The Effect of Anterior Cruciate Ligament Femoral Entheseal Shape on Ligament Strain

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The anterior cruciate ligament (ACL) is the most commonly injured ligament in the human knee. The ACL has a limited ability to repair itself, due to its poor vascularity and cellularity. Thus, complete tears require surgical reconstruction. Most ACL failures occur at the femoral enthesis (the attachment site of the ACL to the femur). Several different entheseal profiles were recently categorized in a histological study. It remains unclear whether certain enthesis shapes produce strain fields which are less likely to cause tearing at the femoral enthesis than other shapes. The goals of this study are to 1) experimentally examine the strain fields within an experimental model of the ACL with varying entheseal profiles and 2) determine which entheseal profiles are most advantageous. The results of this study may help tissue engineers design artificial ligaments with mechanically advantageous enthesis shapes as well as determine which people are at higher risk for ACL tears.

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Abstract

The anterior cruciate ligament (ACL) is the most commonly injured ligament in the human knee. The ACL has a limited ability to repair itself, due to its poor vascularity and cellularity. Thus, complete tears require surgical reconstruction. Most ACL failures occur at the femoral enthesis (the attachment site of the ACL to the femur). Several different entheseal profiles were recently categorized in a histological study. It remains unclear whether certain enthesis shapes produce strain fields which are less likely to cause tearing at the femoral enthesis than other shapes. The goals of this study are to 1) experimentally examine the strain fields within an experimental model of the ACL with varying entheseal profiles and 2) determine which entheseal profiles are most advantageous. The results of this study may help tissue engineers design artificial ligaments with mechanically advantageous enthesis shapes as well as determine which people are at higher risk for ACL tears.

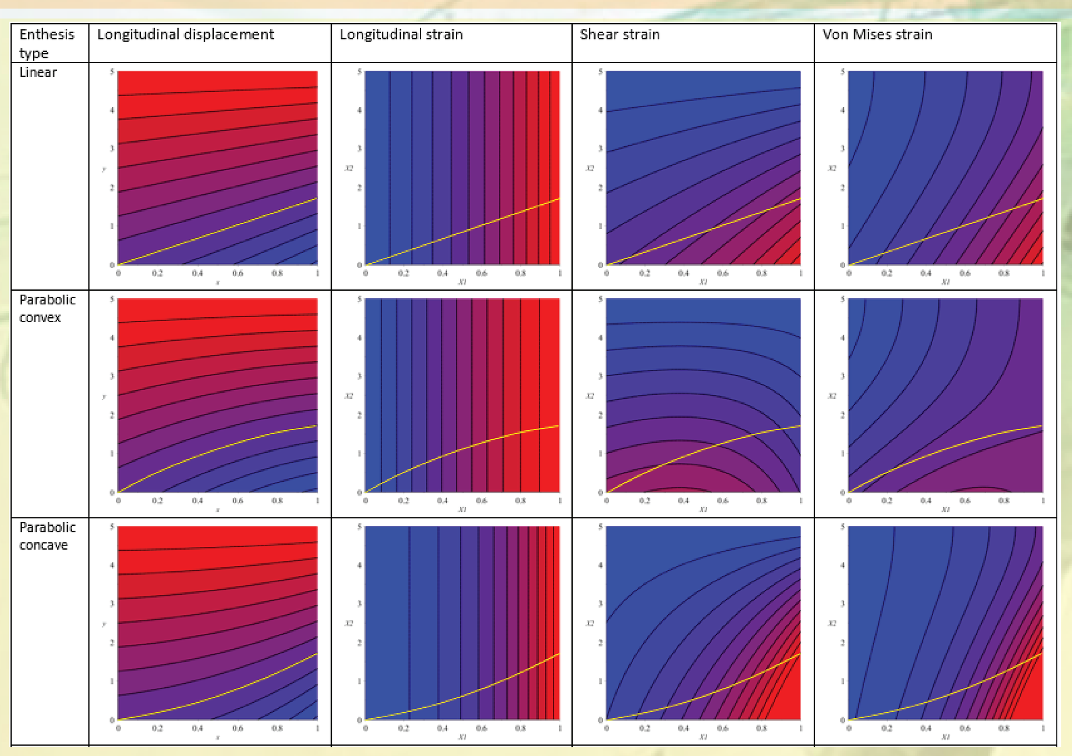


Figure 2: Longitudinal, Shear, and Von Mises Strain hypothesis of different femoral enthesis.

Objective

The objective of this project is to find the best femoral entheseal shape by comparing the strain field of different profiles for future use in artificial ligaments and narrow down which members of the population are at higher risk to tear the ACL.

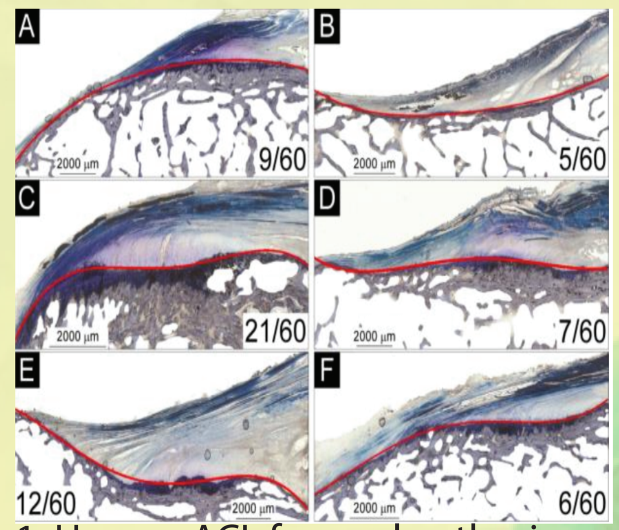


Figure1: Human ACL femoral enthesis profiles and their respective frequency in 60 sample sections. Reproduced from figure 5.3 in[1].

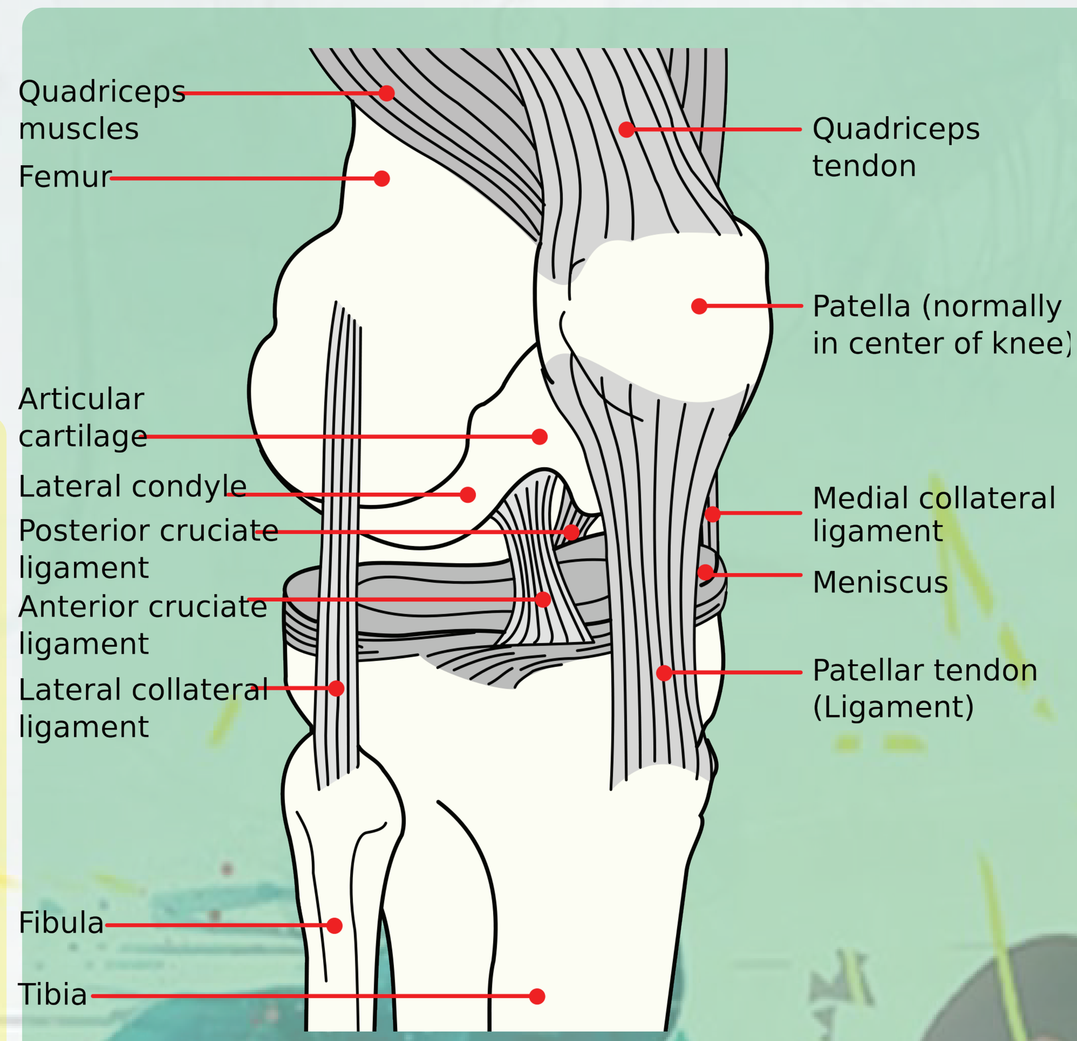


Figure 4: Diagram of the Knee

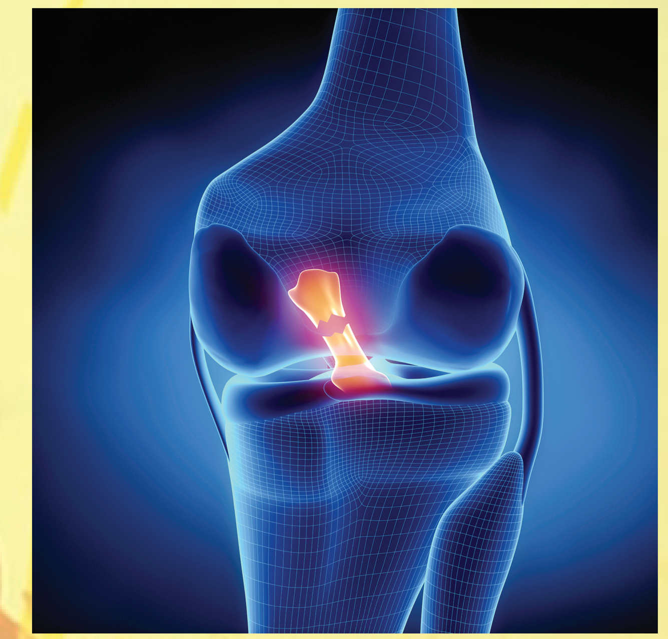


Figure 3: Highlighted ACL

Results

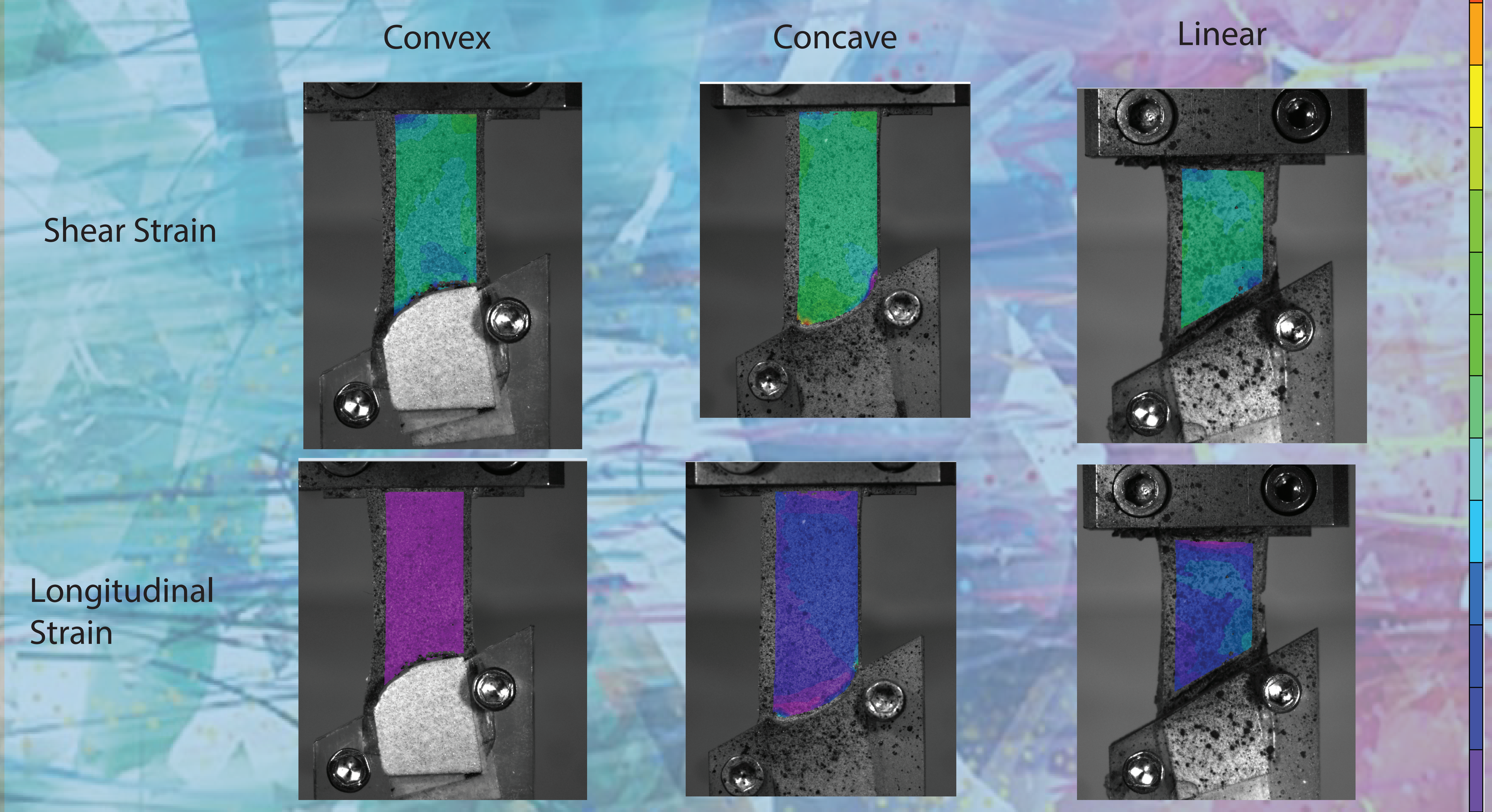
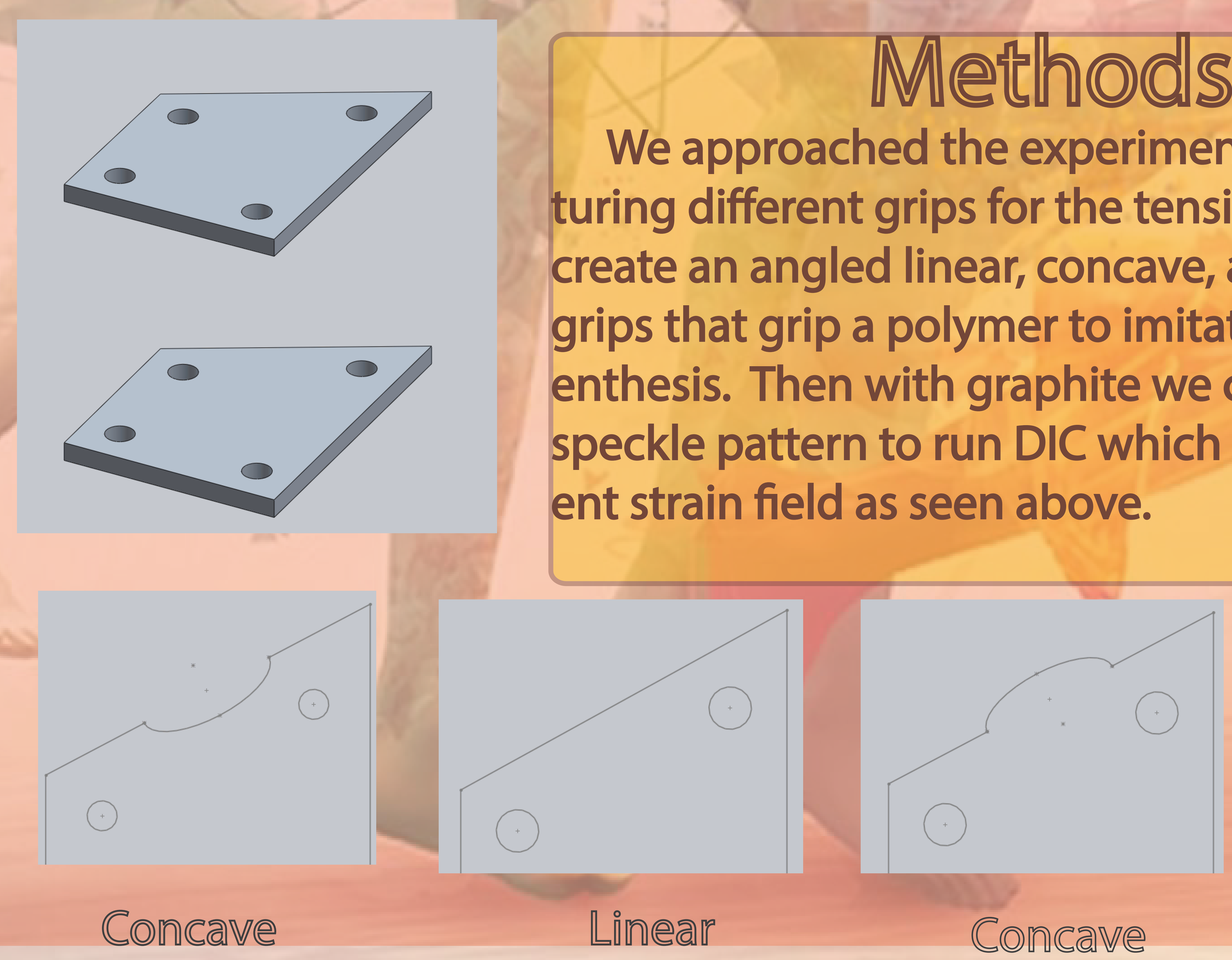


Figure 5: Longitudinal and Shear Strain using manufactured grips and polymers.

Methods



We approached the experiments by manufacturing different grips for the tensionmeter to create an angled linear, concave, and convex grips that grip a polymer to imitate the femoral enthesis. Then with graphite we created a speckle pattern to run DIC which gives us different strain field as seen above.

Conclusion and Future Steps

Although the grips were a great way to imitate the different femoral enthesis, the clamping force produce by the grip complicated the data. The next step of this project would be to:

- Preform a test with an assembled polymer that has different bundles to imitate the shape of the ACl.
- Fix the inaccuracy of the clamping force produce by the grips.

Sources

1. Beaulieu ML. Doctoral Dissertation School of Kinesiology, University of Michigan, 2014.