Can Fixation Methods for First Metatarsophalangeal Joint Arthrodesis Sustain Weight-bearing as Tolerated?

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My disclosure is in the Final AOFAS Mobile App.

I am a consultant for Integra Lifesciences which supplied the hardware for this study.
Metatarsophalangeal Arthrodesis

A Comparison of Four Fixation Modalities

Objective: Determine whether any fixation allows for unrestricted postop weight-bearing
Introduction

• The possible fixations for joint arthrodesis
  – A. Unlocked Plate
  – B. Locked Plate
  – C. Unlocked Plate plus Screw
  – D. Dual Cross Screw

• Test fixations with Sawbones for comparison and validate stiffest constructs with cadavers

Previous Literature

- Strength of plate with a single lag screw shown by Curtis et al. 1993
- Trnka et al. 2000
  - Reference to Failure criteria
    - Load was applied continuously until non-union (gross bony fracture, screw pull out, or gapping greater than 2 mm at the osteotomy site)
- 2 mm as the criterion for non-union derived from bone fracture literature
1st - Make Predictions based on Sawbones testing

- 1000 Cycles of Testing
- Calculate Force and Displacement
- Calculate Stiffness

Test Sawbones

Test Cadavers
- 250 then 750 Cycles of Testing
- Calculate Force and Displacement
- Calculate Stiffness

Failuer Test Both
- Calculate Linear Force and Displacement
- Calculate Stiffness

Compare Data from Cadaver testing to predictions
Methods –
Test Fixations with a 40 N load. 40 N causes 2 mm gap formation at the joint for the least stiff case (unlocked plate) i.e., 2 mm = non-union

- **Composite bones** *(Sawbones)*
  - Mounted with PVC/ABS and resin
  - Tested at 1 Hz for 1000 cycles
  - Data collection with Spicatek Motion Capture

- **Cadavers** *(1st two Rays)*
  - Mounted with PVC/ABS and resin
  - Tested at 1 Hz for 250 and 750 cycles
  - Four Conditions
    - Tissue Intact
    - Transect tissue between 1st and 2nd rays
    - Remove of Plantar Tissue
    - Open Joint Capsule
Sawbones Prediction of Failure Load at Non-Union (2 mm gap)

• Failure load increases as stiffness increases (predicted values in table, next slide)

Stiffest modality: plate plus screw (light blue line)

Least stiff modality: unlocked plate (dark blue line)

• Comparison with cadavers (table, next slide)
<table>
<thead>
<tr>
<th>Sawbones</th>
<th>Cyclic Loading</th>
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<tbody>
<tr>
<td></td>
<td>Displacement @ 40 N Load [mm]</td>
<td>Stiffness [N/mm^2]</td>
<td>Predicted Failure [N]</td>
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<tr>
<td>Unlocked</td>
<td>2.63</td>
<td>13.7</td>
<td>27.4</td>
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<tr>
<td>Locked</td>
<td>2.21</td>
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<td>34.6</td>
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<td>Plate Plus Lag Screw</td>
<td>0.44</td>
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<td>0.16</td>
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<tr>
<td>Cadaver</td>
<td>Displacement [mm]</td>
<td>Stiffness [N/mm^2]</td>
<td>Predicted Failure [N]</td>
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<tr>
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<td>Sawbones</td>
<td>Maximum Allowable Load (N)</td>
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<tr>
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<tr>
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<tr>
<td>Cadaver</td>
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Conclusions

• Post-op Weightbearing
  – No fixation modality allows initial unrestricted full weight-bearing
  – A plate plus a screw offers most stiffness
  – Crossed screws offers the most strength

• Testing Sawbones versus Cadavers
  – Failure loading generally agreed but stiffness did not
  – Stiffness was a poor predictor for failure loading
  – Difference in testing with and without tissue was insignificant
References

- Bayomy, Ahmad et al. JB&JS, 2010
- Ledoux, William et al. Gait and Posture, 2002

AGH Orthopaedic Biomechanics Laboratory