Active Project list as of 12/21/23

Musculoskeletal research projects available in the Department of Orthopedics and Rehabilitation during 2023

Project 1: Osteoporosis Management Follow-up for Patients with Vertebral Compression Fractures.

Faculty mentors: Chason Ziino MD and Shawn Best MD

This will be a be a retrospective review of osteoporosis follow up (medication adherence, subsequent fracture, functional status, etc.) for patients who present with vertebral compression fractures.

The work will involve one MS1 student

Project 2: Subacute, Outpatient Management of Adult Both Bone Forearm Fractures

Faculty mentors: Kevin Lutsky MD, Michel Benoit MD, and Luke Seeker MD

At most level I trauma centers, the current standard of care for adult both bone forearm fractures is fixation within 1-2 days; however, at our institution these injuries are routinely fixed in the 1-2 week timeframe, and the patients are subsequently discharged home. The short- and long-term outcomes of adult both bone forearm fractures treated in a delayed and outpatient fashion are not described in the literature. The reasoning for expedited treatment is based on old literature that cites increased risk of synostosis and increased difficulty of surgery. Our hypothesis is that delayed management that involves closed reduction followed by subacute definitive open reduction internal fixation of adult both bone forearm fractures results in low levels of adverse outcomes and complication as defined by radiographic synostosis at final follow-up, need for fasciotomy, and rate of reoperation.

This study will be a single institution, retrospective, safety study. Our institution has a population of adult patients who have a unique treatment algorithm for both bone forearm fractures. All patients with billing codes for diaphyseal radius and ulna fractures who were seen at the University of Vermont Orthopedic upper extremity or trauma clinics will be included. Injury radiographs as well as final radiographs will be included. Injury radiographs will be reviewed and subclassified into proximal third, middle third and distal third diaphyseal fractures. The primary outcome measures will consist of time to definitive fixation, radiographic evidence of union at the final clinic visit, and radiographic evidence synostosis at the final clinic visit. Secondary outcome measures will be the need for secondary procedures, need for fasciotomy, time to union, infection, and presence of open fracture.

The work will involve one MS1 student

Project 3: Gardner-Wells Tongs (GWT) are Safe and Effective for Intraoperative Positioning in Spine Surgery

Faculty mentors: Chason Ziino MD, Greg Roy MD, Dhiraj Patel MS2

There is a paucity within the literature on the topic of complications following the use of Gardner-Wells Tongs (GWT). Few studies have reported on the rate of complications, and each of these studies are limited in their own ways. One study reported a high complication rate of 37.5%, consisting of loosening pins, asymmetric pins and infection; however, they had only one superficial infection and no severe complications reported. True rates of severe complications such as brain abscess, medial table penetration, and neurovascular injury, are largely unknown as they are rare. Most of the data in the literature have been obtained through case reports. This study will further elucidate the complications and their rates. Gaining a better understanding of the complications and their prevalence will inform the safety profile of GWT use and possibly expand their utility to other applications. It will also seek to confirm the work of other investigators in that complications associated with Gardner-Wells tongs are minor and rare. This is important information as there are described complications with major morbidity and possible mortality with little information on the prevalence of these complications in the literature.

This study will be a chart review that documents the prevalence of major (medial table breach, deep infection/abscess, neurovascular injury, vision disturbance) and minor complications (pin loosening, minor bleeding, superficial infection) following the use of GWT in various spine surgeries performed by a single-provider at UVM-MC.

Major and minor complications will be defined as follows:

Major complications: medial table breach, neurovascular injury, deep infection/abscess, pin pull out, vision disturbance (increased intra-ocular pressure) at any time point.

Minor complications: minor bleeding requiring staples, superficial infection, pin loosening, at any time point.

The work will involve one MS1 student.

Project 4. Systematic review of surgical techniques and clinical outcomes in patients with a parameniscal cyst undergoing meniscal repair with biological augmentation

Faculty mentor: Andrew Geeslin MD

The types of biological augmentation considered in the systematic review would include platelet rich plasma, fibrin clot, bone marrow aspirate injection, marrow venting procedure (penetration of the lateral femoral notch anterior to the ACL attachment). If there is insufficient data in the literature to conduct a systematic review, this could be expanded to include repair or resection of meniscal tears in patients with parameniscal cysts. The work will involve one MS1 student.

Project 5. Skeletally immature MRI anterolateral complex of the knee anatomy

Faculty mentors: Andrew Geeslin MD, Matt Geeslin MD, and Mike Danaher MD

Limited information is available in the literature on the anatomy of the anterolateral complex (ALC; Kaplan fibers, anterolateral ligament, capsule-osseous layer of the iliotibial band) of the knee in skeletally immature patients. Skeletally immature patients suffer ACL injury as well as ACL graft failure after reconstruction at a higher rate than older individuals. Anterolateral complex reconstruction (lateral extra-articular tenodesis or anterolateral ligament [ALL] reconstruction) in the setting of ACL reconstruction has been shown to reduce ACL graft failure rate (Getgood Stability AJSM 2020, Sonnery-Cottet/SANTI studies) compared to controls. A qualitative and quantitative anatomical study using MRI is warranted to better understand this anatomy. Non-injured skeletally immature patients with an MRI (specifically excluding patients with evidence of ligamentous injury or structural abnormality of the lateral knee) will be included from the UVMMC imaging database.

The work will involve one MS1 student

Project 6: Systematic review of the Anterolateral complex on MRI in normal (uninjured) skeletally mature knees

Faculty mentor: Andrew Geeslin MD, Matt Geeslin MD

This would be similar to the skeletally immature anatomy study (Project 5 seen above) but done in skeletally mature patients and done in the form of a systematic review of existing studies on this topic.

The work will involve one MS1 student

Project 7: Assessing changes in articular cartilage proteoglycan content and collagen distribution in ACL-injured patients with and without concomitant meniscal injury at one-year follow-up

Faculty mentor: Bruce Beynnon MS PhD, Andy Geeslin MD, Matt Geeslin MD, Ty Walker MS2, and Em Battle MS2

Articular cartilage (AC) is hydrated specialized connective tissue with viscoelastic properties. It covers the bony surfaces of joints such as the patellofemoral and tibiofemoral joints of the knee and functions to transmit contact stress to underlying subchondral bone. The biomechanical properties of cartilage depend on the integrity of its matrix components and an appropriate distribution of water, proteoglycan, and collagen throughout its matrix.

Damaged AC degrades over time and can lead to osteoarthritis (OA), a leading cause of musculoskeletal morbidity associated with pain and progressive loss of joint function. Indeed, severe joint injuries such as an ACL disruption can initiate post- traumatic OA (PTOA) progression. This been observed in greater than 80% of subjects 10 -15 years following the index injury.

T2* and T1rho are research-based MRI imaging modalities that our group has applied to evaluate proteoglycan content and collagen organization within AC. Collagen damage and subsequent change in cartilage hydration are early indicators of post- traumatic osteoarthritis that can be measured with T2* and T1rho imaging. Accordingly, these imaging techniques are increasingly being utilized by our group and other researchers in the field as image-based biomarkers to assess changes in PTOA progression in pre-symptomatic patients following ACL injury.

Concomitant meniscus tears are observed in more than 60% of patients with ACL injuries, and this combined injury increases the risk of developing PTOA. Previous research has shown that T2* and T1rho relaxation times are increased soon after severe joint trauma and that early T2* / T1rho changes correlate with later cartilage loss and osteoarthritis progression. T2* and T1rho are considered useful tools for imaging the onset and initial progression of the PTOA degenerative process at a subclinical stage where clinicians could initiate intervention that prevents the progression of PTOA to end-stage disease. Assessing early, sex-specific changes in proteoglycan content and collagen organization in ACL-injured patients with and without concomitant meniscal injury will help determine how these factors influence PTOA progression.

Active individuals aged 13-35 who suffered a first-time ACL rupture with and without meniscus injury participated are the focus of this investigation. To date, 65 subjects have been enrolled and underwent bilateral MRI scans to measure T2* and T1rho relaxation times after the index trauma but before surgery. Twenty of the 65 ACL-injured subjects (5 males and 5 females with and without concomitant lateral meniscal injury) were processed last summer by Ty Walker and Em Battle (currently, MS2s). The tibiofemoral articular cartilage was segmented manually in each MRI image slice to establish 3-dimensional T2*/T1rho relaxation time maps for the injured and contralateral normal knees. Regions of interest include trochlea of the femur, as well as anterior, middle, and posterior aspects of the medial and lateral tibial plateau and femoral condyles. These data are currently being analyzed to determie the patterns of injury-related changes in cartilage proteoglycan content and collagen orientation (again, demonstrated by T2* and T1rho relaxation times) based on injury type (ACL tear with or without meniscal injury) and patient sex. The work will establish the effect of injury on T2* and T1rho relaxation times soon after injury and prior to surgery, and will be used to confirm or refute our hypothesis that injury type (ACL tear with and without meniscus injury) and patient sex are factors that modify the effect of ACL-injury on cartilage proteoglycan content and distribution, and in turn modulate the risk for developing PTOA.

At the current point in time, we are conducting 1-year follow-up MRI acquisitions on the same 20 subjects that were the focus of last years' research conducted by Ty and Em as part of their MS1 summer fellowship. The purpose of the current research study is to build on last year's work that was focused on the effect of the injury by assessing the post-injury to one year follow-up (i.e. the effect of injury, reconstruction, rehabilitation, return to activity and 1 year of healing) changes in cartilage proteoglycan content and distribution (again, with T1rho and T2*) in ACL-injured patients with and without concomitant meniscal injury. The data will be analyzed in a sex-specific manner since we have identified that males and females demonstrate different patterns of morphological change and cartilage degeneration following ACL injury.

The work will involve two MS1s (one will process theT1rho acquisitions, and the other will process the T2* acquisitions) who will post process the MRI data acquired from the 20 subjects.

Project 8: Combined injury to the ACL and meniscus alters the geometry of articular cartilage and meniscus soon after initial trauma

Faculty mentor: Bruce Beynnon MS, PhD, Andy Geeslin MD, and Matt Geeslin MD

Combined injury to the anterior cruciate ligament (ACL) and meniscus is associated with earlier onset and increased rates of post traumatic osteoarthritis (PTOA) about the knee compared to isolated ACL injury at 10-to-15 year follow-up. There is; however, little known about the initial changes in knee joint structures associated with these different types of trauma. Our group has recently established that concomitant meniscus tears are observed in more than 60% of patients that suffer severe knee injury that involves the ACL, and has studied subjects that underwent MRI scanning soon after ACL injury and prior to surgery (Beynnon J Orthop Res 2020 38(4):759-67 PMID: PMC7071961) that demonstrated those that suffered injury to the ACL and lateral meniscus underwent changes in the lateral tibial compartment (increases in the posterior-inferior directed slopes of the articular cartilage surface, and the wedge angle of the posterior horn of the meniscus) and medial compartment (the cartilage-to-bone height decreased in the region located under the posterior horn of the meniscus, and the thickness of cartilage increased and decreased in the mid and posterior regions of the plateau, respectively). Subjects that suffered an isolated ACL tear did not undergo the same magnitude of change to these structures. A majority of the changes in morphometry occurred in the lateral compartment of the knee; however, change in the medial compartment of the knee with a normal appearing meniscus also occurred.

Our work characterizing the initial, gross morphological changes to the articular structures about the knee following severe ligament trauma is certainly important; however, if we are going to understand the mechanisms and temporal events associated with the onset of PTOA, we need to also understand the effect of injury, reconstruction Indeed, studies targeting the time period after injury, surgical reconstruction and return to preinjury activities may provide an opportunity to understand the biomechanical and biological mechanisms of isolated ACL injury and combined ACL and meniscus injury that will aid in successful treatments that prevent PTOA. In the current study, we hypothesize that ACL disruption in combination with injury to the meniscus: (e.g. ACL with concomitant medial meniscus injury: ACLMM, ACL with concomitant lateral meniscus injury: ACLLM, and ACL injury with combined medial and lateral meniscus injury: ACLMM+ACLLM groups) have an effect on morphometry of the articular cartilage and meniscus about the entire tibial plateau that is more pronounced than an ACL tear without concomitant meniscus injury, and the response is different for females compared to males.

This investigation is an extension of a prospective cohort study of the risk factors associated with suffering a contralateral ACL injury following a first time ACL injury. Our institution's Committee on Human Research in the Medical Sciences approved this investigation and each participant, as well as a parent or legal guardian if the participant was younger than 18 years of age, has provided signed informed consent prior to participation.

We have enrolled 196 male and female subjects that are between 13 and 26 years of age, suffered their first ACL rupture (to either knee) with or without meniscus injury, undergone ACL reconstruction of their disrupted ACL (confirmed by self-report and direct observation), completed their rehabilitation and were cleared to return to their sport/preinjury activities. Subjects that suffered partial ACL injury or re-injury to an ACL graft were excluded. ACL injuries were diagnosed by an orthopedic surgeon and confirmed by magnetic resonance imaging (MRI) and subsequent arthroscopic visualization. Following ACL reconstruction surgery, rehabilitation and at the time they were cleared to return to preinjury activities all participants underwent 3T MRI scans using the same scanner (Phillips Acheiva 3T MRI system) on both their reconstructed and uninjured knees using a previously described protocol that has been shown to be reliable. Subjects were positioned supine within an eight channel SENSE knee coil by the same technician with the knee in extension, and three-dimensional and T1-weighted fast field echo (FFE) scans (slice thickness 1.2 mm; in plane resolution 0.3 mm by 0.3 mm) were acquired.

Each injured subject had arthroscopic findings regarding the status of their articular cartilage and menisci of their ACL injured knee documented at the time of surgery by the same orthopedic surgeons.

Characterization of the position of the tibia relative to the femur during MRI acquisition will be accomplished by establishing three-dimensional, bone-based coordinate systems within the femur and tibia. The following three-dimensional (3D) measurements of the geometry of the tibial articular cartilage surface, underlying tibial subchondral bone, and meniscus were made relative to the 3D bone based coordinate systems using the approaches that we developed and described (Table 1).[15,16] In the medial and lateral compartments of the tibia, the profiles of the articular cartilage surfaces will be characterized as the slopes of the middle and posterior regions at that sagittal MRI slice that is located at the point of maximum depth of concavity in the articular surface (M_{edial}MCS, M_{edial}PCS, L_{ateral}MCS, L_{ateral}PCS), the wedge angles formed between the superior surface of the posterior horn of the meniscus relative to the underlying articular cartilage (M_{edial}MCA, L_{ateral}MCA) and relative to subchondral bone (M_{edial}MBA, L_{ateral}MBA) will be characterized. In addition, we will measure the slopes of the underlying subchondral bone in both compartments of the tibial plateau (M_{edial}BS and L_{ateral}BS), heights of the posterior aspect of the meniscus relative to the surface of the articular cartilage (M_{edial}MCH, L_{ateral}MCH), and the posterior surface of the articular cartilage relative to subchondral bone (M_{edial}CBH, L_{ateral}CBH). Tibial articular cartilage thicknesses maps will be derived as the perpendicular distance between the three-dimensional profiles of articular cartilage and subchondral bone surfaces at 1 mm by 1 mm grid points evenly spaced over the tibia bone surface as previously described by our group, and this was done for the lateral and medial compartments. Geometry of the tibial articular cartilage surfaces, underlying tibial subchondral bone, menisci, and cartilage thickness maps will be acquired with a high level of measurement reliability as described by our research group.

To test our hypothesis we will initially make within subject (injured-to-normal side) comparisons of the before mentioned geometric features of the articular cartilage, meniscus, subchondral bone and position of the tibia relative to the femur using a Student's paired T-test after confirming normality of the data. Comparisons will be done separately for the males and females and for the ACL group and the ACL with concomitant meniscus injury: medial meniscus (ACLMM), lateral meniscus (ACLLM) and combined medial and lateral meniscus (ACLMM+ACLLM) group. For each sex, this will be followed by comparisons between the groups (ACL, ACLMM, ACLLM and ACLMM+ACLLM) using a non-paired T-test after confirming normality.

A two-step process will be used to analyze the cartilage thickness maps. The first step was to process data from the matched (based on age, sport and sex), uninjured control subjects.[9] At each point on the 1 mm by 1 mm grid we calculated the side-to-side difference in cartilage thickness with corresponding 95% confidence intervals and used this data to establish the normal limits of cartilage thickness difference values outside of which we have the capacity to detect an injured-to-normal side difference for the ACL injured subjects. Second, each compartment was divided into three regions (anterior, central, and posterior) as described previously.[9] A Student's paired T-test was applied to each compartment and region of the ACL inured group (Injured-to-contralateral normal side) while accounting for multiple comparisons with the Benjamini-Hochberg method[21] using the approach we have described.[9] Injured-to-normal thickness differences that were greater than the 95% CI of normal and statistically different were considered thicker, while differences that were less than the 95% CI of normal and statistically different will be considered thinner.

The work will involve one MS1 student