clubs which are generously organized and hosted by Theodore and Iris Wagner in their home. They are designed to provide an informal interdisciplinary knowledge forum for residents, ACE's, fellows, UW faculty and community colleagues. We are also proud of our over 10 year track record of hosting the Annual HMC spine symposium, which has been fully subscribed since its inception and has drawn notable international lecturers as well as attendees from a wide geographic drawing area. Many of these lectures have become very popular on a variety of e-media outlets. If you are interested in these shows please check them out under www.uwv.org/schedule/ enter spine or spine related topic or www.orthop.washington.edu/uw/tabID__3438/

Default.aspx or download them as a Podcast from I-Tunes (Podcasts>Itunes U>Research Channel>Health and Medicine).

Our research efforts are highlighted by a strong emphasis on patient outcomes in patients with traumatic and degenerative spinal conditions. In addition, biomechanical studies have assessed the impact on spinal stability of various surgical approaches to common degenerative spinal conditions. We have also participated in a number of large multicenter studies on geriatric odontoid fractures and cervical spondylotic myelopathy.

Featured Clinical Practice:

Among our more traditionally arranged spine care sites within UWMedicine and Seattle Childrens, the Spine Center at Harborview presents a novel integrated multispecialty service line delivering state-of-the-art clinical care, teaching and research.

This patient friendly, cost effective multidisciplinary approach to spine care brings together an array of specialists, resulting in a unique partnership of physiatrists, neurosurgeons, orthopaedic surgeons, radiologists, and anesthesiologists, working together to evaluate each individual patient's spinal condition in order to decide the best course of surgical or non-surgical treatment. We provide personalized, expert care for patients with both simple and complex disorders of the spine. Our philosophy of having patients actively participate in their own health-care decisions is evident throughout the continuum of care. We acknowledge and respect the individuality of each patient and treat each one accordingly.

HMC Surgical Spine Clinic:

During the five years since the inception of the Harborview Spine Center:

- Overall clinic visits have increased by nearly 50%.
- New patient referrals have progressively increased to current levels of over 130 per month, resulting in a monthly new patient average of 25%.



Over the years our residents and Spine ACE's have become prominently represented in Washington State spine care. From left to right: Mark Freeborn ACE '09 – Evergreen MC; Jason Thompson ACE '05 – Valley Orthopaedic Associates; Alexis Falikov Res '04 – Swedish MC; Joel Hoekema Res '00 – Bellingham; Jens R. Chapman.

Name	Title	Practice Locations	Special Functions
Carlo Bellabarba	Associate Prof / OS	HMC	Director, UW Ortho Spine Fellowship & HMC Ortho Spine
Eching Bertelsen-Voon	PA-C	UWMC – R2	
Kirk Butler	PA-C	HMC	
Richard J Bransford	Assistant Prof / OS	HMC	Director Ortho Spine Residency Education
Jens R. Chapman	Professor / OS	HMC, UWMC – R2	Chief UWSpine
Randy Chesnut	Professor / NS	HMC	Chief Neurotrauma and Neurosurgical Spine
Sue Earls	PA-C	UWMC – R2	
Nelson Hager	Clin Assoc Prof / RM	UWMC	Chief B&J Center
Mark Harrast	Clin Assoc Prof / RM	HMC, ESC	Co-Director of the UW Medicine SSP Fellowship Program
Stan Herring	Clin Prof / RM	HMC	Chair MSK – Spine Committee Medical Director of UW Medicine Spine Care
Virany Hillard	Assistant Prof / NS	UWMC, ESC	
Marla Kaufman	Clin Assist Prof / RM	UWMC	
Brian Krabak	Clin Assoc Prof / RM	UWMC, Sports Medicine	
Wally Kregel III	Clin Assoc Prof / OS	SCH	Chief Pediatric Spine
Scott Laker	Clin Assist Prof / RM	HMC	
Michael J. Lee	Assistant Prof / OS	UWMC, ESC	Chief UWSpine Research and Chief UWMC 6SE
Patricia O’Leary Crutcher	Director	HMC	Service Line Manager
Pat Merenda	ARNP	HMC	
Dena Pruitt	PA-C	HMC	
Chris Standaert	Clin Assoc Prof / RM	HMC	Member HTA, HCA
Trent Tredway	Assistant Prof / NS	UWMC	Fellowship Director NS-Spine Chief Minimally Invasive spine surgery
Theodore Wagner	Clin Prof / OS	UWMC, SCH	Chief of UWMC Orthopaedic Spine Service
Stuart Weinstein	Clin Assoc Prof / RM	HMC	Liaison WA State L&I program Co-Director of the UW Medicine SSP Fellowship Program
Fangyi Zhang	Associate Professor	HMC	

- Surgical volumes (both emergent and elective) have increased by over 50%.

- Initial appointments are available within two weeks of referral, reflecting the priority placed on access to services.

- The no-show rate has decreased to 6%, consistently one of the lowest at HMC.

- A move to a new location in the newly opened Ninth & Jefferson Building, Fifth floor, took place last year, in order to accommodate for growth.

Acknowledgements

Harborview Medical Center’s Cares award is given to one Department and two physicians quarterly for demonstrating the Service Excellence Model. Both Dr. Carlo Bellabarba and Dr. Richard Bransford have received this award individually as has the Spine Clinic as a whole.

In 2010, we were awarded the Blue Distinction Center of Excellence for Surgical Spine designation by Blue Cross Blue Shield.

Dr. Michael J. Lee won the AO Spine Young Investigator Award for his proposal on identifying risk profiles in

Spine surgery patients. He was also elected to serve as UWMC 6 SE Medical Center director with the goal to advance patient safety and effective delivery of care. Dr. Abilio Reis, Spine ACE 2010, won the AOSpine Clinical Research Prize for his work on comparing survival rates of cranio-cervical dissociations before and after changes in diagnostic algorithms. (Please look for an excerpt of this project in the spine section of this report.)

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Director, UW Orthopaedic Spine Fellowship Program
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Immunohistochemical Detection of Type IX Collagen in the Intervertebral Discs of Surgical Patients Genotyped for Degeneration-Associated SNPs

Abstract: Disc tissue removed at spinal fusion surgery was analyzed immunohistochemically to determine if collagen type IX was present in adult annulus fibrosus and nucleus pulposus and if abnormal accumulation of collagen type IX was associated either with severity of degeneration or incidence of a collagen IX tryptophan single nucleotide polymorphism genotype.

Study Rationale and Context:

Genetic factors are strongly associated with risk of development and/or progression of disc degeneration. Two single nucleotide polymorphisms (SNPs) that introduce tryptophan polymorphisms in different collagen type IX genes, Gln326Trp in COL9A2 and Arg103Trp in COL9A3, are independently linked to an increased risk of lumbar disc disease [1-4]. Although tryptophan variants are associated with accelerated degeneration, it is not known if collagen IX can be detected in adult disc tissue.

Objective

To determine if collagen IX can be detected in adult disc tissue removed at spinal fusion surgery from patients genotyped for degeneration-associated tryptophan single nucleotide polymorphisms (SNPs) and whether the distribution can shed light on the mechanism through which tryptophan-encoding SNPs can accelerate degeneration.

Material and Methods

Under informed consent as part of an IRB approved study, disc

tissue was obtained from patients undergoing spinal fusion surgery for lumbar degenerative disease or lumbar fracture [2]. We selected age-matched disc samples from five clinical groups: Fracture with Trp(-) (6 cases), Herniation (6 cases), Degeneration (5 cases), Spondylolisthesis with Trp(-) (8 cases) and Spondylolisthesis/Herniation/Fracture with Trp(+) (7 cases). A total of 78 sections from 32 patients were analyzed by H&E staining and immunohistochemical staining (collagen IX and collagen IIA). Selected disc tissues were assayed biochemically for type IX collagen [5].

Results

Focal deposition of collagen IX was observed in regions of adult human disc tissue from spines showing degenerative changes in patients whether or not they were positive for a tryptophan SNP. However, in non-degenerative control disc tissue from fracture cases, little or no collagen IX was detected. The latter finding was confirmed by direct biochemical analyses for collagen IX in pooled samples of normal adult human annulus fibrosus or nucleus pulposus.

Discussion

- Strong staining for type IIA procollagen and type IX collagen was seen in disc samples from patients with disc degeneration but not from the control fracture group. The most likely explanation for this is the expression of type IIA and type IX collagen in regions of disc tissue undergoing degenerative changes in response to injury.

- The amount of collagen IX deposited in degenerate discs does not appear to be related to the patient's Trp SNP genotype status. The main determinant appears to be whether degenerative changes have occurred or not, and herniation seems to result in the greatest amount.

- A possible mechanism for accelerated disc degeneration in genetically susceptible individuals is through chronic activation of macrophages by the newly expressed tryptophan-containing collagen IX.

Conclusions

During growth and maturation of the disc, collagen IX is removed completely during matrix remodeling so that the protein disappears from adult annulus and nucleus but can

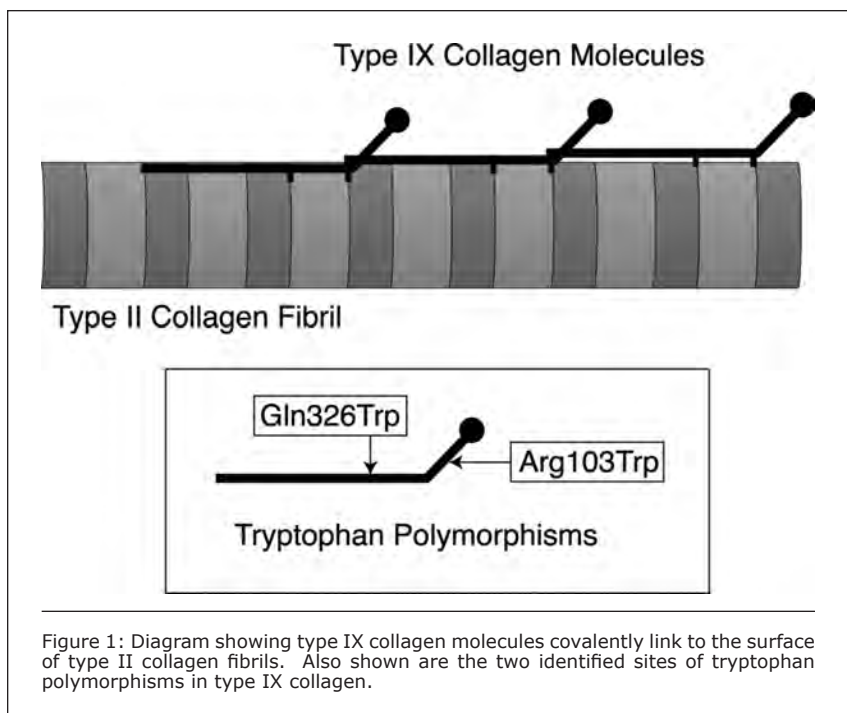


Figure 1: Diagram showing type IX collagen molecules covalently link to the surface of type II collagen fibrils. Also shown are the two identified sites of tryptophan polymorphisms in type IX collagen.

reappear at sites of degeneration as part of a repair response to mechanical injury.

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This work was supported in part by U.S. National Institutes of Health grants AR37318 and AR36794 and the Burgess Chair Endowment of the University of Washington.

Pt	Age	Sex	Race	Dx	Trp	Location	IIA			Type IX		
							NP	EP	IA	NP	EP	IA
1	16	F	C	Fx	(-)	T11-L1	-	n/a	-	±	n/a	-
2	19	F	C	Fx	(-)	L2-4	-	-	-	-	-	-
3	26	M	B	Fx	(-)	L3-4	-	-	+	-	-	+
4	47	F	C	Fx	(-)	L1-2	-	n/a	-	-	n/a	-
5	56	M	A	Fx	(-)	L1-2	-	-	±	±	-	+
6	64	F	C	Fx	(-)	L1-2	-	n/a	-	-	n/a	-
7	24	F	C	SP	W3	L4-S1	++	-	++	±	±	±
8	33	M	B	H	W3	L4-S1	++	±	++	+	±	+
9	44	F	C	SP	W3	L5-S1	++	±	++	-	±	-
10	50	F	C	SP	W3	L5-S1	+	-	++	-	±	+
11	52	F	B	SP	W2	L4-5	+	±	+	±	±	++
12	66	M	C	Fx	W3	T4-6	-	-	-	-	-	+
13	77	M	C	SP	W3	L1-S1	++	±	-	-	-	±

Table 1: Patient characteristics and findings for the fracture group (Trp-) and lumbar degenerative spondylolisthesis/disc herniation/fracture group (Trp+)

F: Female; M: Male; a: Asian; b: African American; c: Caucasian; Fx: Fracture; H: Disc Herniation; SP: Spondylolisthesis; W2: Tryptophan polymorphism at residue 326 of the α2(IX) chain; W3: Tryptophan polymorphism at residue 103 of the α3(IX) chain; IIA: type IIA procollagen; α1(IX) NC4: long form of α1(IX) chain; NP: nucleus pulposus; EP: end plate; IA: inner annulus; (-): negative; (±): weak positive staining; (+): Clear positive staining; (++): strong positive staining; n/a: tissue is not available; *: Positive staining on annulus just adjacent to EP.



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Lordosis Restoration in the Lumbar Spine after Smith Petersen Osteotomies Without and With Interbody Strut Placement

Abstract: In this cadaveric study, we examined the lordosis in lumbar spine specimens in the 1) intact specimen, 2) after Smith Peterson osteotomies and, 3) Smith Petersen Osteotomies with Interbody Strut Placement. We compared the amount of lordosis restoration in these three conditions using lateral x-ray and ImageJ software in 18 human lumbar spines from L2-L5. The average lordosis in an intact specimen was 7.03 degrees (s.d.2.21), after Smith Petersen Osteotomies 11.05 degrees (s.d.1.95), and after Smith Petersen Osteotomies and interbody strut placement 15.72 degrees (s.d.3.19). This study presents an alternative technique in the restoration of lordosis of the lumbar spine.

Study Rationale and Background:

Varying strategies have been described to restore lordosis in a kyphotic spine. In 1945, Smith-Petersen described an osteotomy which has been reported restore roughly 10 degrees of lordosis per level[1-3]. A pedicle subtraction osteotomy has been suggested to restore at least 30 degrees, but this technique is associated with substantial blood loss and technical difficulty[1, 2, 4]. The purpose of the present study was to assess the extent of segmental lordosis restoration in human lumbar cadaveric specimens with Smith Petersen Osteotomies and a lumbar interbody strut placement

Clinical Question:

- How much segmental lumbar lordosis can be achieved with Smith-Petersen Osteotomies and lumbar interbody strut placement?

Methods:

Study Design

Cadaveric radiographic study

Inclusion and Exclusion criteria:

- 6 human lumbar cadaveric specimens: 18 lumbar segments.

Outcomes and Analysis:

- Segmental lumbar lordosis measured on lateral x-rays using ImageJ software in three separate conditions:

- 1) Without osteotomy and discectomy in maximal extension, (Figure 1A)

- 2) After bilateral pars and inferior facet resection of L2, L3 and L4 and in maximal extension with pedicle screw fixation from L2-L5, (Figure 1B (Osteotomy))

- 3) After bilateral pars and inferior facet resection of L2, L3, and L4, bilateral discectomy and interbody strut placement at L2-3, L3-4, L4-5, and in maximal extension with pedicle screw fixation from L2-L5, (Figure 1C (Osteotomy + Interbody))

Results:

- The average segmental lordosis of the 6 specimens (18 segments) was evaluated without osteotomy was 7.03 degrees (s.d. 2.21).

- After Smith Petersen osteotomies, the average lordosis increased to 11.05 degrees (s.d. 1.95).

- After Smith Petersen osteotomies and interbody strut placement, the

average lordosis increased to 15.72 degrees (s.d. 3.19)

- Using the paired two sample t test, the use of interbody strut yielded a statistically significant increase in lordosis ($p < 0.01$) (Figure 2)

Discussion:

- This study demonstrates that Smith Peterson Osteotomy combined with interbody strut yields on average 15 degrees of lordosis restoration

- Our data for average lordosis correction for Smith Petersen Osteotomies (11.05 degrees) is consistent with what has been reported to the literature

- Though we did not test this against a pedicle subtraction osteotomy in this study, or clinically, the Smith-Petersen Osteotomy with Interbody technique (Figure 3) done at 2 levels may yield comparable correction as compared to a pedicle subtraction osteotomy (Figure 4).

- The proposed hypothetical advantages of the studied technique over a pedicle subtraction osteotomy is 1) likely substantially less blood loss than PSO, 2) maintenance of anterior column length and likely less

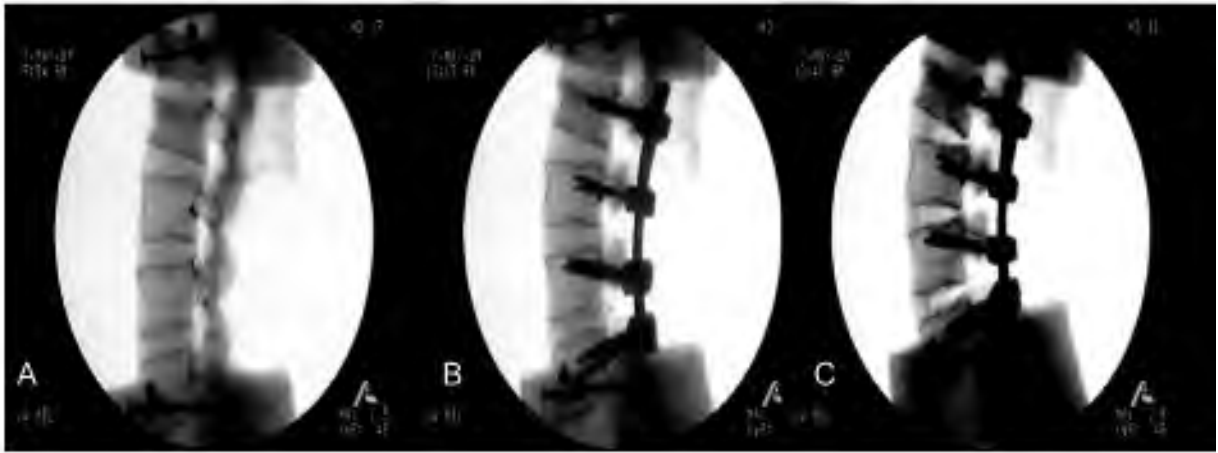


Figure 1 : A) the intact specimen. B) After Smith Petersen Osteotomies from L2-L5. C) After Smith Petersen Osteotomies and Interbody Strut Placement from L2- L5

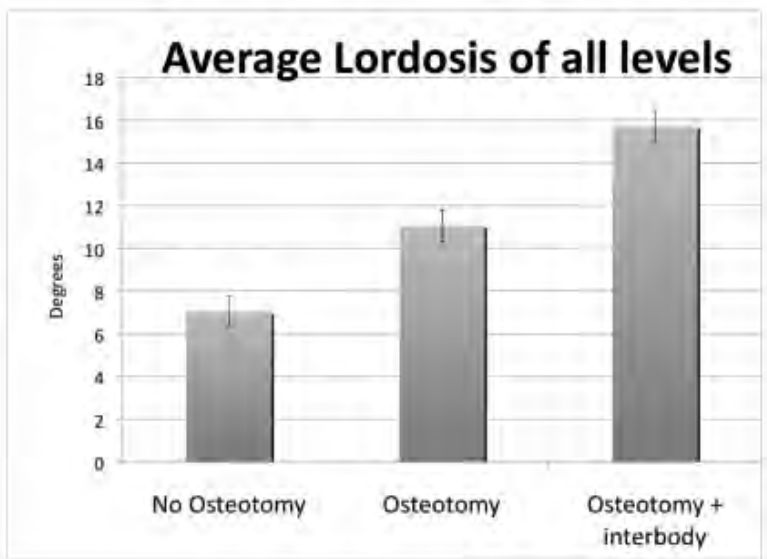


Figure 2: Degrees of Lordosis in the 1) intact specimen, 2) after Smith-Petersen Osteotomy, 3) after Smith-Petersen Osteotomy and interbody strut placement.

dural redundancy and potentially less neurological injury.

- Future studies comparing these techniques clinically are needed to further assess the advantages and disadvantages of various techniques.

Conclusions:

- The present study suggests that up to 15 degrees of lordosis can be restored segmentally with Smith-Petersen Osteotomy and lumbar interbody strut placement.

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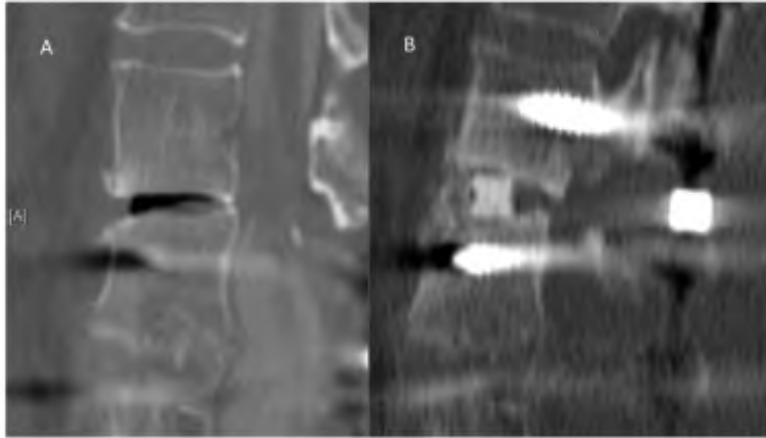


Figure 3: CT scan of patient before (A) and after (B) Smith Petersen Osteotomies with interbody strut placement demonstrating improvement of lordosis.



Figure 4: X-rays of patient before and after pedicle subtraction osteotomy demonstrating the substantial lordosis correction. The pedicle subtraction osteotomy has been associated with substantial blood loss and surgical morbidity [1, 2].



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Diagnosis and Treatment of Craniocervical Dissociation in 48 Consecutive Survivors

Abstract: In this case series we wanted to determine if any improvements have been made in the timing to diagnosis and the neurological outcome of patients with craniocervical dissociation. Using our institutional trauma database, 48 consecutive CCD survivors were identified between 1996 and 2009. The initial 17 patients were compared with the latter 31 patients. Despite significant improvement being made in time to diagnosis there was no significant difference in the final neurologic function at the latest follow-up.

Study Rationale And Context

Craniocervical dissociation (CCD) is a rare and frequently fatal condition. Despite being rather dramatic, these injuries are unfortunately frequently missed. Lack of familiarity with the anatomy, preoccupation with other organ systems in these commonly polytraumatized patients, disruption of the established spine clearance algorithm and the relative rarity of these injuries all contribute to this circumstance. Our previous study had reported 17 survivors, which at the time was the largest reported series of CCD patients. We had identified a 76 % rate of missed injuries in that study, which was frequently associated with secondary neurologic deterioration. This study represents the largest series in the literature and provides guidelines for treatment and describing outcomes.

Clinical Question

- Do changes in triaging of patients and spine clearance with CT protocols change the rate of detection of unstable CCD?
- Do CCD survivors undergoing rigid internal fixation have improved neurologic outcomes when diagnosed earlier?

Methods

Study design: Case series (IRB approved)

Inclusion criteria

All CCD survivors undergoing rigid internal fixation from occiput to C2 between 1996 and 2008

Exclusion criteria

Any CCD patient deceased prior to surgical treatment or not requiring surgery.

Patient population and interventions

- Forty-eight consecutive survivors were identified.
- Thirty-one patients treated from 2003 to 2008 were compared to 17 patients who were treated from 1996 to 2002 and reported previously[1].
- All patients sustained high-energy injuries and were evaluated according to standard ATLS protocols.
- Once CCD was identified or suspected (Figures 1 & 2), provisional stabilization was applied and MRI evaluation performed (Figure 3).

- Definitive surgical management with rigid posterior instrumentation and fusion was performed as soon as physiologically possible (Figures 4 & 5).

Outcomes

- Primary outcomes: Average time to diagnosis, mean initial and final ASIA

motor scores.

- Secondary outcomes: Modality used for diagnosis, clinical effect of delayed diagnosis, potential clinical or imaging warning signs, and response to treatment. Means were compared using the student t-test.

Results

- Craniocervical dissociation (CCD) was identified on initial cervical spine imaging in 26 patients (84%). The remaining 5 patients (16%) were diagnosed by cervical spine MRI.

- Twenty-six patients (83.9%) were diagnosed within 24 hours of presentation, 4 (12.9%) were diagnosed between 24 and 48 hours, and 1 (3.2%) experienced a delay of greater than 48 hours (Table 1).

- By comparison, 4 (24%) of the previously treated 17 patients were diagnosed on initial cervical spine imaging. Four patients (24%) were diagnosed within 24 hours of presentation, 9 (52%) were diagnosed between 24 and 48 hours, and 4 (24%) experienced a delay of greater than 48 hours.

- There were no cases of craniocervical pseudarthrosis or hardware failure during a mean



Figure 1: Initial lateral C-spine radiograph obtained as part of the initial ATLS survey demonstrating an occiput-C1 distractive injury.



Figure 2: Sagittal C-spine CT scan obtained as part of the initial ATLS survey demonstrating an occiput-C2 distractive injury.

Delay in Diagnosis	Previous Study	Current Study
Less than 24 hours	4 (24%)	26 (83.9%)
Between 24 and 48 hours	9 (52%)	7 (12.9%)
More than 48 hours	4 (24%)	1 (3.2%)

Table 1: Time to diagnosis.

	Mean Initial ASIA Motor Score	Mean Final ASIA Motor Score
Previous Study (17 patients)	50	79
Current Study (31 patients)	47	60
P-value	0.82	0.12

Table 2: Mean ASIA motor scores.

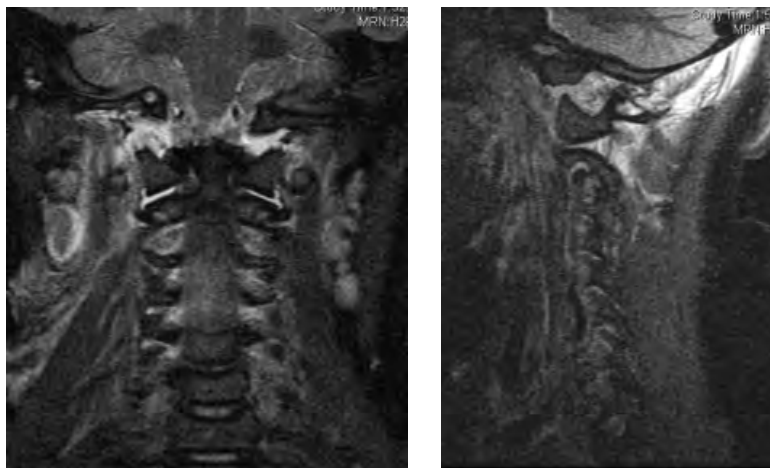


Figure 3: Pre-operative coronal and sagittal T2 MRI sequences demonstrating increased signal intensity on the occiput-C1 and C1-2 joints.

9-month follow-up period.

- The mean American Spinal Injury Association (ASIA) motor score of 47 improved to 60, and the number of patients with useful motor function (ASIA Grade D or E) increased from 8 (26%) preoperatively to 17 (55%) postoperatively (Table 2).

Discussion

- Despite demonstrating a significant improvement in time to diagnosis, the study was unable to demonstrate a significant improvement in final ASIA motor score.

- This significant improvement in time to diagnosis can be explained in part by the routine use of cervical spine CT scans using rapid acquisition technology as part of the ATLS evaluation.

- Differences in length of follow-up may account for the lack of improvement in final ASIA motor score.

- Strengths: This is the largest series of CCD survivors ever reported in the literature.

- Limitations: Case control study design and rare pathology limits our capacity to detect significant differences between groups.

Conclusion

- Improvements have been made in the time to diagnosis of CCD in recent years.

- Increased awareness and the routine use of CT scan as part of the initial ATLS evaluation are likely responsible for this progress.

- Expedited diagnosis has



Figure 4: Post-operative lateral C-spine radiograph showing rigid posterior instrumented fusion from occiput to C2.



Figure 5: Post-operative sagittal C-spine radiograph showing rigid posterior instrumented fusion from occiput to C2.

decreased preoperative neurological deterioration. However, differences in length of follow-up between the two groups preclude conclusions about its effect on long-term neurological outcome.

- Work that remains to be done includes establishing new CCD classification system, which differentiates anatomic and biomechanical considerations and guides treatments and outcomes.

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Risk Factors for Surgical Site Infection After Spine Surgery

Abstract: In this prospective cohort study, we performed a univariate and multivariate analysis of risk factors for surgical site infection (SSI) after spine surgery. The Spine End Results Registry (SERR) is an IRB approved, prospective registry of patients who have undergone spine surgery in the University of Washington Medical Center or Harborview Medical Center. We analyzed the data of 1524 patients who underwent spine surgery from 2003 to 2004. The outcome of measure was surgical site infection requiring return to the operating theatre for debridement and irrigation. Our multivariate analysis suggested that revision surgery, obesity, underlying diagnosis (trauma, neoplasm), surgical level (thoraco-lumbar), and surgical invasiveness were risk factors for the development of SSI.

Study Rationale and Background:

Numerous studies have analyzed risk factors for SSI[1-5]. Risk factors suggested have included: diabetes, smoking, obesity, diagnosis, surgical level, approach and surgical invasiveness. Prior studies examining this subject were done retrospectively and with randomly generated matched control groups for comparison. The purpose of the present study was to evaluate risk factors and their relative risks for SSI after spine surgery using prospective collected data from the SERR.

Clinical Question:

- What are risk factors and their relative risks for SSI after spine surgery?

Methods:

Study Design
Prospective cohort study

Inclusion and Exclusion Criteria:

- All patients who underwent spine surgery at UWMC or HMC from Jan 1st 2003 to Dec 31st 2004 over 18 years of age.

- We excluded patients with history or prior spinal infection, and patients who were taken to the operating theatre for a non-invasive procedure (i.e. casting).

Outcomes and Analysis:

- The primary measure of outcome was surgical site infection requiring IV antibiotics with or without return to the operating theatre for irrigation and debridement.

- Univariate analysis examining age, diabetes, smoking, obesity, gender, alcohol, drug use, Charlson Co-Morbidity score, revision surgery, surgical level, surgical approach, diagnosis, and surgical invasiveness was performed.

- Multivariate analysis was performed analyzing risk factors in the univariate analysis that suggested statistical significance, and risk factors identified by previous literature.

- We utilized the unpaired two-sample t test for comparison of continuous variables and proportion analysis for comparison of categorical variables.

Results:

- The incidence of SSI requiring return to the OR for washout was 8% (120 patients).

- In the univariate analysis, we identified revision surgery, surgical level (thoraco-lumbar-sacral), and surgical invasiveness as statistically significant risk factors for SSI. Obesity, diagnosis (trauma, neoplasm) and Charlson co-morbidity approached statistical significance (Table 1).

- In the multivariate analysis, diagnosis (trauma), surgical level (thoraco-lumbar-sacral) and surgical invasiveness were identified as statistically significant risk factors. Revision surgery, obesity and a tumor diagnosis trended towards statistical significance (Table 2).

- Diabetes and smoking were not significant risk factors in the univariate or multivariate analysis.

Discussion:

- The present study's multivariate analysis identifies surgical invasiveness, surgical level, and a trauma diagnosis as statistically significant risk factors

- While obesity, diagnosis of

Risk Factors	RR of SSI	95% CI	p-value
Age (yr), mean (sd)			
18 - 39	1.00	-	-
40 - 64	1.19	0.77 - 1.82	0.43
≥65	1.44	0.87 - 2.38	0.15
Gender			
Male	1.00	-	-
Female	1.13	0.80 - 1.60	0.48
Smoking			
No	1.00	-	-
Yes	1.02	0.70 - 1.50	0.91
Alcohol			
No	1.00	-	-
Yes	0.84	0.59 - 1.20	0.35
Drug Use			
No	1.00	-	-
Yes	0.75	0.37 - 1.50	0.40
Diabetes			
No	1.00	-	-
Yes	1.32	0.79 - 2.20	0.30
BMI			0.28
Underweight (< 18.5)	1.00	-	-
Normal (18.5 - < 25)			
Overweight (25 - < 30)	0.64	0.41 - 1.02	0.06
Obese (30 - < 35)	1.07	0.67 - 1.72	0.77
≥ 35	1.50	0.92 - 2.44	0.10
Charlson Comorbidity Adjusted, mean (sd)			0.18
0	1.00	-	-
1	0.83	0.52 - 1.32	0.43
2	1.62	1.03 - 2.55	0.04
3	0.75	0.31 - 1.82	0.67
4	1.74	0.80 - 3.82	0.16
>5	1.49	0.50 - 4.44	0.45

Risk Factors	RR	95% CI	p-value
Gender (female)	0.97	0.66 - 1.41	0.86
Diabetes (yes)	1.29	0.73 - 2.29	0.38
Revision (yes)	1.53	0.96 - 2.46	0.08
Age (yr)			
18 - 39	1.00	-	-
40 - 64	1.09	0.68 - 1.76	0.72
≥ 65	1.04	0.58 - 1.85	0.90
BMI			
Underweight / Normal (< 25)	1.00	-	-
Overweight (25 - < 30)	0.63	0.39 - 1.01	0.06
Obese (30 - < 35)	1.05	0.63 - 1.75	0.86
> 35	1.64	0.95 - 2.84	0.08
Charlson Comorbidity Adjusted			
0	1.00	-	-
>=1	0.91	0.61 - 1.34	0.62
Diagnosis Group			
Degenerative	1.00	-	-
Trauma	1.78	1.04 - 3.02	0.03
Neoplasm	1.69	0.86 - 3.35	0.13
Other	0.84	0.32 - 2.19	0.71
Diagnosis Level			
Cervical	1.00	-	-
Lumbar	1.64	1.01 - 2.66	0.05
Thoracic	1.78	1.01 - 3.17	0.05
Sacral	3.85	1.29 - 11.5	0.02
Invasiveness Index			
1 - 5	1.00	-	-
6 - 10	1.50	0.87 - 2.60	0.15
11 - 15	2.44	1.40 - 4.25	0.002
>16	3.80	2.19 - 6.58	<0.001

Table 1 and 2: 1) (left) Univariate Analysis of Relative Risk for Surgical Site Infection, 2) (right) Multivariate Analysis of Relative Risk for Surgical Site Infection.

tumor, and revision surgery were not observed to be statistically significant risk factors, their relationship with SSI trended towards significance. With larger numbers this association may be better defined. Clinically, based on our experience and prior studies we regard these as risk factors for SSI[1-5].

- Diabetes and smoking have been suggested to be risk factors for SSI, but this was not observed in the present study. This may be reflective of one of the weaknesses of this study in that these data were recorded as Boolean variables (yes/no). The severity of diabetes and extent of smoking were not prospectively recorded. Further analysis examining peri-operative glucose levels, Hemoglobin A1C, extent of cigarette smoking may provide a more accurate assessment of the relationship between smoking, diabetes and SSI. Clinically, we regard diabetes and smoking to be risk factors for SSI.

Conclusions:

- The present study identifies surgical level, diagnosis of trauma, and

surgical invasiveness as statistically significant risk factors for SSI.

- Obesity, diagnosis of tumor, and revision surgery is likely associated with SS.

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4. Browne, J.A., et al., Diabetes and early postoperative outcomes following lumbar fusion. *Spine (Phila Pa 1976)*, 2007. 32(20): p. 2214-9.
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Veterans

The Puget Sound Veteran's Administration Medical Center (VA) continues to be a very popular rotation for the Orthopaedic residents. We have a general tertiary care orthopaedic practice at the VA and we see patients from the entire northwest including Alaska as well as states outside of the Northwest. We see a wide variety of both general orthopaedics, as well as complex orthopaedic problems. This past year we performed approximately 1,100 cases and remained one of the busiest VA orthopaedic programs in the country.

Our University of Washington residents continue to rate the VA rotation as one of their favorites. While closely supervised, they are given graduated responsibility throughout their training at the VA. Our goal at the VA is to train residents that are dedicated to caring for patients with potentially difficult socioeconomic issues, as well as residents who if they so choose, would be able to graduate from our residency and achieve a high level of expertise in a general orthopaedic practice.

Research at the VA continues to be robust. The VA Center of Excellence for Limb Loss and Prevention and Prosthetic Engineering is directed by Bruce Sangeorzan, MD, and co-directed by Joe Czerniecki, MD, a member of the Department of Rehabilitation Medicine. Liu Yang, PhD, and Howard A. Chansky, MD direct the Sarcoma and Cartilage Biology Laboratory and have developed unique animal models to study the EWS/FLI1 sarcoma fusion protein and ESET, a protein that appears to play an important role in skeletal development. Residents are involved in various projects in both of these laboratories, as well as other clinical outcome studies of patients at the VA.

As the clinical demands on our service have grown we have been fortunate to hire and retain excellent staff. Steve Casowitz, PA has recently joined Dustin Higbee, PAC as the physician-assistant stalwarts of our surgical service. Jenny Chen-Lau, NP, Sue Grischott, NP, Monette Manio, RN and Annette Testa, LPN, manage our busy outpatient clinics. Overseeing



A bird's eye view of Puget Sound Veteran's Administration Medical Center.

the entire orthopaedics enterprise is our Administrative Officer and armed forces veteran, Richmond Sanders. John Sack, MD somehow still finds time to practice hand surgery at several different hospitals, one of them fortunately being the VA. Fred Huang, MD and Mike McAdam, MD two of our stellar former residents continue to maintain a presence at the VA and we are fortunate to have their involvement in teaching and clinical care. A perennial favorite of our residents, patients and surgical attendings is our orthopaedic charge nurse Anne Dinsmore, RN. We have been fortunate to have Anne on our side to keep our complex surgical operation running as smoothly as possible.

The Puget Sound VA Medical Center itself is undergoing a major expansion with the addition of a new research building, as well as extensive additions to the clinical tower and the addition of extensive above and underground parking facilities. All of this construction should improve the quality of care for our veterans and their families and the quality of the work environment.

Last but certainly not least, we are very excited about the recruitment of Jason Wilcox, MD, to a full-time position at the VA beginning this August. Jason graduated from the University of Washington Orthopaedic Residency in 2009 and is currently enrolled in

a Sports Medicine Fellowship at the University of Utah. We have never had a fellowship trained sports surgeon based at the VA and thus Jason will bring a new dimension of orthopaedic care to the veterans of the northwest. Dr. Wilcox also has an interest in orthopaedic outcome studies, as well as in issues pertaining to the training of orthopaedic residents. Jason will bring fresh insights and energy to our program as we move forward. Finally, we have active plans to recruit in conjunction with our academic partners an additional surgeon to develop a spine program at the VA.

Howard A. Chansky, M.D.
Professor and Vice Chair

Pediatrics

The Department of Orthopedics specializes in providing the highest-quality pediatric care for both general and specialized pediatric orthopedic problems to patients in the Northwest. Our sites of clinical care include Seattle Children's Hospital and locations in Bellevue, Federal Way, Olympia and Everett as well as outreach facilities in Yakima, Wenatchee, and the Tri-Cities in Washington and in Anchorage, Alaska. Our clinical volumes have increased 50% in the past five years, and our access time has decreased from one month to one week. According to patient/family surveys, our quality of care has improved and has been integrated into all aspects of care with our Value Stream work at the hospital. Our faculty, including some of the most accomplished pediatric orthopedic surgeons in North America, is dedicated to providing immediate access and care to all children in our region. Each year, we treat 2,000 pediatric fractures in addition to spinal deformities, pediatric foot and hand deformities and musculoskeletal tumors and infections.

We collaborate with our pediatric colleagues on treating complicated neuromuscular disorders, including cerebral palsy and myelomeningocele; congenital deformities; and skeletal dysplasias, including achondroplasia. Our pediatric sports program has developed a multidisciplinary sports service dedicated to the healthcare of all pediatric athletes. Pediatricians, rehabilitation specialists, pediatric cardiologists and sports psychologists participate in our pediatric orthopedic team. Our greatest resource in the sports program consists of our Children's sports trainers, who provide sports healthcare to 15 high schools in the Seattle/Bellevue area in addition to many community-based sports programs. Children's trainers allow our program to connect well with the needs of our children and their families. We are excited to be part of Seattle Children's Hospital's comprehensive initiative to improve the health of the young in our region.

Ernest U. Conrad, M.D.
Professor and Vice Chair



Our Children's Sports Trainers are pictured here with benefactor Jamal Crawford (center) (Ranier Beach High School / National Basketball Association's Atlanta Hawks) and Monique Burton (far right), our Pediatric Sports Medical Director.

Our Facilities

The University of Washington Department of Orthopaedics and Sports Medicine uses many facilities around the Puget Sound Region. Chief among them is the University of Washington Medical Center (UWMC). A 450 bed facility with over 4000 employees, our department operates on the majority of our patients at this location. UWMC recently expanded with a new Surgery Pavilion (where many of our hand, shoulder, elbow, hip, and knee operations are performed). This facility will expand again in the fall of 2011 with a larger neonatal intensive care unit that will care for up to 50 newborns, a 32-bed adult acute care unit, and additional space for the most advanced diagnostic imaging technology.



The Bone and Joint Center is our main clinic and out-patient unit. Located on Roosevelt Way, patients are seen for a variety of ailments from shoulder pain to broken fingers to arthritic conditions. Many of our patients suffering from hand injuries are treated at this location with surgery and physical therapy.



Harborview Medical Center provides numerous orthopedic services including skeletal realignments and stabilizations using closed, percutaneous, external, and internal fixation techniques. Similarly, Harborview treats associated soft tissue injuries using a variety of methods.

As a Level I adult and pediatric trauma center, Harborview cares for some of the most complex orthopedic injuries in the Pacific Northwest. Services include complex pelvic and acetabular fractures, a limb viability service for individuals with amputations, a sports medicine program, as well as a hand clinic.

The Sigvard T. Hansen Foot and Ankle Institute provides consultation and surgical procedures for complex foot and ankle reconstruction including genetic anomalies

and traumatic injury. Innovations in ankle reconstruction have been pioneered here. A podiatry service is also available through the institute.

A complex spine service is offered in conjunction with Harborview's Department of Neurological Surgery. This service treats injuries that result in severe damage to the spinal column, which often creates, compressed nerves, painful disc degeneration or abnormal movement and alignment of the spinal column.

Multidisciplinary research into improved orthopaedic care continues at all our facilities and focuses on neck injuries, osteoporosis, and arthritis at this facility.



Children's offers a level of dedicated pediatric expertise that is unmatched in the region. Children's Hospital has a medical staff of almost 1,000 physicians that includes almost 500 hospital-based physicians and 500 community physicians who refer and care for patients. These doctors represent a unique talent pool that has earned national recognition for the hospital and for the Department of Pediatrics of the University of Washington School of Medicine, which is based at Children's. The Hospital's affiliation with the UW has helped Children's become a renowned research center and to serve as an academic resource for teaching future health care providers.

As team physicians for the UW Huskies, our expertise is in treating athletic injuries.

We are committed to providing care to injuries sustained at all levels of physical activity...whether a weekend basketball-warrior, recreational skier, experienced mountaineer, or professional athlete. At the UW Sports Medicine Clinic we offer innovative, advanced and minimally-invasive treatment options to get active individuals "back in the game".

In Bellevue, we have our Eastside Specialty Center. This clinic is the first of its kind: a multi-specialty outpatient care clinic featuring some of the most highly qualified, experienced physicians the University of Washington has to offer.

We provide comprehensive care for orthopaedic injuries to veterans of our military at the Veteran's Affairs Puget Sound Healthcare System Seattle Division.

The Seattle Cancer Care Alliance unites the doctors from Fred Hutchinson Cancer Research Center, UW Medicine, and Seattle Children's to form a world-class treatment center that provides advanced therapies and clinical studies for cancers and other related diseases. Our sarcoma service sees the majority of their patients at this facility.

In addition, orthopaedic care is provided at seven UW Medicine Neighborhood Clinics (Belltown, Factoria, Federal Way, Issaquah, Kent/Des Moines, Shoreline, and Woodinville).



Residency

Who Are The Orthopaedic Surgeons Of The Twenty First Century?

As we enter this “new era” of well intended but “ill defined” health care, I am comforted knowing that at the University of Washington, the typical orthopaedic resident represents an energetic, enthusiastic individual who looks

forward to a promising future. A future that allows them to pursue the most significant motivating factors in choosing Orthopaedic Surgery as a livelihood. A profession that prompts them to recognize problems, identifies solutions and allows them to execute

those solutions. They, as a group, are more innately talented than at any time in the history of this profession. Our typical resident now represents the top 10% of medical school peers, achieved honors in surgical and medicine clerkships and scored above the 75 percentile in national medical board examinations. They actively participated in team sports or similar time consuming extracurricular activities throughout, high school, college and medical school. They assumed leadership and team building positions and were recognized for their achievements. One in five are women. They are a group who, when given a goal and the tools to achieve that goal, do so. A recent example of this in our program is the improvement seen in the “Orthopaedic In Training Exam”, the OITE. This annual examination, given to all levels of orthopedic residents, reflects assimilation of base knowledge in musculoskeletal disease and treatment. At our institution it is a closed book, proctored examination, taken by all residents on the same day in November. As director of this residency it is my belief that the examination reflects a residents pursuit of knowledge beyond the immediate clinical setting, and reflects a residents efforts to read and pursue that knowledge on their own. This disciplined approach to self-education is an essential tool for the adult learner, and establishing those practices now is especially important for continuing self-education beyond residency training. Answering the challenge, our residents have steadily raised their OITE scores, when compared as a group to other orthopaedic residency programs in the country. This year our residents as a group scored in the **94th percentile**.

This pursuit of knowledge is reflected in the success and uneventful passage of part 1 of the American Board of Orthopaedic Surgeons, the essential accreditation examination in this profession. 55 of 56 residents, completing their training in the last 10 years, successfully passed on the first attempt and the individual who



Figure 1: Our Program director Dr. Doug Hanel and Program Coordinator Angela Weiss celebrate a very successful match 2010.



Figure 2: The new Harborview ISIS lab has provided a new home for our customary Monday morning resident conferences. It provides a modern conference space directly next to a generous hands-on training area. Dr. Aaron Chamberlain, PGY-4, and Dr. Barei organized the inaugural session that took place April 5th, 2010.



Figure 3: Orthopaedic residents performing cadaver dissections in the new HMC-ISIS lab during Monday morning training. From left to right: Josh Lindsey PGY-4, Derek Rains, PGY-4, Jennifer Hagen PGY-2, Grant Lohse PGY-4.

failed on his first attempt succeeded a year later.

Who did these young surgeons become?

Four entered private group practice after residency, while 52 pursued another year of formal education, doing Fellowships throughout the country, in all aspects of Orthopaedics. Sports medicine, spine, shoulder and hand were the most commonly completed fellowships. Of these 52, seven joined academic programs while the others entered private practice and have become recognized leaders in their communities.

Most importantly to this residency program, our former residents recognizing the importance of their "book knowledge" continue to generously support the resident's book and education fund. As federal regulation of the medical equipment industry contribution to resident education is curtailed, the financing of resident education and research has become increasingly burdensome. This makes continued support of our former residents all the more important. Their help is deeply appreciated.

What next?

Our goal remains unchanged, producing the best-trained Orthopaedic surgeons, not only with the tools we

give them now, but by providing them with the tools that will allow them to continue to meet the goals and challenges the coming decades.

Doug P. Hanel, M.D.
Director of Orthopaedic Education

Graduating Residents



Sean Amann, M.D.

Following residency, Sean will complete an adult reconstruction fellowship at Colorado Joint Replacement in Denver, Colorado. He plans to practice in the Mountain West region.



Aric Christal, M.D.

Following residency, Aric will complete a total joint arthroplasty fellowship at OrthoCarolina in Charlotte, North Carolina. Next year he and his wife will return to private practice in Edmonds, Washington.



Jeremy Bauer, M.D.

Next year, Jeremy will complete a Pediatric Orthopedics Fellowship at the Portland Shriners Hospital. Following his fellowship he and his wife Suzanne plan on moving to either upstate New York or back to Washington.



Wendy Emerson, M.D.

After graduation, Gwendolyn will complete a sports medicine fellowship in Minneapolis, Minnesota at TRIA Orthopaedic Center. After completion of her fellowship, she plans to practice in the Midwest to be near family and friends.

Graduating Residents



Michael Hwang, M.D.

Following residency, Michael will complete a sports medicine fellowship at the Taos Orthopaedic Institute in New Mexico. Afterwards, he plans to move to the Portland area with his wife Erica and daughter Emilia to practice orthopaedics.



Christopher Wolf, M.D.

After graduation, Christopher plans to complete a spine fellowship at UCLA and then enter into private practice.



Lee Pace, M.D.

Next year Lee will complete a fellowship in pediatric orthopedics at Children's Hospital Los Angeles followed by a fellowship in sports medicine at Boston Children's Hospital. After completion of these fellowships he plans to be a part of a pediatric sports medicine program at a children's hospital on the West Coast.



Vinko Zlomislic, M.D.

Following residency, Vinko will complete a fellowship in spine surgery at the University of California, San Diego.

Incoming Residents



Sid Baucom

Sid Baucom is from Salt Lake City, Utah. He completed his undergraduate education and medical training at the University of Utah. Away from work, he enjoys fishing, hiking, golf, and spending time with his wife and kids.



Jacques Hacquebord

Jacques Hacquebord is from Madison, Wisconsin. He attended college at Lawrence University and completed medical school at the University of Wisconsin. His main areas of clinical interest at this time are spine and hand injuries. Outside of his medical interests, he enjoys windsurfing, skiing, hiking, and traveling.



Nathan Coleman

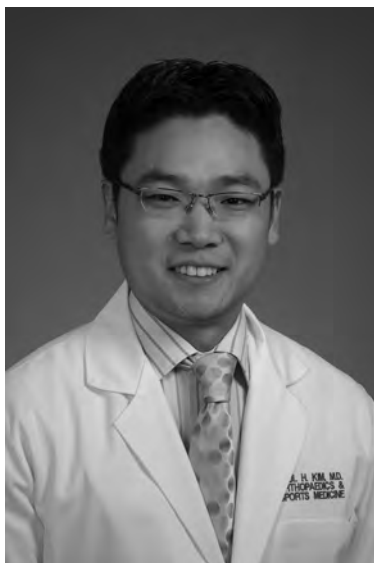
Nathan Coleman is from Grand Rapids, Minnesota. He attended college at the University of St. Thomas. For medical school, he went to Johns Hopkins in Baltimore, Maryland. He is most interested in sports medicine. In his free time he enjoys running, cycling, snowboarding, and playing the piano.



Nicholas Iannuzzi

Nicholas Iannuzzi is from Lewisville, North Carolina. He attended college at Princeton University. For medical school, he attended the University of North Carolina at Chapel Hill. His orthopaedic interests include trauma and hand injuries. In his spare time, he likes running, hiking, reading, and photography.

Incoming Residents



Paul Kim

From Oakland, California, Paul Kim attended the University of California, Irvine. For medical school, he attended Wayne State University. Currently, his orthopaedic interests include foot and ankle, upper extremity injuries, and the hand. When away from the University of Washington, he enjoys snowboarding, working out, traveling, BBQ-ing, microbrews & wine, playing Texas Hold 'em and spending time with his wife.



Nicholas Wegner

Nicholas Wegner is from Omaha, Nebraska. He attended college at the University of Southern California and medical school at Northwestern University. His clinical and research interests include trauma, total joints, and pediatrics. He likes to spend his free time traveling, running, trying out new restaurants with his wife, and spending time with family and friends.



Ted Sousa

Ted Sousa is from Missoula, Montana. For his undergraduate education, he attended the University of Southern California. For medical school, he graduated from the University of Washington. Trauma injuries, as well as sarcoma and rural orthopaedics, are his major fields of clinical and research interests. He enjoys horseback riding, flyfishing, sea kayaking, golf, cooking, and getting outside to enjoy the outdoors anyway he can.



David Zeltser

David Zeltser is from Valencia, California. For his undergraduate education, he attended the University of California, Berkeley. For medical school, he attended Washington University. Hand, shoulder, and trauma injuries are his current orthopaedic interests. Away from his residency, he enjoys music, soccer, the beach, good food, and wine and beer with friends.

ACEs

FOOT/ANKLE



David J. Dalstrom, M.D.



Sarah S. Hanslow, MBBS



Benjamin W. Stevens, M.D.

SPINE



Roland S. Kent, M.D.



Maximilian Reinhold, M.D.



Abilio A. Reis, M.D.

TRAUMA



Julius A. Bishop, M.D.



William W. Cross, M.D.



Gregory D. Dikos, M.D.



Donald L. Glasgow, M.D.



R. Allan Maples, M.D.



Christopher M. McAndrew, M.D.

ACEs

SHOULDER/ELBOW



Erica M. Burns, M.D.



Daniel R. Heaston, M.D.

ONCOLOGY



Kevin M. MacDonald, M.D.

PEDIATRICS



Craig Shank, M.D.

Fellows

HAND



David Gerlach, M.D.



David Hioshi Kawamura, M.D.



Nilpesh Mahesh Patel, M.D.



Lee M. Reichel, M.D.

Grand Rounds

The New UW Orthopaedic Grand Rounds Format: “Defining State-Of-The-Art: Monthly UW Orthopaedic Mini-Symposia”

The University of Washington Department of Orthopaedics and Sports Medicine is pleased to announce a new format for our Grand Rounds for the 2011-2012 academic year. As an incoming Chief resident I have been involved with looking into ways to enhance delivery of our educational Grand Rounds content to the largest possible audience. In response to this task, a group consisting of myself, our Acting Chair **Dr. Jens Chapman**, our Program Director **Dr. Doug Hanel** and our Program Coordinator **Angela Weiss** in conjunction with **Connie Robertson**, Secretary Senior, created a new format, identified a new location and sought to engage community colleagues as well as audience engagement by utilizing the help of UWTV.

Goal: Big picture topics with community and interdisciplinary appeal

Location: Foege Auditorium, UW Genomics Building, Ground Floor

Time: 1st Wednesday of month, 0645 - 0745am

Format:

- PGY-4 Introduction, case presentation and subject epidemiology
- Experts provide their view points
- Interactive Case discussions
- UWTV Grand Rounds taping (topic based)

Invited experts include UW and Community Orthopaedic Surgeons, Research Faculty, Visiting Professors, and specialists with interests of mutual concern.

Our kickoff session took place April 7th, 2010 with a special presentation concerning the topic of “Delivering Orthopaedic care in times of a catastrophe: The Haiti experience” with lectures by **Dr. Samir Mehta**, Visiting Assistant Professor from the University of Pennsylvania and **Dr. Jim Krieg** from our own department. Participants included **Drs. Tom Green and Lyle**



Dr. James Krieg presents his experiences with emergency orthopaedic care in Haiti during the kick-off inaugural UW Orthopaedic Mini-symposia on April 6th, 2010. To view this event please go to:
<http://uwtv.org/programs/displayevent.aspx?rID=31498>



Dr. Samir Mehta, Assistant Professor, Department of Orthopaedic Surgery, University of Pennsylvania, reflects on his experiences with Partners in Health during his time in Haiti.

Sorensen from Virginia Mason and **Dr. Lew Zirkle** from Richland, WA who reflected on their own personal Haiti experiences.

Please see the schedule on this page for some examples of past and planned future topics.

The new venue provides easy access and egress from I-5 in a sophisticated and inviting environment. We hope that with this new mini-symposium format and its more direct involvement of the many expert Orthopaedic surgeons in our region as well as invited Guest Speakers will prove an engaging and valuable learning and continued education resource for all those interested in musculoskeletal medicine and also provide a regular community forum for members of our profession. From a resident perspective we look forward to collaborating with and learning from the many giants of Orthopaedics that surround us with this new format. Also, all Grand Rounds symposia have been approved for Medical Continuing Education credits for those interested in receiving CME credit for attendance. We appreciate your support!

Aaron Chamberlain, M.D.

Date	Resident Organizer	Experts	Topic area	Topic
May 5, 2010	B. Daines	H. Chansky, D. Barei	Adult Recon and Trauma	<i>Periprosthetic fractures</i>
June 2, 2010	B. Wiater	S.K.Benirschke, W. Warme	Trauma and Shoulder/Elbow	<i>Clavicle fractures: Controversies</i>
July 7, 2010	D. Rains	K. Smith, C.J.Wahl	Shoulder/Elbow	<i>Rotator Cuff Tears: update on controversies</i>
Aug. 4, 2010	G. Lohse	L.Taitsman, I Abrass, W. McCormack	Bone metabolism/epidemiology	<i>Fragility fracture: how to counter an epidemic</i>
Sept. 1, 2010	J. Lindsay	M. Neff, D. Beingsner	Adult Recon	<i>Lung and Long bones</i>
Oct. 6, 2010	B. Amis	M.B.Henley & L. Zirkle	Trauma	<i>IM Nails: High or 'low tech'?</i>
Dec. 1, 2010	A. Merritt	S.T.Hansen TBD	Foot & Ankle	<i>Comparative effectiveness: Ankle replacement or fusion?</i>
Feb. 2, 2010	M. Lyons	D. Hanel, N.Vedder	Hand	<i>Contemporary Perspectives in Distal Radius Fixation</i>
March 2, 2010	N. Sampatacos	C.J.Wahl, TBD	Sports	<i>Management of Cartilage injuries</i>
May 4, 2010	A. Bakker	V. Mosca R. Vieth	Pediatric Orthopaedics	<i>Clubfoot</i>
June 1, 2010	G. Blaisdell	<u>Tentative</u> E.U. Conrad and H. Chansky	Orthopaedic Oncology	<i>Tumors for the General Orthopaedist</i>

Please also look for special announcements for noted visiting Guest Lecturers on November 3rd, 2010 and January 5th and April 6th, 2011!

Research Grants

National Institutes of Health (NIH)

Aging-Related Degradation in Bone
Mechanotransduction
Sunder Srinivasan, Ph.D.
Ted S. Gross, Ph.D.

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

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

Collagens of Cartilage and the Intervertebral Disc
David R. Eyre, Ph.D.

Collagen Cross-Linking in Skeletal Aging and Diseases
David R. Eyre, Ph.D.

Design Criteria for Therapeutic Footwear in Diabetes
Peter R. Cavanagh, Ph.D. D.Sc.

Disuse Induced Osteocyte Hypoxia
Ted S. Gross, Ph.D.
Steven D. Bain, Ph.D.
Sunder Srinivasan, Ph.D.

Skeletal Dysplasias
David R. Eyre, Ph.D.
Russell J. Fernandes, Ph.D.

National Aeronautics and Space Administration

A Quantitative Test of On-Orbit Exercise
Countermeasures for Bone Demineralization Using a
Bedrest Analog
Peter R. Cavanagh, Ph.D. D.Sc.

National Space Biomedical Research Institute

Monitoring Bone Health by Daily Load Stimulus
Measurement During Lunar Missions
Peter R. Cavanagh, Ph.D. D.Sc.

An Integrated Musculoskeletal Countermeasure
Battery for Long-Duration Lunar Mission
Peter R. Cavanagh, Ph.D. D.Sc.

A Quantitative Test of On-Orbit Exercise
Countermeasures for Bone Demineralization Using a
Bedrest Analog
Peter R. Cavanagh, Ph.D. D.Sc.

Extent, Causes, and Countermeasures of Impaired
Fracture Healing in Hypogravity
Peter R. Cavanagh, Ph.D. D.Sc.

Veterans Affairs Rehabilitation Research and Development Service

Ewing's Sarcoma Fusion Proteins and mRNA Splicing
Factors
Howard A. Chansky, M.D.

Reducing Internal Stresses in Deformed Diabetic Feet
Bruce J. Sangeorzan, M.D.
Peter R. Cavanagh, Ph.D. D.Sc.

Surgically Reestablishing Foot Shape in Severely
Deformed Flatfeet
Bruce J. Sangeorzan, M.D.

Treatment Outcomes for Ankle Arthritis
Bruce J. Sangeorzan, M.D.

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

VA Merit Review Functional Analysis of EWS/FLI-1
Howard A. Chansky, M.D.

A.O. North America

An Observational Study Assessment of Surgical
Techniques for Treating Cervical Spondylotic
Myelopathy (CSM)
Jens R. Chapman, M.D.

An Observational Study Comparing Surgical to
Conservative Management in the Treatment of Type II
Odontoid Fractures Among the Elderly
Jens R. Chapman, M.D.

AO North America Orthopaedic Trauma Fellowship
Bruce J. Sangeorzan, M.D.

AO Spine North America Fellowship
Carlo Bellabarba, M.D.

Does Transient Muscle Paralysis Alter Trabecular Bone
Development in Growing Mice?
Ted S. Gross, Ph.D.

Ascension Orthopedics, Inc.

Safety and Effectiveness Study of Ascension's
PyroCarbon Radial Head Compared to Ascension's
Metal Radial Head to Treat Arthritis, Fractures of the
Radial Head, Relief of Symptoms After Radial Head
Resection, or Revision of a Failed Radial Head Implant
Thomas E. Trumble, M.D.

BioAxone Therapeutique, Inc.

Cethrin Trial
Jens R. Chapman, M.D.

Research Grants

Boston Medical Center

Intramedullary Nails versus Plate Fixation
Re-Evaluation Study in Proximal Tibia Fractures a
Multi-Center Randomized Trial Comparing Nails and
Platel Fixation
Robert P. Dunbar, M.D.

DePuy Spine, Inc. (Johnson & Johnson, Inc.)

Clinical Spine Fellowship Grant
Theodore A. Wagner, M.D.

Kyphosis Correction From Combined Smith Peterson
Osteotomy and an Interbody Strut
Michael J. Lee, M.D.

Johns Hopkins University (JHU)

The Major Extremity Trauma Research Consortium
Bruce J. Sangeorzan, M.D.

National Science Foundation

University of Washington Engineered Biomaterials
Paul A. Manner, M.D.

Orthopaedic Research and Education Foundation (OREF)

Clinical Efficacy and Cost Implications of Acute BMP-2
David P. Barei, M.D.

OREF Trauma Fellowship Grant
David P. Barei, M.D.

Orthopaedic Research & Education Foundation
Fellowship Grant
Ernest U. Conrad III, M.D.

Perioperative Economic Analysis of Minimally Invasive
Versus Traditional Total Knee Arthroplasty
Seth S. Leopold, M.D.

Orthopaedic Trauma Association (OTA)

Development of Fracture Specific MFA
Brad M. Henley, M.D.

Ostex International, Inc.

Molecular Markers of Connective Tissue Degradation
David R. Eyre, Ph.D.

Paradigm Spine LLC

A Multi-Center, Prospective, Randomized, Clinical Trial
Comparing Stabilization with Coflex vs. Pedicle Screw
Fixation and Fusion after Decompression for at Least
Moderate Lumbar Spinal Stenosis
Jens R. Chapman, M.D.

Smith & Nephew, Inc.

University of Washington Arthroscopy, Research and
Training (ART) Lab
Christopher J. Wahl, M.D.

SYNTHEs

Biomechanical Analysis of the Less Invasive
Stabilization System for Mechanically Unstable
Fractures of the Distal Femur: Comparison of
Titanium versus Stainless Steel and Bicortical
versus Unicortical Fixation
Daphne M. Beingsesner, M.D.

Clinical Experience with Hindfoot Arthrodesis Nail for
the Surgical Treatment of Ankle and Hindfoot
Pathologies
Sigvard T. Hansen Jr., M.D.

PRODISC-C Versus Anterior Cervical Discectomy and
Fusion (ACDF)
Jens R. Chapman, M.D.
Steven D. Bain, Ph.D.
Ted S. Gross, Ph.D.

Regulation of Bone Repair by Physiologic Loading
Steven D. Bain, Ph.D.
Ted S. Gross, Ph.D.

Spine End-Results Research Fund
Frederick A. Matsen III, M.D.

The Role of Muscle Function in Fracture Healing:
Development of a Translational Model
Sean E. Nork, M.D.
Steven D. Bain, Ph.D.
Ted S. Gross, Ph.D.

The Boeing Company

Randomized Clinical Trial of Open versus Endoscopic
Carpal Tunnel Release and Hand Therapy Comparing
Patient Satisfaction: Functional Outcome and
Cost Effectiveness
Thomas E. Trumble, M.D.

US Army Research Office

Digit Regeneration in Mammals
Christopher H. Allan, M.D.

UW Team-Advance on Single Nuclear Detection and
Atomic-Scale Imaging
John A. Sidles, Ph.D.

US Department of Education

Advancing Orthotic and Prosthetic Care Through
Research, Standards of Practice and Outreach
Douglas G. Smith, M.D.

Department Publications 2009-2010

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Committees and UW Organizational Work

The word 'Committee' frequently creates visions of endless and unproductive meetings and can be synonymous with bureaucratic stalemates. However, if put together well, committees allow for participation of a large cross-section of a Department and enable the 'wisdom of crowds'.

We are deeply indebted to a large number of faculty and staff who are willing to participate in creating platforms for a better future for our Department and our many activities.

Local and National Committees

(Please note – these are just excerpts of the many Board and Committee functions our Department members are engaged in. For a more complete listing please follow our future Website and UWMedicine)

Julie Agel	Coding Committee OTA
David Barei	Chairman Membership Committee OTA Education committee OTA
Carlo Bellabarba	AOSpine Education Committee
Rick Bransford	AOSpine Scientific Committee
Jens R. Chapman	Chairman AOSpine NA
Ernest U. Conrad	Medical Director, Northwest Tissue Center
Bob Dunbar	Public Relations Committee, OTA
M. Bradford Henley	Director, American Academy of Orthopaedic Surgeons Director, American Association of Orthopaedic Surgeons Chairman, Board of Specialty Societies Member, CPT Editorial Panel, AMA
Ken Karbowski	Chair, Medical School Administrators' (MSA) Steering Committee, AY 2011
Jim Krieg	Board Examiner, ABOS LFP Program, AAOS AONA Technical Expert Commission North American Musculoskeletal Trauma Education Committee (NAMTEC)
Michael J. Lee	Faculty Senator UW
Seth L. Leopold	Consulting Editor, J.B.J.S.-A
Paul Manner	Regional Board of Director Arthritis Foundation
Sean Nork	Education Committee OTA
M.L.'Chip' Routt	AONA Technical Expert Commission North American Musculoskeletal Trauma Education Committee (NAMTEC)
Bruce Sangeorzan	Chief Compliance Officer, University of Washington Physicians
Lisa Taitsman	ACGME Residency Review Committee Graduate Medical Education Council UW

UWDOSM Finance Committee

Task: To advise Chair and Leadership Group on discretionary expenditures, identify opportunities for enhanced financial productivity within the UW system and evaluate orthopaedic opportunities outside of UWMedicine to fiscally support our core mission of improving patient lives through excellence in patient care, research and education.

Members:

M. Brad Henley, M.D., M.B.A. (Chair)
Ken Karbowski, M.P.H. (Senior member)
Karl Engdahl, M.B.A. (Senior member)
Steve Bain, Ph.D.
Jerry Huang, M.D.
Wally Krengel, M.D.
Jim Krieg, M.D.
Paul Manner, M.D.
Chris Wahl, M.D.

Project Task Forces (PTFs)

Mission: to foster a basis for meaningful fundable interdisciplinary translational research and education capable of influencing and guiding musculoskeletal patient care of the future.

Due to the complexities and bandwidth of Orthopaedics we have formed 6 PTF's, of which some have started regular meetings. These PTF's are tasked to reach out to other specialties and disciplines to form connections and create an environment for progress in the focal areas of concern identified.

Spinal Column / Cord

Carlo Bellabarba
Rick Bransford
Jens R. Chapman
Wally Krengel
Mike Lee
Ted Wagner
James Wu

Bone / Fracture

Steve Bain
David Barei
Daphne Beingsner
(Ted Gross)
Jim Krieg
Chip Routt
Sundar Srinivasan

Residency / Education

Doug Hanel
Bruce Sangeorzan
Lisa Taitsman
Winston Warme
Jason Wilcox

Cartilage / Arthritis

Peter Cavanagh
Howard Chansky
David Eyre
Russell Fernandes
Paul Manner
Rick Matsen
Bruce Sangeorzan
James Wu
Liu Yang

Hand / UE

Chris Allan
Doug Hanel
Jerry Huang
Tom Trumble

Growth / Tumor*

Howard Chansky
Ernest U. Conrad
Michael Goldberg
Kit Song
Klane White
Liu Yang
* to be constituted
at a later date

Residency Selection Committee:

Goal: To develop criteria and select the best and brightest graduating medical students to ensure a continuation of our Department's role in the future of Orthopaedic Surgery.

Doug Hanel (Chair)
Lisa Taitsman
Steven Bain
David Barei
Daphne Beingessner
Aaron Chamberlain
Howard Chansky
Josh Lindsey
Andrew Merritt
Christopher Wahl
Brett Wiater

Research:

Goal: To launch and coordinate research endeavours within and beyond our department and secure funding for future efforts.

Peter Cavanagh (Chair)
Paul Manner
Ted Gross
Bruce Sangeorzan
David Eyre
Chris Allen
Dave Barei
Howard Chansky
Karl Engdahl
Tom Zorich

UW Ortho Internet Forum

Goal: To address the developing needs of our Department and UWMedicine on the net in regards to patient information and access, Education and Research in a fashion representative of our multidimensional enterprise and its various needs.

Calina Brown Garcia
Ken Karbowski
Gholam Fazelinia
John Eickerman
Hongjun Wang
Michael Burdett
Daphne Beingessner
Jens R. Chapman
Peter Cavanagh
Frederick Matsen III
Seth Leopold
ML Chip Routt
Carol Teitz
Ted Wagner
Chris Wahl

Alumni

- 1952
Park W. Gloyd, M.D. ★
- 1954
Trygve Forland, M.D. ★
- 1955
Robert W. Florence, M.D.
- 1956
J. Michael Egglin, M.D. ★
John E. Goeckler, M.D.
Robert L. Romano, M.D.
- 1957
John H. Aberle, M.D. ★
John R. Beebe, M.D.
- 1958
Harry H. Kretzler, Jr., M.D. ★
James R. Friend, M.D. ★
Kenneth L. Martin, M.D. ★
Samuel L. Clifford, M.D.
- 1959
James W. Tupper, M.D.
- 1960
Irving Tobin, M.D. ★
William V. Smith, M.D. ★
- 1961
Robert C. Colburn, M.D.
- 1962
Arthur Ratcliffe, M.D.
Marr P. Mullen, M.D. ★★★
- 1963
Alfred I. Blue, M.D.
Robert A. Kraft, M.D.
- 1964
David E. Karges, M.D. ★★★★★
Harold J. Forney, M.D. ★
Theodore K. Greenlee II, M.D.
★★★★★
Thomas E. Soderberg, M.D.
- 1966
F. Richard Convery, M.D. ★
Joseph S. Mezistrano, M.D. ★
William A. Reilly, Jr., M.D.
- 1967
Ivar W. Birkeland, M.D.
J. Conrad Clifford, M.D. ★
Robert F. Smith, M.D. ★★★★★
- 1968
Lynn T. Staheli, M.D. ★
Stewart M. Scham, M.D. ★
William T. Thieme, M.D. ★★
- 1969
Edward E. Almquist, M.D. ★★★
Edward L. Lester, M.D.
Hugh E. Toomey, M.D. ★★★
Sigvard T. Hansen, Jr., M.D. ★★★★★
- 1970
John C. Brown, M.D. ★
John M. Coletti, Jr., M.D. ★
Malcolm B. Madenwald, M.D. ★
Michael T. Phillips, M.D. ★
Robert D Schrock, Jr., M.D.
- 1971
Bruce E. Bradley, Jr., M.D.
Franklin G. Alvine, M.D. ★★★★★
Jerome H. Zechmann, M.D.
Louis A. Roser, M.D. ★
Nils Fauchald, Jr., M.D.
- 1972
David J. LaGasse, M.D.
David R. Nank, M.D. ★★
Donald D. Hubbard, M.D. ★
John A. Neufeld, M.D. ★
Thomas L. Gritzka, M.D. ★
- 1973
Frederick J. Davis, M.D. ★
Larry D. Hull, M.D. ★
Robert P. Watkins, Jr., M.D. ★
Theodore A. Wagner, M.D. ★★★★★
- 1974
Richard A. Dimond, M.D. ★★
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Samuel R. Baker, M.D. ★★
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- 1975
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Frederick A. Matsen III, M.D.
★★★★★
Gunter Knittel, M.D.
Larry R. Pedegana, M.D. ★
Thomas M. Green, M.D. ★★★★★
William M. Backlund, M.D., P.S. ★
- 1976
Douglas K. Kehl, M.D.
Douglas T. Davidson III, M.D. ★
John F. Burns, M.D. ★
Peter Melcher, M.D.
Richard A. Zorn, M.D. ★
- 1977
Carl A. Andrews, M.D. ★
Geoffrey W. Sheridan, M.D. ★★
Larry D. Iversen, M.D. ★
Mark C. Olson, M.D. ★
Steven T. Bramwell, M.D.
- 1978
Arnold G. Peterson, M.D. ★★★★★
Gary J. Clancey, M.D. ★★★★★
John W. Brantigan, M.D.
Richard S. Westbrook, M.D. ★★
Robert J. Strukel, M.D.
William Oppenheim, M.D. ★★
- 1979
Allan W. Bach, M.D. ★★★★★
Gregory M. Engel, M.D. ★★
Jonathan L. Knight, M.D. ★★
Richard L. Semon, M.D. ★★★★★
- 1980
Carol C. Teitz, M.D. ★★★
Douglas G. Norquist, M.D.
John M. Hendrickson, M.D. ★★
Michael A. Sousa, M.D. ★★★★★
Stuart R. Hutchinson, M.D. ★
- 1981
Dennis J. Kvidera, M.D. ★
John M. Clark, Jr., M.D., Ph.D. ★★★★★
Martin S. Tullus, M.D. ★★★★★
Robert G. Veith, M.D. ★★★★★★
- 1982
John L. Thayer, M.D. ★
Richard M. Kirby, M.D. ★★★★★★
Steven S. Ratcliffe, M.D. ★★
William D. Burman, M.D.
- 1983
Elizabeth Anne Ouellette, M.D. ★★
Edward L. Farrar III, M.D. ★★★★★
Henry K. Yee, M.D.
Joseph D. Zuckerman, M.D. ★★★★★
Keith A. Mayo, M.D. ★★★★★
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1984
Jeffrey C. Parker, M.D. ★
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Kevin P. Schoenfelder, M.D. ★
Marc F. Swiontkowski, M.D. ★★★★★★
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1985
Daniel L. Flugstad, M.D. ★★★★★★
Jeffrey N. Hansen, M.D. ★★★
Paul J. Abbott, M.D. ★★★★★
Richard J. Barry, M.D. ★
William P. Barrett, M.D. ★★★★★★

1986
Carleton A. Keck, Jr., M.D. ★★★
Gary Bergman, M.D. ★★★★★★
Lawrence E. Holland, M.D. ★
Michael E. Morris, M.D. ★★★★★

1987
Craig T. Arntz, M.D. ★★★
Herbert R. Clark, M.D. ★★
Michael K. Gannon, M.D. ★
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1988
Jonathan L. Franklin, M.D. ★★★★★★
Michael A. Thorpe, M.D. ★★★★★★
Richard V. Williamson, M.D. ★

1989
James P. Crutcher, M.D. ★★★★★★
Lawrence V. Page, D.O. ★★★
Martin G. Mankey, M.D. ★★★★★★
Nancy J. Ensley, M.D.
Steve C. Thomas, M.D. ★★★★★

1990
David M. Kieras, M.D. ★
J. Roberto R. Carreon, M.D.
Jay A. Winzenried, M.D. ★★
Ken Fujii, M.D. ★
Walter F. Kregel III, M.D. ★★★

1991
David H. Bishop, M.D. ★★
Kit M. Song, M.D.
Mark Remington, M.D. ★★★★★
Mark E. Murphy, M.D., Ph.D. ★★
Tim P. Lovell, M.D. ★★

1992
Curt Rodin, M.D.
Don Striplin, M.D. ★★
Eli Powell, M.D. ★
Jeff Stickney, M.D. ★★
John D. West, M.D. ★★
Michael Sailer, M.D. ★★★★★

1993
J. Eric Vanderhooft, M.D. ★★★★★★
Lyle S. Sorensen, M.D. ★★★★★★
Philip J. Kregor, M.D. ★★
Susan R. Cero, M.D. ★★★★★★

1994
Brodie Wood, M.D. ★★
Eric Bowton, M.D. ★★
Jim Vahey, M.D. ★
Sohail K. Mirza, M.D. ★
William Obrebsky, M.D. ★★★★★

1995
Ron Kristensen, M.D. ★
Scott Hormel, M.D. ★★★★★
Timothy Beals, M.D. ★★
Todd Clarke, M.D. ★★★★★
William J. Mills III, M.D. ★★★★★

1996
David Deneka, M.D. ★★
Peter Mitchell, M.D. ★★★★★
Peter T. Simonian, M.D. ★★★★★
Vernon Cooley, M.D. ★★
William Wagner, M.D. ★★★★★

1997
Daniel Stechschulte, Jr., M.D.
David Levinsohn, M.D. ★★
L. Anthony Agtarap, M.D. ★
Mohammad Diab, M.D.
Randall W. Viola, M.D.

1998
Colin Poole, M.D. ★
David Belfie, M.D. ★
Don Ericksen, M.D. ★★★★★★
Jay Crary, M.D. ★★★★★
Oriente DiTano, M.D. ★

1999
Craig Boatright, M.D.
Jeffrey Garr, M.D.
John Michelotti, M.D. ★★
Julie A. Switzer, M.D.
Thomas D. Chi, M.D. ★

2000
Brett Quigley, M.D. ★
Cara Beth Lee, M.D.
Daniel Jones, M.D. ★
Joel Hoekema, M.D. ★★
Patrick McNair, M.D.

2001
Eric Novack, M.D.
Frederick Huang, M.D. ★★★★★
Matthew Camuso, M.D.
Michael Metcalf, M.D. ★★★★★
Richard Bransford, M.D. ★

2002
Timothy DuMontier, M.D.
Scott Hacker, M.D. ★
Timothy Rapp, M.D. ★
William Sims, M.D. ★
Carla Smith, M.D. ★

2003
Ben DuBois, M.D. ★
Andy Howlett, M.D.
Guy Schmidt, M.D. ★
Brian Shafer, M.D. ★
Emma Woodhouse, M.D. ★

2004
Jon Braman, M.D. ★
Alexis Falicov, M.D. ★
Mike McAdam, M.D. ★
Jason Thompson, M.D. ★
Thea Khan-Farooqi, M.D.

2005
Tony Buoncristiani, M.D. ★
Waqar Khan-Farooqi, M.D.
Wren McCallister, M.D.
Tim O'Mara, M.D. ★
David Stevens, M.D. ★

2006
Heidi Shors, M.D. ★
Stacey Donion, M.D.
Eric Klineberg, M.D. ★
Bill Montgomery, M.D. ★
Mel Wahl, M.D.
Burt Yaszay, M.D.

2007
Jamie Antoine, M.D. ★
Jeremiah Clinton, M.D. ★
Mary Cunningham, M.D. ★
Evan Ellis, M.D. ★
Joseph Lynch, M.D. ★
Allison MacLennan, M.D. ★

2008
Drew Fehsenfeld, M.D. ★
Mark Freeborn, M.D. ★
Christopher Howe, M.D. ★
John Howlett, M.D. ★
Michael Lee, M.D. ★
Gregg Nicandri, M.D. ★

2009
Jason King, M.D. ★
Rajshri Maheshwari, M.D. ★
Soren Olson, M.D. ★
Karen Perser, M.D. ★
Scott Ruhlman, M.D. ★
Addison Stone, M.D. ★
Jason Wilcox, M.D. ★

2010
Sean Amann, M.D.
Jeremy Bauer, M.D.
Aric Christal, M.D.
Wendy Emerson, M.D.
Mike Hwang, M.D.
Lee Pace, M.D.
Chris Wolf, M.D.
Vinko Zlomislic, M.D.

STARS INDICATE TOTAL DONATIONS IN SUPPORT OF THE RESIDENCY

★★★★★★ = \$20,000 and above
★★★★★ = \$15,000 - \$19,999
★★★★ = \$10,000 - \$14,999
★★★ = \$7,500 - \$9,999
★★ = \$5,000 - \$7,499
★ = \$2,500 - \$4,999
 = \$1 - \$2,499

Endowments

We express our appreciation to all who have contributed to the endowments of the Department of Orthopaedics and Sports Medicine. This assistance makes possible special research activities, educational programs, and other projects that we could not offer without this extra support from our alumni, faculty, and friends in the community. If you have any questions, please contact our Acting Chair, Jens Chapman (jenschap@u.washington.edu), or our Director, Ken Karbowski (kkarb@u.washington.edu).

HansJörg Wyss Endowed Chair - Jens R. Chapman, M.D.

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Sigvard T. Hansen Jr. Endowed Chair in Orthopaedic Traumatology - Ted S. Gross, Ph.D.

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