



The Robert Larner, M.D.
College of Medicine

THE UNIVERSITY OF VERMONT

**Department of Orthopaedics and Rehabilitation
McClure Musculoskeletal Research Center**

Research Day
Friday, June 18, 2021

A Virtual Event via Zoom

<https://uvmcom.zoom.us/j/108497630>

Research Day Program

7:00 am

Visiting Professor:

Gregory Grabowski, MD

Vice Chair, Academics

Prisma Health USC Orthopedic Center

Associate Professor

University of South Carolina Department of Orthopedic Surgery

Residency Program Director

Prisma Health USC Orthopedic Center

Medical Director, Orthopedic Surgery

Prisma Health USC Spine Center

UVM Resident Alumni 2005-2010

Program

7:00 AM **Keynote Presentation: Gregory Grabowski, MD**
Introduction: **Claude E. Nichols, III, MD**

7:05 – 7:35 Title: Educational Research -- Not an Oxymoron
By: Gregory Grabowski, MD

7:35 – 7:45 Questions

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Lead Discussant: **Gregory Grabowski, MD**

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Raymond F. Kuhlmann, MD Resident Research Award
-Awarded to the Outstanding Presentation by a Chief Resident

McClure Musculoskeletal Research Award
-Awarded to the Outstanding Presentation by a Researcher (non-faculty)

Risk Factors and Epidemiology of Diaphyseal Forearm Fractures in Skiers and Snowboarders

Ryan Caldwell, Peter Twining, Mike DeSarno, Ethan Blackburn, Adam Shafritz

Background: Skiing and snowboarding are popular sports that are associated with high rates of orthopedic injuries. Diaphyseal forearm fractures are an important subset of these injuries. The epidemiology of and risk factors for these injuries has not been described.

Questions / Purposes: The purposes of our study were to determine the following: (1) What are the mechanisms and epidemiology of diaphyseal forearm fractures in skiers and snowboarders? (2) What are the risk factors associated with these injuries? (3) What is the effect of wrist guard use on these injuries?

Methods: This was a case control study. A university run clinic at the base of a major ski resort has maintained an injury database since 1972. Data collected for injured participants and uninjured controls included mechanism of injury, experience level, equipment, radiographs of injuries, skiing/snowboarding habits, and other potential risk factors. All cases of forearm fractures were identified from our database and classified radiographically. Logistic regression was used to identify risk factors associated with diaphyseal forearm fractures, as well as their subclassifications according to the AO classification system.

Results: There were 83 identified diaphyseal forearm fractures from 1972-2018, 38 in skiers and 45 in snowboarders. When adjusted for participant days, diaphyseal forearm fractures were 7.5 times more common in snowboarders ($p < 0.001$). Factors associated with forearm fractures in skiers were older age (OR 0.92, $p < 0.001$), female sex (OR 0.08, $p = 0.002$), not moving at the time of fall (OR 18.16, $p = 0.001$) and skiing on green trails (OR 0.27, $p = 0.04$). Factors associated with forearm fractures in snowboarders were older age (OR 0.93, $p = 0.015$), increased weight (OR 0.98, $p = 0.004$) snowboarding on moderately steep terrain (OR 0.11, $p = 0.012$), snowboarding on “other” (OR 0.14, $p = 0.005$) or wet heavy (OR 0.04, $p = 0.006$) snow type. Wrist guard use was associated with increased risk (OR 9.09, $p = 0.004$) of simple both-bone forearm fractures (AO 22-A3) on univariate analysis.

Conclusions: Diaphyseal forearm fractures were most common in young, male, snowboarders, and intermediate level skiers on blue slopes. Further research is needed to assess the effects of wrist guards on forearm fractures.

Level of Evidence: Level III: Case control study

Outcomes of First Metatarsophalangeal Joint Arthrodesis Comparing Different Fixation Constructs

Mark Haimes MD, Michael Roberts MD, Lauren Bougioukas BS, James Michelson MD

First metatarsophalangeal (MTP) joint arthrodesis is a common procedure and widely considered the gold standard for treatment of advanced stages of hallux rigidus as well as failed first MTP arthroplasty or hallux valgus correction. Despite an abundance of clinical and biomechanical investigations, the ideal fixation method remains uncertain. Advocates for the use of locking plates frequently cite low profile of the plate, ease of use, increased stiffness, potentially higher union rates, and theoretical decreased operative time as additional advantages. Clinical studies, however, have not found a correlation between increasing stiffness of the construct and higher union rates. Determining whether there is a difference in clinical outcomes between nonlocking and locking implants is particularly important considering the substantial discrepancy in cost. This study compares the nonunion and re-operation rates of patients undergoing first metatarsophalangeal arthrodesis with either a non-contoured semitubular plate or a precontoured locking plate.

Methods: Retrospective review of billing data at our institution between Jan 1, 2013 and December 31, 2018 was analyzed for great toe metatarsophalangeal joint fusion (CPT 27850). Patients were identified; clinical charts and radiographic libraries were reviewed to assess fixation construct, plate type, radiographic nonunion, clinical evidence of symptomatic hardware, and subsequent surgery for hardware removal or non-union. The criteria for a nonunion was: 1. Persistent radiolucent line at the fusion site that is seen at 9 months postoperatively or is unchanged over a 3-month interval, 2. Broken hardware seen radiographically, 3. Re-operation with nonunion confirmed. The criteria for symptomatic hardware is clinical recording of such symptoms, with subsequent surgery to remove the hardware. Demographics were gathered via chart review for patient age, sex, BMI, alcohol, and tobacco use. Categorical data was assessed using the Chi-square test. For cost analysis, our institution conducted a year-long quality project in which the costs of first metatarsophalangeal joint arthrodesis was measured.

Results: Two hundred forty-two MTP fusions were identified, and those clinical charts and radiographic libraries were reviewed. Seventeen were revision surgeries and therefore excluded. Two hundred twenty-five patients were included. There were no significant differences in the age, sex, or alcohol use between the study groups. Patients who had standard plates used had higher BMI's than those who had locking plates (30 kg/m^2 vs 27.6 kg/m^2 , $p=.04$), and were also more likely to use tobacco (23.7% vs 6.5%, $p=.005$). Thirty-one patients (13.8%) underwent revision surgery. Nineteen of those (8.4%) underwent revision surgery due to the nonunion. Eleven patients (4.9%) underwent revision due to painful/prominent hardware. One patient (0.4%) underwent revision surgery due to soft tissue infection. Twenty-nine patients (12.9%) had a radiographic or intraoperatively diagnosed nonunion. Joint-specific locking plates were used in 92 cases (40.9%) and 1/3 tubular plates contoured intraoperatively were used in 97 cases (43.1%). A plate was used along with lag screws in 76 cases (33.8%) and a plate alone was used in 113 cases (50.2%). Screw-only instrumentation was performed in 36 cases (16%).

Joint-specific locking plates compared to standard non-locking plates showed no difference in revision rate (11 (12.0%) vs 11 (11.3%) $p = 0.895$), nonunion requiring revision (6 (6.5%) vs 7 (7.2%) $p = 0.850$), hardware pain (2 (2.2%) vs 5 (5.2%) $p = 0.278$), with a trend towards a higher nonunion rate with locking plates (13 (14.1%) vs 6 (6.2%) $p=0.069$). When comparing fixation constructs using a plate, screws alone had a significantly higher revision rate (9 (25.0%) vs 22 (11.6%) $p = 0.03$), nonunion rate (10 (27.8%) vs 19 (10.1%) $p = 0.004$), and a trend toward an increase in hardware pain (4 (11.1%) vs 7 (3.7%) $p = 0.059$) and nonunion requiring revision (6 (16.7%) vs 13 (6.9%) $p = 0.053$). The cost difference between the joint-specific locking plates and the standard non-locking plates is approximately \$1300.

Conclusion: This data demonstrates no difference between locking and nonlocking dorsal plate fixation for 1st MTP arthrodesis in revision rate, nonunion requiring revision, and hardware pain. Locking plates even showed a trend towards a higher nonunion rate compared to non-locking plates. Screw fixation alone had significant worse outcomes of higher revision rate and nonunion rate. Tobacco use and a higher BMI were also associated with the use of nonlocking plates. This suggested that even in a population with known risk factors for nonunion, there are favorable results with the nonlocking plate fixation. With the significant increase in cost of the joint-specific locking plates and no difference in outcomes, routine use in primary 1st MTP arthrodesis should be discouraged.

Iliac Dymorphism: Defining Radiographic Characteristics and Association with Pelvic Osseous Corridor Size

Miqi Wang MD, Weston Pack PhD, Robert Jacobs MD, Craig Bartlett MD, Patrick Schottel MD

Introduction: Surgical treatment of acetabular, pelvic, and sacral fractures commonly utilizes intracortical pelvic corridors known as osseous fixation pathways (OFPs). Multiple pathways have been described, including the anterior column, posterior column, gluteal pillar, supraacetabular, and transiliac-transsacral corridors. Unfortunately, the width of these corridors is variable and may not always be sufficient for implant placement. Due to the complex anatomy of the pelvis, the boundaries of these OFPs are not readily visible on standard x-ray and computed tomography (CT) imaging. We hypothesized that the shape of the pelvis will be predictive of OFP size and sought to identify radiographic parameters that will help surgeons determine the feasibility of implant placement with standard imaging modalities.

Methods: CT scans of 100 male and 100 female adult hemipelves without evidence of trauma were evaluated using the Intellispace Portal 7.0 (Koninklijke Philips – Amsterdam, Netherlands). Radiographic characteristics of the ilia were measured, such as axial angle on CT and inlet and outlet angles on x-ray (Figure 1). The dimensions of the anterior column, posterior column, supraacetabular, and gluteal pillar corridors were determined through manual best-fit analysis. Presence of sacral dymorphism was identified. Corridor dimensions were sorted by clinically relevant parameters, such as less than 4.0mm and larger than 7.3mm. Student T test was used to assess for differences in iliac angles between these groups. Analysis of variance (ANOVA) was used to compare the interaction effects between corridor sizes.

Results: The mean axial, inlet, and outlet angles were 155° (132.1-180), 150.8° (117.5-193.2), and 132.3° (102-152) respectively. Female pelves had significantly smaller corridors than male pelves, though there was no association with presence of sacral dymorphism. The average axial angle in pelves with an SA corridor < 4mm was 160.7° and > 7.3mm was 154°. The average inlet angle in pelves with a gluteal pillar < 4mm was 144.3° and > 6.5mm was 152°. The average outlet angle in pelves with an anterior column corridor < 4mm was 128.9° and > 6.5mm was 134.8°. The average outlet angle in pelves with a posterior column corridor < 10mm was 129.2° and > 10mm was 133.1°. Pelves that have one small corridor are likely to have all small corridors and vice versa. Sacral dymorphism does not correlate with iliac morphology or corridor size.

Conclusions: Iliac morphology is associated with the size of iliac OFPs. Standard CT and x-ray imaging can be used to predict OFP size by identifying the shape of the ilium on axial, inlet, and outlet views. Currently, specialty imaging programs or intraoperative fluoroscopy are required to determine which implant, if any, could be successfully implanted into the pelvis. Using this technique, the determination could be made preoperatively and alternate fixation pursued if necessary. Additionally, we have shown that patients with one small corridor likely have associated small corridors throughout. Sacral morphology is not related to iliac morphology, so the utility of sacral OFPs must be separately assessed.

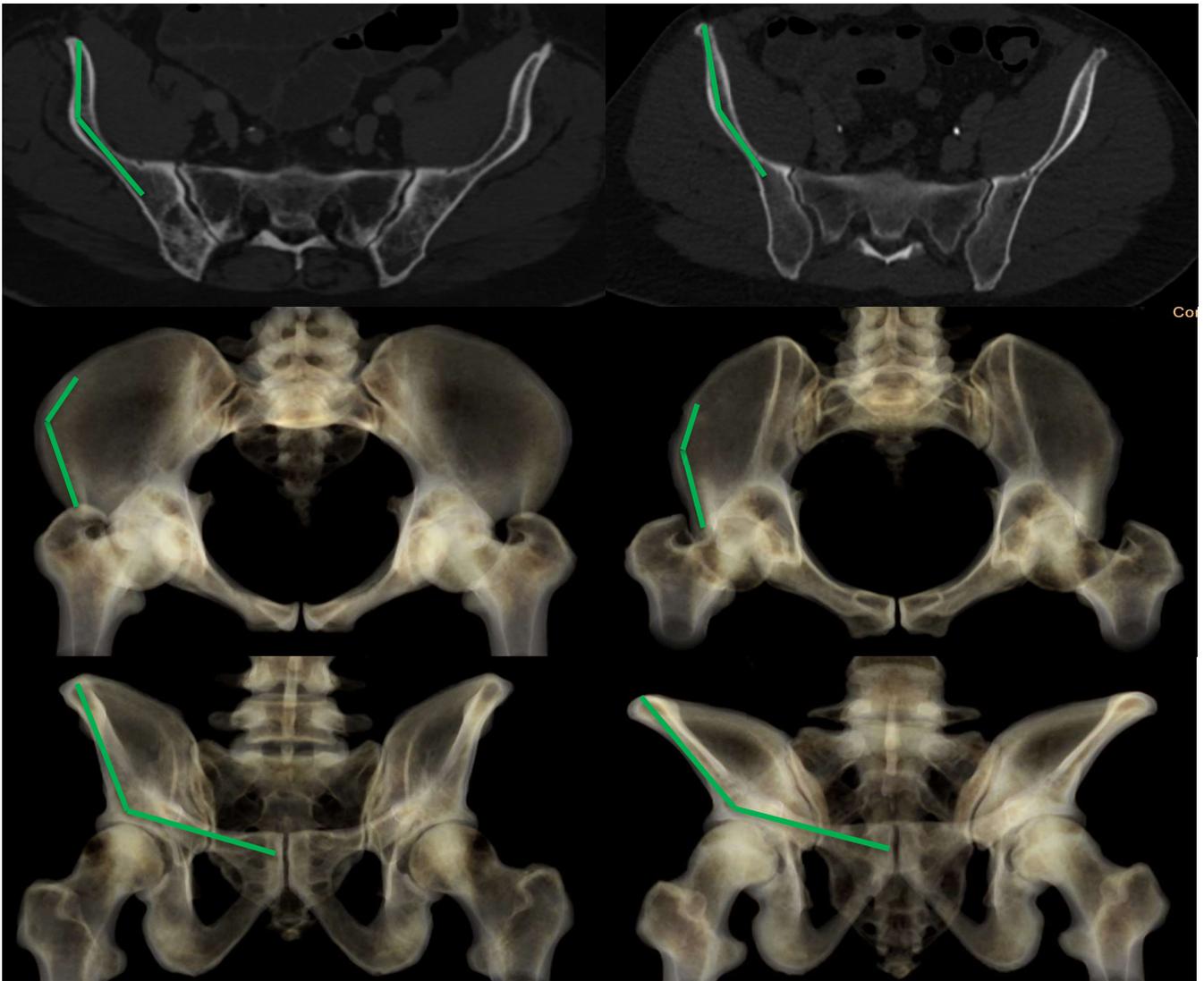


Figure 1: Examples of low (left) and high (right) axial, inlet, and outlet angles.

Non-operative Treatment of Flexor Hallucis Longus Tendonitis: Success rate of a Specific Stretching Protocol and Risk Factors for Failure

James D. Michelson, MD, Jacob W Bernknopf, BA, Mark D Charlson, MD,
Stephen J Merena, DPM, Lara M Stone, DPM

Background: Diagnosis and treatment of tendonitis/entrapment of the flexor hallucis longus (FHL) has been sporadically described in the literature, primarily in the context of dancers and other athletes. Although various nonspecific nonoperative treatments have been described, it is not clear how often they are successful.

Question/Purposes: The present study was designed to address the following questions regarding the nonoperative treatment of FHL tendonitis: 1. What is the overall success for a specific standardized nonoperative treatment program for FHL tendonitis, as defined by the avoidance of the need for surgical treatment? 2. Are there any identifiable risk factors for failure of nonoperative treatment?

Methods: Patients included were all those initially treated non-operatively in the Foot & Ankle Division between January, 2009, and December, 2018, who were diagnosed with FHL tendinitis. Demographics, co-morbidities, examination findings, imaging results, pain scores, treatment instituted, and final outcome was obtained from the electronic medical record. The primary outcome was failure of non-operative treatment as defined by the need for subsequent surgery. Comparison of patients successful versus unsuccessful non-operative treatment was by univariate and multivariate statistics using demographics, co-morbidities, and clinical findings as potential risk factors, with $p < .05$.

Results: The institution of a specific FHL stretching program was successful in 69% of all patients. Multivariate analysis showed that patients with clinical hallux rigidus (OR 4.5, 95% CI 1.8-11.6, $p = .002$), os trigonum on radiographs (OR 6.7, 95% CI 2.8-15.8, $p < .001$), or the need for immobilization (OR 5.7, 95% CI 2.9-11.4, $p < .001$), had increased risk for failure of nonoperative treatment.

Conclusions: FHL tendonitis is more common than the previous literature suggests, and frequently occurs in non-athletes. Once diagnosed by detection of posteromedial ankle tenderness at the fibro-osseous tunnel, non-operative treatment focused on specific FHL stretching is successful in up to 71% of patients. The key to its diagnosis is awareness of the possibility, since the vast majority of the patients treated in this study had been previously seen by orthopaedic providers who had not appreciated the presence of the condition, leading to a delay in diagnosis and treatment of over a year in many patients.

Level of Evidence: III

Reliability of a Simple Fluoroscopic Image to Assess Leg Length Discrepancy during Direct Anterior Approach Total Hip Arthroplasty

Sandi Caus¹ BS, Hailee Reist² MD, Christopher Bernard¹ MD,
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Background: Direct anterior approach (DAA) total hip arthroplasty (THA) in a supine position provides a unique opportunity to assess leg length discrepancy (LLD) intra-operatively with fluoroscopy. Reported fluoroscopic techniques are useful but are generally complicated or costly. Despite the use of multiple techniques for leg length assessment, LLD continues to be a major post-operative source of patient dissatisfaction further emphasizing the importance of near-anatomic restoration. The utility of an alternative direct measurement of LLD on an intra-operative fluoroscopic pelvic image during DAA THA has not been reported.

Methods: 171 patients who underwent DAA THA were included for analysis. Intra-operative fluoroscopic and post-operative anterior-posterior (AP) radiographs were imported to TraumaCad and calibrated for LLD measurement. LLD was measured on each image using the right-left hip differences in lesser trochanter to pelvic reference line distances. Pelvic reference points included the teardrops and ischia. Fluoroscopic LLD was compared to the gold-standard measurement of LLD measured on a post-operative radiograph.

Results: Mean absolute difference in teardrop referenced LLD between fluoroscopic and post-operative radiographs was 2.17 mm and based on the ischia mean absolute difference was 2.63 mm. Linear regression of fluoroscopic and post-operative radiograph LLD based on teardrop and ischia LLD found r^2 values of 0.57 and 0.84, respectively. Mean absolute difference between fluoroscopic and post-operative x-ray LLD was within 5 mm in 95% of cases regardless of pelvic reference.

Conclusions: This study demonstrates that a single fluoroscopic view obtained during DAA THA for leg length assessment is clinically useful.

The Relationship between Geometric Characteristics of the Knee (ACL Volume, Alpha Angle, and Femoral Notch Width) and the Risk of Noncontact CACL Injury

It is widely accepted that injuries to the anterior cruciate ligament (ACL) are relatively common, debilitating, and associated with a pre-mature onset of osteoarthritis. Subsequent and similar injuries to the contralateral ACL (CACL) are also quite debilitating with respect to relative frequency, severity, and similar associations to osteoarthritis. Previous research in the literature have investigated several risk factors specific to individuals of increased risk of primary non-contact ACL injury, but the association between these identified risk factors and injury of the CACL have not been actively researched. This study was a secondary analysis of a previously NIH-funded and IRB-approved study that included participants aged 13-26 who participated in organized sports and suffered a first-time non-contact ACL injury. The objectives of this study were two-fold: (1) to determine if there exists an association between geometric measurements of the knee – i.e. ACL volume, alpha angle, and femoral notch width – and CACL injury; (2) to determine if there exists an association between geometric measurements of the knee and clinical assessment of knee laxity. Understanding the relationship between anatomical knee geometries and the associated risk of CACL injury following a primary non-contact ACL injury can further refine treatment plans and the development of prevention strategies for individuals identified to be of high-risk. Due to the limitations brought by the Covid-19 pandemic, preliminary analysis including MRI segmentation and data collection has been limited thus far to 105 out of 134 participants. As of May 2021, three participants have had a CACL injury, and eight participants have had an ACL-graft injury. The next steps in data analysis include logistical regression analysis via UVM's Orthopaedics Research Program's MATLAB program to investigate if a relationship exists between the geometric characteristics of the knee that are associated with an increased risk of non-contact CACL injury and decreased knee stiffness as measured by anterior-posterior knee laxity and that this relationship is different between males and females. Persistent difficulties brought by the Covid-19 pandemic have hindered the advancement of this research. Continued efforts in data analysis, data collection, participant recruitment, and pursuit of additional areas of study are encouraged. Further areas of study include the notable rates of ACL graft rupture observed within this cohort. It is important to contextualize the rates of ACL graft injury and CACL injury in the context of the Covid-19 pandemic, which had an immense effect on the opportunity of injury in athletics and sport.

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Sex, sport and level of play influence the overall risk of concussion in high school athletes

Alexa K Pius BS , Pamela M Vacek PhD , Rebecca Choquette BS, ATC, Mickey Krug BS, ATC ,
James R Slauterbeck MD , Bruce D Beynnon MS, PhD

Background: In the United States alone, estimates show that greater than 300,000 sports-related concussions occur annually.¹ Of these, 100,000 concussions yearly can be attributed to high school athletes.¹ While there has been increasing focus on concussions at the professional and collegiate level, there is relatively few data regarding concussions in high school athletes.

Hypothesis/Purpose: The purpose of this study was to describe the incidence of concussions in high school sports, and the influence of sex, sport, and level of play on the overall risk of concussion. The influence of level of play (varsity vs JV/freshman) on the rates of concussion has also not been described in the literature to the authors' knowledge.

Study Design: Descriptive epidemiology study

Methods: Athletic exposure and injury data were collected from 14 high schools. Comparable data were collected from both control and intervention schools during the 2016-2017 school year, as well as the 2017-2018 school year. Poisson regression was used to estimate the relative risk for concussion injury associated with participant sex, type of sport, and level of play after adjustment of the other two factors. Data was collected for the following high school sports: soccer (girls' and boys'), lacrosse (girls' and boys'), basketball (girls' and boys'), and football (boys'). Data were collected for varsity, junior varsity, and freshman teams. Data were recorded at the time of injury by a certified athletic trainer employed by each included school.

Results: Concussions occurred on all types of sport teams studied with the highest incidence observed for boys' freshman and junior varsity football (1.51/1000 AE) and the lowest incidence for boys' varsity basketball (0.09/1000 AE). A majority of concussions were first-time (88.1%) rather than repeat injuries, and 71.2% occurred during a game rather than practice. Nearly all concussions were caused by contact or collision, most often with another player, and 13% occurred with a foul being called. Most concussions were classified as moderate (8-28 days of missed participation in sport). There was a significant interaction ($p = .004$) between sex and sport, reflecting a higher risk of concussion among females than males for basketball (RR, 2.61; 95% CI, 1.47 – 4.66) and soccer (RR, 1.81; 95% CI, 1.12 – 2.90) but not for lacrosse (RR, 0.73; 95% CI, 0.43 – 1.25). After adjustment for this interaction and level of play, females had about double the concussion risk compared to males (RR, 2.14; 95% CI, 1.48 - 3.08) independent of the effects of level of play and sport.

Conclusion: Concussion rates in high school athletes vary by sex, sport, and level of play. Females have two times the risk of concussion compared to males, irrespective of sport and level of play. The highest-risk sports for concussion were football and basketball. Characterizing the rate of concussions in high-school athletes is an important step in the development of future prevention and treatment strategies and can inform concussion policies that would decrease long-term morbidity in young athletes.

1. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007;42(4):495-503.

Tibiofemoral Arthrokinematics: A High-Speed Dual Fluoroscopy with Model-Based Tracking Approach

John C. Ramsdell BS¹, Niccolo M. Fiorentino PhD^{1,2,3}

¹University of Vermont Department of Electrical and Biomedical Engineering, ²University of Vermont Department of Orthopaedics and Rehabilitation, ³University of Vermont Department of Mechanical Engineering

Background:

A prevailing hypothesis postulates that abnormal joint arthrokinematics post-surgery result in irregular loading experienced by the articulating cartilage during dynamic movements. Changes to the joint's loading environment may play a key role in the cascade of events that lead to cartilage loss following joint trauma, or Post-Traumatic Osteoarthritis (PTOA). Thus, the ability to accurately quantify abnormal arthrokinematics is pivotal in providing supporting evidence of the mechanisms that drive PTOA. The purpose of this study was to develop and validate the accuracy of a method for quantifying tibiofemoral arthrokinematics. The proposed imaging method combines high-speed dual fluoroscopy with a model-based tracking (MBT) technique. The accuracy of the proposed method was determined by comparing the 6 degree of freedom (DOF) kinematics of the proposed method to an invasive "gold standard" technique of tracking implanted radiopaque markers (RSA). A secondary purpose was to present a method of quantifying arthrokinematic metrics that if were altered in a patient population would introduce an abnormal loading environment to the articular cartilage.

Materials/Methods:

Prior to imaging, radiopaque markers were implanted into the femur and tibia of two cadaveric knee specimens. The knee specimens were then imaged while simulating a static standing pose, a dynamic gait trial, and a dynamic lunge trial by a custom built dual fluoroscopic imaging system (DFIS). The DFIS consisted of two coupled x-ray emitters and two image intensifiers paired with synchronized high-speed digital cameras (Fig. 1). Computed tomography (CT) images were also collected and used to create 3D reconstructed knee models of each specimen.

The 6DOF kinematics of each data collection were generated via the proposed MBT method by three different researchers, and once via the gold standard RSA method. Solving for the poses of the bones using MBT involved virtually reconstructing the DFIS and semi-manually matching digitally reconstructed radiographs of the 3D bone models to the true radiographs captured during data collection. The RSA method involved tracking the 2D positions of the implanted markers in the fluoroscopic images and utilizing the known 3D defined locations of the implanted markers generated from the CT scans to solve for the poses of each bone. The accuracy of the MBT was defined by calculating the bias, precision, and root mean squared difference (RMSD) of the 6DOF kinematics between the two methods for each trial.

The arthrokinematic models derived from the 6DOF kinematics and 3D reconstructed bone models included dynamic joint space width (JSW) maps, medial and lateral subchondral point of proximity (SPP) paths, and sliding velocities. The dynamic JSW maps were calculated by coloring the surfaces of the bones that fit a contact region of interest (ROI) criteria based on their closest distance to the surface of the other bone at each instance. The SPP which are meant to represent the point of contact in each compartment were estimated using the previously described ROIs to define a weighted centroid based on JSW. The sliding velocities were estimated by solving for the velocity of the femoral surface closest to the tibia's SPP.

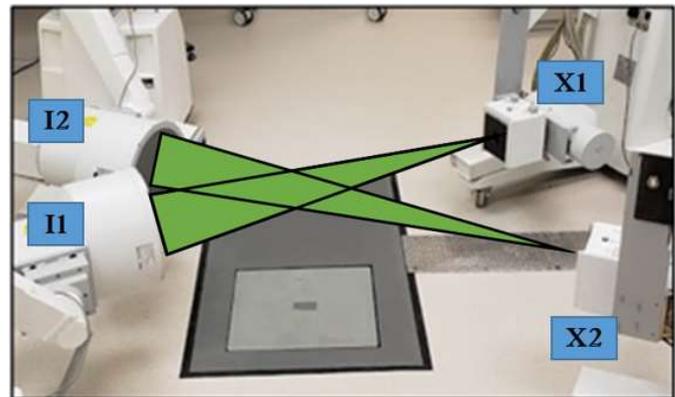


Figure 1: DFIS consisted of x-ray emitters X1 and X2 that are projected onto their corresponding image intensifiers I1 and I2.

Results:

In all instances of trial type and degree of freedom, the average RMSD across researchers of the two specimens for the proposed MBT did not exceed 0.9 mm in translation or 0.9 degrees in rotation when compared to the gold standard RSA method. The 6 DOF kinematics along with the 3D reconstructed knee models were used to generate arthrokinematics outcome metrics of dynamic joint space width maps, point of proximity paths, and sliding velocities (Fig. 2).

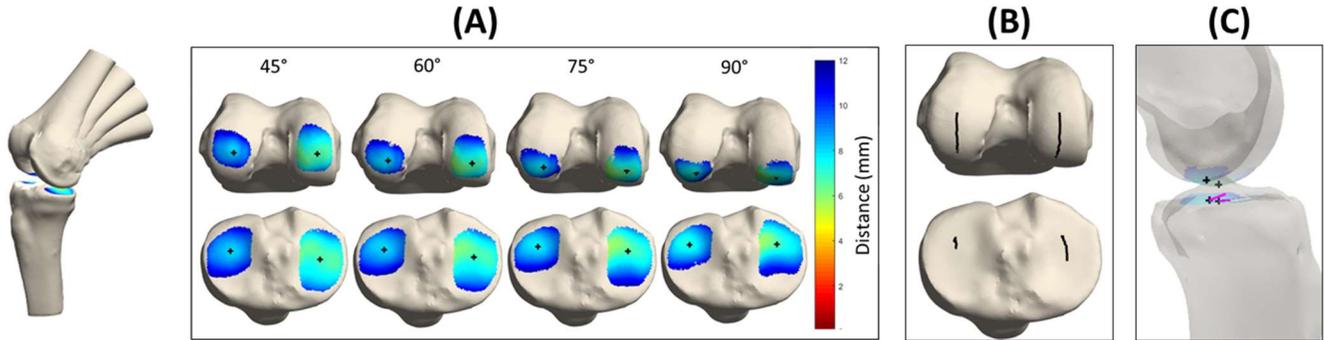


Figure 2: (A) The dynamic joint space width maps along with the subchondral points of proximity in each compartment plotted as (+) are shown of one of the cadaveric specimens simulating a lunge at 45,60,75, and 90 degrees of flexion. (B). The path throughout the entire lunge trial of the subchondral point of proximity is shown. (C) Sliding velocities at the points of proximity are presented as purple vectors that represent the velocity of the subchondral surface of the femur.

Conclusion:

The proposed method of combining high-speed dual fluoroscopy with MBT was shown in this study to accurately quantify the 6 DOF kinematics with errors on the order of 1/10 of a millimeter when compared to the gold standard RSA. Therefore, the methods of quantifying arthrokinematics presented in this study have the potential to provide key evidence for the hypothesis that abnormal loading environments of the articular cartilage following joint trauma lead to the development of PTOA. Furthermore, an abnormal loading environment may provide a target for development of early therapeutic interventions.

Short-term Clinical Outcomes of ProChondrix® Osteochondral Allograft in the Knee - A case series

Evan Boyd MD, Michael Barnum BS, Bruce Beynnon PhD, James Slauterbeck MD

Background: Focal articular cartilage injuries are common, can cause significant functional impairment, and may lead to progression of osteoarthritis. The complications associated with traditional treatment strategies and the complexity of hyaline cartilage regeneration have influenced the development of new biotechnologies, such as the ProChondrix® osteochondral allograft. Clinical evidence on the short-term or long-term outcomes associated with ProChondrix® osteochondral allograft are limited.

Purpose: To evaluate the short-term clinical outcomes following ProChondrix® osteochondral allograft implant.

Study Design: Case series; Level of evidence, 4.

Methods: We retrospectively identified 6 patients treated with a ProChondrix® osteochondral allograft by a single surgeon between January 2016 and December 2019. Patients completed patient-reported outcome surveys which included the Knee injury and Osteoarthritis Outcome Score (KOOS), consisting of the 5 subscales of Pain, Symptoms, Activities of Daily Living, Sports and Recreation, and Quality of Life, the Marx Activity Scale, and the visual analog pain scale.

Results: Of the 6 patients, there were 3 females and 3 males, with median age of 33.5 years (range 18-48 years). All patients had a minimum follow-up of 6 months. The median follow-up duration was 15 months (range 9-24 months). There were 4 patellar grafts, 1 medial femoral condyle graft, and 1 lateral femoral condyle graft, with a median defect size of 18.5mm (range 13-20mm). At the most recent clinical follow-up, all six patients were pain free and all patients had returned to pre-op activity level. The median scores for each subdomain of the Knee injury and Osteoarthritis Outcome Scores were as follows: 79 for symptoms, 92 for pain, 96.5 activities of daily living, 72.5 for sports and recreation, 59.5 for quality of life and a median Marx Activity Scale of 6.5.

Conclusion: This case series of 6 patients who underwent fixation of cartilage defects in the knee with a ProChondrix® osteochondral allograft has demonstrated clinically meaningful patient reported clinical outcomes at short-term follow-up.

Clinical Relevance: The original intent of this review was for a quality improvement project to determine if we should continue to utilize this product. In our study, ProChondrix® osteochondral allograft has demonstrated promising short-term results.

Key Terms: osteochondral allograft, cartilage, knee

What is known about the subject: Focal articular cartilage injuries are common and treatment remains challenging as articular cartilage has limited regenerative capacity and often necessitating surgical repair. Traditional treatment strategies are limited by the generation of

fibrocartilage, hyaline-like articular cartilage, or are limited by cadaver availability, shelf life, and disease transmission. These limitations have influenced the development of biotechnologies such as ProChondrix®. Published clinical data on the use of ProChondrix® and clinical outcomes are lacking in the scientific literature.

What this study adds to existing knowledge: To our knowledge, this is the first study to report the clinical outcome, activity level, and patient orientated outcomes in a case series of patients following treatment of an isolated cartilage defect with a ProChondrix® osteochondral allograft implant. Our study demonstrates promising short-term results in patient reported clinical outcome scores at median follow-up of 15 months (range 9-24 months). [DAP1]

Outcomes of Nonoperatively Treated Periprosthetic Fractures around Total Hip Arthroplasty Femoral Stems without Subsidence

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Background/Significance: The numbers of both primary and revision total hip arthroplasty (THA) procedures are increasing as the average life expectancy continues to increase.[1] Although hip arthroplasty is one of the most successful procedures in Orthopaedic surgery[2], it is not without complications. With the increasing number of these procedures being performed on both elderly and younger populations, there will be a concordant increase in associated complications.[3]

Periprosthetic femoral fractures (PPFx) are a severe complication of primary and revision hip arthroplasty. With an incidence estimated as high as 0.1%-2.1% for primary THA and 4.2% for revision THA, PPFx are the third most common cause of revision surgery.[4, 5] These injuries often occur after a low energy fall and are associated with osteoporosis, osteolysis/aseptic loosening, female sex, revision surgery, and press-fit stem use. A recent analysis of the American Joint Replacement Registry showed an increasing trend towards press-fit stem use associated PPFx. [6-8]

Classification and treatment of these fractures is commonly based on the well-validated Vancouver system.[9] Type B1 fractures, those that occur at the level of the stem but have a stable, well-fixed implant, are standardly treated by open reduction internal fixation while maintaining the pre-existing implant.[10] Although common practice, these surgeries carry with them an estimated one-year mortality rate as high as 11.6% and five-year mortality rate of 25.6%. Postoperative morbidity associated with re-operation, bleeding, dislocation, DVT, infection, stroke, and cardiac failure are also not uncommon in an already sick (ASA>3) geriatric patient population.[7, 11, 12]

Given the increasing rates of THA, increasing rate of PPFx, and the high rate of morbidity and mortality associated with surgical treatment of these fractures in an already frail patient population, there is the need to explore the role of non-operative management in select patient populations. This could become increasingly important in post COVID-19 era. We are only aware of one study investigating the role of nonoperatively treated PPFx patients using only press-fit stems and treated with teriparatide.[13] The objective of our study is to report the outcomes of minimally displaced periprosthetic fractures around THA without stem subsidence in a geriatric patient population.

Study Aims and Hypothesis: We aim to delineate which patient, implant, and fracture factors are associated with radiographic union and return to function in nonoperatively managed minimally displaced Vancouver B1 fractures without stem subsidence. We hypothesize that in select patients with minimally displaced Vancouver B1 fractures without stem subsidence, non-operative management will result in radiographic union and return to function. We also aim to define the specific fracture characteristics/morphology and implant type that lead to appropriate patient selection for conservative management of these PPFx.

Study Design: This will be a retrospective case control study performed in a level I trauma center of 21 patients 75 years of age or older who sustained a minimally displaced Vancouver B1 periprosthetic fracture around THA without stem subsidence during a 5 year period. Cases will be matched 1:2 with operatively treated Vancouver B1 fractures and outcomes between groups compared.

Intervention: Nonoperative treatment. Reasons for nonoperative management will be identified retrospectively from the chart review. After the treating surgeon determined that nonoperative treatment was suitable, the risks and benefits associated with operative and nonoperative treatment were discussed with the patient and/or the family. Following an informed discussion, the shared decision to proceed with nonoperative management was made by the surgeon, patient, and family. All patients were treated with a standard protocol of touch down weight bearing. All patients were evaluated by a physical therapist and were ordered and encouraged to be out of bed to chair and participate in assisted ambulation. All patients were discharged to a rehabilitation facility or home with scheduled outpatient or in-home physical therapy. Deep venous thrombosis prophylaxis was administered. Follow up was arranged with repeat x-rays at 4-6 weeks.

Primary outcome measures: Subsequent surgical intervention within 12 months and 1-year mortality rates.

Secondary outcome measures: radiographic union, time to union, return to pre-injury weight bearing status, LOS, pain medication requirements during hospitalization, discharge location, complications

Statistical methods: Twenty-one cases of nonoperatively treated Vancouver B1 fractures will be matched in 1:2 fashion with control patients having Vancouver B1 fractures treated operatively. Matching will be based on age, sex, fracture pattern, comorbidities, preinjury living status, and preinjury ambulatory status.

The following data will be extracted from electronic medical records: age, sex, mechanism of injury, ambulatory status prior to injury, living status, preexisting osteoporosis, medical comorbidities, date of index arthroplasty procedure and associated injuries

Radiographic features: Fracture pattern and angulation and femoral implant design will be classified by fellowship-trained orthopaedic trauma/arthroplasty surgeons according to Vancouver classification. Distance from the most distal fracture line extension and tip of stem will be measured.

Innovation: As previously described, the standard of care for Vancouver B1 fractures is currently open reduction and internal fixation regardless of fracture morphology and patient factors. Our study aims to define specific fracture patterns and patients that may benefit from an alternative, more conservative treatment algorithm.

Sources of Bias: This is a retrospective study. This carries with it potential for a host of biases however; given the limited existing literature surrounding this topic our study will lay the groundwork for future comparative studies.

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A Novel Fluoroscopic Method for Assessing Rotational Malalignment of the Tibia

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Objective: To evaluate the accuracy and reliability of a novel fluoroscopic technique for assessing tibial rotation and compare it to a previously described fluoroscopic method.

Methods: A multiplanar circular ring external fixator was secured to the tibial diaphysis of five cadaveric lower extremity specimens. Using deformity correction software, the frame and tibia were programmed to randomly rotate 5, 10, 15, 20, 25, and 30 degrees of internal and external rotation. Following each rotation, two blinded, independent observers measured the degree of tibial rotation using two different fluoroscopic methods: the previously described “mortise” method and the novel “intermalleolar” method. A total of 65 measurements were made by each observer. Accuracy and inter-observer reliability were calculated.

Results: Both intermalleolar and mortise methods had a mean absolute rotational difference from the true torsion of 3 degrees (SE 1, range 0-10 degrees intermalleolar versus 0-18 degrees mortise). We found that 98.5% (128/130) of measurements using the intermalleolar method were less than 10 degrees from the true rotation, compared to 93.8% (122/130) using the mortise method. Both the intermalleolar and mortise methods had excellent inter-observer reliability (ICC 0.99 and 0.96, respectively).

Conclusion: Measuring tibial rotation fluoroscopically using the intermalleolar method is both accurate and reliable. Compared to the previously described mortise method, it has similar accuracy and provides a value that approximates the true tibial rotation. Also, it can be employed reliably and effectively intraoperatively to identify tibial malrotation and assist in intraoperative rotational corrections.