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<td>Cheung, JPY; Fung, BKK; Ip, WY</td>
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Biomechanical comparative study of the JuggerKnot™ soft anchor technique with other common mallet finger fracture fixation techniques

Jason Pui Yin Cheung, Boris Fung, Wing Yuk Ip

Department of Orthopaedics and Traumatology
The University of Hong Kong
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: $\tan \theta$ 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><strong>Before osteotomy</strong></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><strong>After fixation</strong></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>
</tr>
<tr>
<td>45°</td>
<td>30.48</td>
<td>11.70-80.80</td>
<td>17.66</td>
<td>0.505</td>
</tr>
<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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</tbody>
</table>
Comparison between Fixation Methods

Peak Load Analysis
**TBW Strongest Fixation**

*Suture Anchor Strong Enough to Resist Normal DIPJ forces*

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