UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Senior Design Project Description

Company Name	*Atrium Musculoskeletal Institute, Atrium Health*	**Date Submitted**	*7/30/2020*
Project Title	*Biomechanical Analysis of Supplemental ACL Reconstruction Tibial-Sided Fixation* **(AH_ACL)**	**Planned Starting Semester**	*Fall 2019*

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	2	Electrical	1
Computer		Systems	
Other (Biomed)	2		

Company and Project Overview:

The Atrium Musculoskeletal Institute was established to be the first and best choice for musculoskeletal care in our region. The MSK Institute includes orthopaedic surgeons, primary care sports medicine, and other health professionals treating a wide range of injuries and conditions. The Division of Research, Quality, and Outcomes, led by Rachel Seymour, PhD, Vice Chair for Research, and Joseph Hsu, MD, Vice Chair for Quality, is focused on pushing innovation in care delivery and outcomes for our patients. We have a robust clinical and translational research infrastructure that includes divisions of clinical research, engineering research, and basic science research. As part of our focus on translational research, biomechanical studies are often undertaken within our engineering department. There is often the need to investigate new procedures/processes, implants, and techniques. Comparing a novel procedure or application for a device against the gold standard or against competing products are tasks regularly conducted in our lab. The proposed study is a scenario where the variance of human cadavers—bone quality, available surface area, etc.-- is essential to determining the most favorable approach to one aspect of anterior cruciate ligament (ACL) repair.

Background and Significance: The incidence of anterior cruciate ligament (ACL) injury is substantial; with reconstruction efforts, the mechanical stability of the initial graft fixation techniques is paramount toward the success of the operation. In the early postoperative phase after ACL reconstruction, the tibial fixation represents the weakest point of fixation because of inferior quality of bone at the tibial metaphysis when compared to the femur [1]. Interference screw fixation has been widely used for tibial-sided fixation of ACL grafts, but the fixation strength is

highly dependent on the bone mineral density and screw insertion angle [1-3]. The ability to mechanically optimize interference graft tibial-sided fixation with supplemental means would, thus, have significant value to the treating surgeon.
The purpose of this study is to compare the time zero biomechanical properties of a commercially available knotless suture anchor and screw post for supplemental cortical tibial fixation of bone-tendon-bone interference graft fixation.
Hypothesis: Supplemental cortical tibial fixation using a knotless suture anchor will provide the most favorable cyclic displacement and ultimate load to failure biomechanical properties in comparison with a screw post.

Project Requirements:

Design a custom apparatus and system (inclusive of sensors) to accomplish the purpose and test the hypothesis of this study:

- Properly fix cadaveric tibias (supplied by Atrium) within a material testing machine
    - Allow for adjustments of varying sizes
    - Allow for adjustment of angles to coincide with tibial tunnel
- Properly fix free end of bone-tendon-bone graft to apply loads (cyclic and pull to failure) to the fixation site
    - Cyclic loads between 50N and 250N for up to 1000 cycles
    - Pull to failure loads (reference literature)
- Designing an actuator to simultaneously apply torque/rotation and thereby more realistically simulating knee motion would be a positive addition.
- Determine best sensor type to monitor global and local displacement/strain
- Create a data acquisition program (LabView) to collect sensor data.
- Create analysis script (Matlab) to analyze and report collected data

Primary variables to be collected are:

- Force:
    - Global: force reported by material testing machine
    - Local: load cell in line with action of force if material testing machine is not sensitive enough
- Displacement:
    - Global: change in length/displacement of entire graft
    - Local: change in length/displacement at fixation site

Expected Deliverables/Results:

- A custom apparatus capable of fixing both the tibia and graft for applying loads
- Any sensors used in tandem with material testing machine
- Software program used to collect data
- Software used to analyze data
- All data and notes collected during scope of project.
- *Should the students get to a point where multiple specimen are tested, statistical analysis or determination of clinical significance is not expected.
- All information and documentation necessary to reproduce the custom apparatus, literature

used to support decisions made, calibration information of sensors/equipment used.

Disposition of Deliverables at the End of the Project:

Handover within a reasonable timeframe following the expo is acceptable.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

Requirements:
Some travel to meet with Atrium Health technical contacts and representatives may be required.

Skills/Courses:

- Programming (Matlab, LabView, CAD)
- Familiarity with and interest in measurements and instrumentation.
- Firm grasp of dynamic systems (MEGR3122), Biomaterials (MEGR3233) and Biodynamics (MEGR3234)
- Beneficial courses: MEGR 3171(L) MEGR 2279 MEGR 3152

References:

1. Brand JC Jr, Pienkowski D, Steenlage E, Hamilton D, Johnson DL, Caborn DN. Interference screw fixation strength of a quadrupled hamstring tendon graft is directly related to bone mineral density and insertion torque. *Am J Sports Med*. 2000; 28(5): 705-710.
2. Jomha NM, Raso VJ, Leung P. Effect of varying angles on the pullout strength of interference screw fixation. *Arthroscopy*. 1993; 9(5): 580-583.
3. Ninomiya T, Tachibana Y, Miyajima T, Yamazaki K, Oda H. Fixation strength of the interference screw in the femoral tunnel: the effect of screw divergence on the coronal plane. *Knee*. 2011; 18(2): 83-87.