Biomechanical Evaluation of Nitinol Staples on Compressive Forces, Contact Area and Mechanical Properties for 1st Tarsometatarsal Arthrodesis

Amiethab Aiyer, MD
Nick Russell, PhD
Matthew Pelletier, PhD
Mark Myerson, MD
William Walsh, PhD
Conflict to Disclose

- Biomechanical Evaluation of Nitinol Staples on Compressive Forces, Contact Area and Mechanical Properties for 1st Tarsometatarsal Arthrodesis
  - Presenter’s name: Amiethab Aiyer

- My disclosure is in the Final AOFAS Mobile App.

- I have a potential conflict with this presentation due to:
  - The study was sponsored by BME
  - One or more authors are paid consultants of BME
Study Goals

• Develop a reproducible 1\textsuperscript{st} TMT arthrodesis biomechanical testing model to study different reconstruction techniques

• Compare crossed screws, plates and staples
  – Stiffness
  – Contact area footprint
  – Compression forces
  – Recovery from plantar gapping
Materials/Methods

- Sawbone model
- 5 per group
  - Pre-hoc power analysis
  - Detect 25% difference between groups
- Alignment maintained
  - Lines down midaxis of medial column
  - Nail plate marking
## Materials/Methods

<table>
<thead>
<tr>
<th>Test Group</th>
<th>Sample Size</th>
<th>Implants</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Single BME SPEED Staple (SE-2020Ti)</td>
<td>Dorsal</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Two BME staples (SE-2020) and (SE-1518)</td>
<td>One dorsal, one medial and slightly plantar</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Crossed cannulated lag screw (Synthes 4.0 x 40 and 4.0 x 32 mm)</td>
<td>Crossed configuration from proximal dorsal to distal plantar</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Compression plate (Wright Claw II 2-hole, 20 mm with 2.7 x 20 mm screws)</td>
<td>Dorsal</td>
</tr>
</tbody>
</table>
Materials/Methods
Materials/Methods

- Constructs placed in MTS machine
  - 4 point bending
  - Dorsal loading to 1, 2, 3 mm of actuator displacement (rate of 1 mm/min)
  - Peak load/stiffness calculated

- Hair dryer used to maintain activation of SMA staples
Results: Contact Force/Area

- Significantly greater (P<0.05) contact force and contact area in both SMA staple groups
  - At time zero
  - At 1 mm /2 mm of actuator displacement
Results: Mechanical Testing

- Screws were stiffest construct ($p < 0.0001$)
- Staples = claw plate
- 1 staple = 2 staples
  - @ 3 mm displacement, 21% and 22% increase in peak load
Results: Plantar Gapping

- SMA staples had complete recovery of plantar gap
  - After 2 mm/3 mm displacement tests
- Permanent, non-recoverable gap was seen other groups
  - Screws: 0.72 mm
  - Plate: 5.3 mm
Conclusions

- Crossed screws are stiffest
- SMA staples generate the highest compression forces
- SMA staples generate the greatest contact area
- SMA staples are able to recover from plantar gapping of 3 mm
References