Biomechanical comparative study of the JuggerKnot™ soft anchor technique with other common mallet finger fracture fixation techniques

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Study Disclosures

• I have no financial disclosures to report
Mallet Finger Deformity
Splinting

- Cumbersome
- Compliance issue

Operative

- Open injury
- Cannot tolerate splinting
- Large avulsion fracture
  - >30% of articulation
Fixation Methods

- Kirschner wire
- Extension block
- Screws
- Hook plate
- Pull-through wires or sutures
- Tension band wiring
- Umbrella handle

All Methods Require Immobilization!
Study Aims

• A biomechanically sound device
  – Early mobilization without protection
    • DIPJ mobilization has force of 5.6N (Husain JHSA 2008)

• Less soft tissue complications

• Biomechanical study
  – Peak load resistance to flexion of DIPJ
  – How do suture anchors compare?
Methods

• 32 specimens (8 fresh frozen cadaveric human hands)
  – 8 of each finger
  – No thumbs

• 8 specimens for trial of procedure
• 24 specimens for analysis
Preparation

• Thawed to room temperature (24°C)
• Amputated at PIPJ
• Sparing of extensor tendon to wrist level
• Nails intact
• None had OA joints and bone defects
Preparation

• H-shaped skin incision at dorsal of DIPJ
  – Osteotomy
  – Fixation

• Fluoroscopic guidance
Fragment Sizing
Fixation Methods

- Kirschner wire
- Pull-out wire
- Tension-band wiring
- Suture Anchor
  - JuggerKnot™

- Randomized block pattern distribution
Biomechanical Testing

- MTS 858 Mini Bionix servo-hydraulic load frame
Mounting Device

- 4N torque screws
- 10N preloaded extensor tendon
- Testing apparatus with clamping device
Biomechanical Testing

• Peak load resistance
• Load testing at DIPJ flexion
  – 30 degrees
  – 45 degrees
  – 60 degrees
• Speed: 10cm/s
• Load distance: Tan θ of mount to nail fold
Biomechanical Testing

• Complications
  – Implant failure
    • Loosening of knot, pull-out of implant, implant fracture
  – Fixation failure
    • >1mm widening of fracture site
Comparability between Digits

Average Peak Load
No differences between Digits

<table>
<thead>
<tr>
<th></th>
<th>Mean (N)</th>
<th>Range (N)</th>
<th>Standard Deviation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Before osteotomy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30°</td>
<td>16.45</td>
<td>8.45-31.25</td>
<td>1.14</td>
<td>0.370</td>
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<tr>
<td>45°</td>
<td>31.32</td>
<td>16.39-52.50</td>
<td>8.79</td>
<td>0.342</td>
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<tr>
<td>60°</td>
<td>57.01</td>
<td>24.26-88.47</td>
<td>19.52</td>
<td>0.450</td>
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<tr>
<td>After fixation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30°</td>
<td>18.88</td>
<td>7.10-50.18</td>
<td>11.03</td>
<td>0.549</td>
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<tr>
<td>45°</td>
<td>30.48</td>
<td>11.70-80.80</td>
<td>17.66</td>
<td>0.505</td>
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<tr>
<td>60°</td>
<td>44.27</td>
<td>17.50-98.80</td>
<td>21.25</td>
<td>0.515</td>
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</table>
Comparison between Fixation Methods

Peak Load Analysis
<table>
<thead>
<tr>
<th>Fixation</th>
<th>Before osteotomy: N (±SD)</th>
<th>After fixation: N (±SD)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>30°</td>
<td>45°</td>
</tr>
<tr>
<td><strong>Kirschner wire</strong></td>
<td>12.37 (±2.67)</td>
<td>23.73 (±6.67)</td>
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<tr>
<td><strong>Pull-out wire</strong></td>
<td>19.01 (±6.27)</td>
<td>34.80 (±9.20)</td>
</tr>
<tr>
<td><strong>Tension-band wire</strong></td>
<td>17.51 (±4.41)</td>
<td>33.75 (±6.71)</td>
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<tr>
<td><strong>Suture Anchor</strong></td>
<td>16.93 (±6.11)</td>
<td>32.99 (±9.35)</td>
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<tr>
<td><strong>p-value</strong></td>
<td>0.161</td>
<td>0.099</td>
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</tbody>
</table>
Complications

• Dorsal skin impingement with TBW in 3 digits

• No implant failure

• No fixation failure
Discussion

• **Only** biomechanical study using suture anchors for mallet injuries

• **Randomization**

• **Standardized** biomechanical testing

• All fixation methods can withstand normal DIPJ movement in terms of peak load resistance
Future Studies

• Information on fatigue failure?

• Animal studies for healing potential

• Clinical trials for applicability in clinical setting
Thank You