Biomechanical Comparison of a Locking Dorsal Circular Plate Versus Lag Screw Fixation for Calcaneocuboid and Talonavicular Arthrodesis

Kenneth Smith M.D.¹, Jefferson B. Sabatini M.D.¹, Rebecca Ellis B.ChE.², Alan Eberhardt Ph.D.², John Kirchner M.D.¹

¹University of Alabama at Birmingham, Department of Surgery, Division of Orthopedic Surgery;
²University of Alabama at Birmingham School of Engineering, Biomedical Engineering Department
Financial Disclosures

• The following relationships exist:
  – Royalties and stock options
    • J. Kirchner – Zimmer, Medshape
  – Consulting income:
    • J. Kirchner - Osteomed
  – Research education and support
    • J. Kirchner - Trimed
Introduction

• Hindfoot arthrodesis is often the treatment of choice for hindfoot pain due to arthritis or advanced deformity.
• Good clinical results are dependent on secure fixation while avoiding hardware related side effects.
• Pseudoarthrosis of the talonavicular and calcaneocuboid joints are a well-documented complication.
• A small radiolucent locking dorsal circular plate placed into the talonavicular and calcaneocuboid joints may provide a low-profile solution for secure fixation of these joints.

1. Chen et al. Foot Ankle Int, 2001
Methods

- Eight matched fresh-frozen cadaveric foot-ankle pairs were utilized.

- The talonavicular and calcaneocuboid joints on one side of each matched pair was plated with a locking dorsal circular plate (Xpode PEEK-Optima plate), and the contralateral foot was fixed with partially threaded 4.5mm cannulated screws.

- All subtalar joints were fixed with two 7.3mm cannulated screws.
Methods

- Translational forces through a mechanical testing system (MTS) were applied to the constructs cyclically for 40 cycles followed by loading to failure.
- Displacement was recorded using two high-speed infrared cameras, following sets of orthogonal marker systems attached to each bone.
Results

• Cyclical loading trials found there to be no significant difference in the stiffness of the two different methods.

• Specimens instrumented with plates had an approximately 400% higher average load to failure (513.3N vs 127.7N) than specimens instrumented with screws.
  – This trended toward statistical significance (p value =0.08)
Results

- The differences in implant stiffness between the plates and screws was not statistically significant.
The differences in total load to failure between the study group (Plate) and the control group (Screw) was not significant with a P value of 0.08 but trends toward significance with a 400% higher load to failure.
Discussion

• Several biomechanical studies have compared hindfoot arthrodesis using screws versus staples\(^2\) and screws versus plates\(^3\)
  – no significance has been found in stiffness or load to failure between these constructs

• Two biomechanical studies have compared these same plates to non-locking plates and K wires in four-corner wrist fusions\(^4,5\)
  – Both found similar resistance to motion and load to failure

3. Jarrell *et al.* Foot Ankle Int, 2009
4. Isaacs *et al.* J Hand Surg Am, 2008
5. Kraisarin *et al.* J Hand Surg Am, 2011
Discussion

These plates have three intriguing attributes:

1. Countersunk profile
   - Decreased prominence to reduce tendon irritation
   - Places the site of fixation along the axis of rotation of the fused joints to lower the moment arm of force transmitted to the bone-plate interface compared to that of a compression plate sitting atop the dorsal cortex\(^6\)

2. Radiolucency
   - This allows for better assessment of fusion mass

3. Fixed angle construct
   - This allows for increased pull out strength in osteoporotic bone

\(^6\) Milshteyn et al. Foot Ankle Int, 2015
Conclusions

• Locking dorsal circular plates are a viable option for the talonavicular and calcaneocuboid joints in triple arthrodesis of the hindfoot

• They provide equivalent stiffness and a trend toward higher load to failure values when compared to screw fixation
Selected References