**OBJECTIVE**

Identify knee ligament characteristics that determine mechanical health.

- Use magnetic resonance imaging (MRI) to observe ligament structure and geometry.
- Conduct mechanical testing to quantify ligament health.
- Determine correlations between MRI data and mechanical testing results.

**INTRODUCTION**

**Background Problem**

- The Anterior Cruciate Ligament (ACL) is one of four ligaments that help stabilize the knee during movement.
- ACL injuries occur more than 200,000 times per year—through both contact and non-contact mechanisms [2].
- Identifying a relationship between MRI data and mechanical health can help medical professionals detect ligament injuries before tearing occurs.

**Solution Approach**

- Use porcine knees as analog to humans.
- Start with the Posterior Cruciate Ligament (PCL) for its large size and ease of measurement.
- Generate correlations by comparing MRI data to mechanical testing results.

**METHODS**

1. **MRI Examination**
   - Use proton density sequences
   - Measure PCL geometry
     - Length
     - Cross-Sectional Area

2. **Mechanical Testing Setup**
   - Utilize load frame and potting fixtures to conduct tensile test on PCL
   - Measure elasticity by calculating slope of stress-strain curve

3. **Experimentation**
   - Dissect knee to leave femur-PCL-tibia complex intact and pot bones into test fixtures
   - Run test using load frame, force/torque sensor, and motion capture system

**RESULTS / ANALYSIS**

<table>
<thead>
<tr>
<th>Initial Length</th>
<th>Cross-Sectional Area</th>
<th>Stiffness</th>
<th>Elastic Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm²</td>
<td>N/mm</td>
<td>MPa</td>
</tr>
<tr>
<td>HR-PK-03</td>
<td>40.36</td>
<td>38.54</td>
<td>38.11</td>
</tr>
<tr>
<td>HR-PK-04</td>
<td>37.81</td>
<td>40.81</td>
<td>36.09</td>
</tr>
</tbody>
</table>

- Samples yielded similar stiffness values
- Samples yielded somewhat different elasticity values
- Error in dimensional measurement explains variability in elasticity
  - 1 mm of uncertainty in width, thickness, and length yields an uncertainty of 8.4 MPa in elastic modulus
- Elastic limit identified
  - Yield Stress: 2.0 MPa (80 N load)
  - Yield Strain: 0.07 mm/mm (2.8 mm extension)

**CONCLUSIONS / FUTURE WORK**

- Ligament geometry measurement is critical and should be improved
- Future work includes inspection of collagen fiber microstructure via Second-Harmonic Generation (SHG) imaging

**REFERENCES**


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