Novel Device for Suture Anchor Augmentation for Tendon Repair

Joseph S. Park, M.D.
Silvia Blemker, PhD
Clinical Problem: Fixation of FDL Tendon to Navicular

1. **Cut posterior tibialis tendon**
2. **Bone tunnel**
3. **Navicular bone**
4. **Harvested FDL tendon**

University of Virginia Orthopaedic Surgery
Consequence of shifting the effective insertion is loss of moment arm

- ~33-50% loss in moment arm
Research Aims

• **Aim 1 is to test strength of compression with:**
  - Suture anchor alone
  - Suture anchor plus suture button prototype
  - Suture anchor plus porous metal spiked button prototype
  In rabbit achilles tendons and bone substitute

• **Aim 2 is to characterize the biologic healing of the tendon-bone interface in surgically-repaired rabbit Achilles tendons**
  - 2a: characterize with H&E staining (1/2 animals)
  - 2b: characterize healing tendon with MRI
  - 2c: perform biomechanical testing of healed tendon
Funding

• Study Funded by the Wallace H. Coulter Foundation Translational Research Award ($100,000)

• http://whcf.org/the-wallace-h-coulter-foundation/#
Problem: Imperfect Tendon Repair

- Problems:
  - Risk of Reinjury
  - Immobilization
  - Scar Tissue

Ruptured Achilles tendon
Goal
Show that the suture button is an improvement to the suture anchor technique
Methods

- Validation of Hypothesis
  1. Increased contact area
  2. Stronger tendon-bone interface

- 3 Tests
  1. Pressure Film
  2. Cyclic Loading
  3. Tensile Load-to-Failure

- 2 Conditions:
  Control
  Device

Suture knot
Tendon
Bone
Suture anchor

Suture knot
Tendon
Bone
Suture anchor
• Use Fuji Pressure Film to characterize compressive force applied.
• Button $\rightarrow$ 3.8 x increase area of compression (P <0.002).

Comparison of Contact Area

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Contact Area (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Suture</td>
</tr>
<tr>
<td>2</td>
<td>Suture</td>
</tr>
<tr>
<td>3</td>
<td>Button</td>
</tr>
<tr>
<td>4</td>
<td>Button</td>
</tr>
<tr>
<td>5</td>
<td>Button</td>
</tr>
</tbody>
</table>

No Button

Button

Contact  Area

University of Virginia Orthopaedic Surgery
• New Zealand White rabbit achilles tendons were attached to bone block substitute (Sawbones.com) via Biomet Juggerknot anchors
• 25 N of force were applied for 50 cycles (0.5 Hz)
• Control: 2.24 mm liftoff
• Device: 0.19 mm liftoff (0.99 mm at 500 cycles)

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Measurement of Liftoff After 50 Cycles</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Distance From Underside of Tendon to Bone Block, mm</td>
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<tr>
<td>Device condition specimens</td>
<td></td>
</tr>
<tr>
<td>1</td>
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<td>2</td>
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<td>Average</td>
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<td>SD</td>
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<td>Average</td>
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<tr>
<td>SD</td>
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Load to Failure

Control

Device

Insertional footprint
Tensile Failure Testing

• Pull to failure tests
• Looked at yield load and ultimate load
  • Yield load: begins to tear
  • Ultimate load: complete failure
Sample Load vs. Extension Graph

Yield Load

Ultimate Load
# TABLE 3

## Results of Load-to-Failure Tensile Test

<table>
<thead>
<tr>
<th></th>
<th>Yield Load, N</th>
<th>Ultimate Load, N</th>
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<tbody>
<tr>
<td><strong>Device condition specimens</strong></td>
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<td></td>
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<tr>
<td>1</td>
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<td>2</td>
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<td><strong>Average</strong></td>
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<td><strong>94.7</strong></td>
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<tr>
<td><strong>SD</strong></td>
<td><strong>14.0</strong></td>
<td><strong>24.3</strong></td>
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<td><strong>Control condition specimens</strong></td>
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<tr>
<td><strong>SD</strong></td>
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</table>

72% increase in Yield Load with Device Condition
• Provisional Patent Filed 9/23/14
• Pursuing partnership for manufacturing of surgical grade buttons (titanium/PEEK).
• Consideration for materials: titanium may allow for thinner implant for both cleated and spiked versions. (10x stronger versus flexion and 6x stronger versus compression)
• Button Optimization: due to fracture of button during initial Instron trials, made holes smaller, centered to increase strength of implant. 3D printed buttons made of Acrylonite Butadiene Styrene (ABS)
• ACUC Animal Protocol approved for rabbit in-vivo study
• IRB being written for MRI study for human subjects s/p tendon reattachment with/without suture button (Blemker/Nacey/Miller)
Research Team

• Silvia Blemker PhD-Biomedical Engineering
• Capstone BME Team: Lauren Baetsen, Cate Markert, John McNulty, Audra Sawyer
• Chris Li, PhD-Mechanical Engineering
• Future Studies-
  • Master’s Student?
  • Hilary Bart-Smith PhD?
  • Stephen Brockmeier MD?
  • Aim 2: In Vivo Rabbit Achilles Study
    • MRI evaluation
    • Histology
    • Mechanical Testing
Thank You! jsp3x@virginia.edu