Biomechanical Comparison of Surgical steel wiring and Suture Tape Tension Band Techniques for Arthrodesis of the MCP Joint

Michael J. McKernan[1], Miguel A. Diaz*[2], Nino Coutelle[2], Michael Kucharik[3], Peter Simon[2], Michael Doarn[1,3]
[1]Florida Orthopaedic Institute, Tampa, FL; [2] Foundation for Orthopaedic Research & Education, Tampa, FL; [3] Department of Orthopedics & Sports Medicine, Morsani College of Medicine, University of South Florida, Tampa, FL
*mdiaz@foreonline.org

Disclosures: Michael J. McKernan (N), Miguel A. Diaz (N), Nino Coutelle (N), Michael Kucharik (N), Peter Simon (N), Michael Doarn (N)

INTRODUCTION: Hand arthritis is a common condition that affects many individuals and has been reported to affect 67% of women and 55% of men aged 55 years. Symptoms include pain, loss of motion, swelling. Small joint arthrodesis is one accepted standard of care in treating this condition, however, there are various methods (interosseous wiring, k-wire tension-band, plating and compression screws) employed to resolve this condition with different pros and cons. The tension band construct with surgical wire has been well described, however, symptoms such as skin irritation, pain, seroma are caused by the rigidity and superficial nature of implanted metal. While advances in tension band techniques have lowered skin irritation and pain compared to the traditional AO method, roughly 30% of patients undergo a second surgical procedure to address the pain caused by the implanted hardware. A recent *ex vivo* study on canine olecranon compared metal wire and FiberWire as tension band techniques and concluded FiberWire showed equivalency and can be applied in place of a metal wire. The purpose of this study was to evaluate the biomechanical performance (bending stiffness, and load-to-failure) of two different repair configurations for MCP joint fusion in a matched-pair cadaveric model. It was hypothesized that the use of suture tape as a technique may offer equivalent biomechanical results compared to surgical steel cable.

METHODS: A total of 16 fingers (index, middle, ring and little) from two matched pair cadaveric hands were utilized. All hands were investigated for any prior pathology by fluoroscopic radiography. All fingers were harvested and divided into two treatment groups where Group I (GI) received the K-wire and surgical steel cable as treatment, serving as the control. The contralateral side was Group II (GII) where these samples were treated with K-wire and suture tape (Figure 1). For both groups, the two antegrade 0.045 (1.1mm) K-wires were placed longitudinally from the proximal MC and proximal phalanx heads into the proximal phalanx and middle phalanx shaft into subchondral bone distally. GI used a 22-gauge wire passed through the transverse hole of the distal bone and wrapped in figure-of-8 fashion around proximal K-wires. In a similar fashion, GII used a 1.3 mm SutureTape through the transverse hole of the distal bone tightened to cause compression at fusion site and tied with a surgeon's knot and 3 half-hitch ties and laid between the proximal two K-wires. Each sample was potted in high strength resin, such that two-thirds of distal end was embedded. The potted ends were then secured to a custom fixture mounted to the hydraulic test frame (MTS Bionix). Each sample underwent cantilever bending in four directions (Flexion, Extension, Ulnar and Radial) at a rate of 0.01 mm/s until a maximum force of 10N (Figure 2). The load applicator was positioned 20 mm from the joint line generating a bending moment of 0.2 Nm. Thereafter, all specimens were loaded in extension until catastrophic failure at a rate of 20 mm/min. Metrics of interest will be collected from test frame DAQ system, and load-displacement curve generated were used to calculate bending stiffness (N/mm), displacements (mm) and peak load to failure (N). Assuming a power of 0.8 and a Type I error rate of 0.05, a sample size of 7 per group powers the study to 0.86. The choice of 8 samples per group powered the study to 0.92 allowing for any possible tissue rejection, or unforeseen failures while retaining proper study power. Commercially available software (SPSS) was used to run paired samples t-test at a significance threshold of 0.05. Data are presented as mean +/- standard deviation.

RESULTS SECTION: During cantilever bending in flexion direction, GI construct was found to be stiffer when compared to GII (GI: 11.3 ± 4.0 N/mm vs. GII: 7.3 ± 2.6 N/mm; p=.0357) and have less displacement (GI: 1.1 ± 0.4 mm vs. GII: 1.6 ± 0.4 mm; p=.0404). In extension direction, no significant differences were detected for stiffness (p=.294) between GI (4.5 ± 1.6 N/mm) and GII (3.6 ± 1.4 N/mm) or for displacement (p=.208) between GI (2.6 ± 0.8 mm) and GII (3.2 ± 0.8 mm). Similarly, no significant differences were detected in stiffness (GI: 6.4 ± 2.7 N/mm vs. GII: 4.9 ± 1.3 N/mm; p=.562) or displacement (GI: 1.8 ± 0.6 mm vs. GII: 2.4 ± 0.9 mm; p=.226) during Ulnar bending. In the radial direction, no significant differences were detected in stiffness (GI: 6.4 ± 3.0 N/mm vs. GII: 4.4 ± 1.2 N/mm; p=.114) or displacement (GI: 2.0 ± 0.8 mm vs. GII: 2.6 ± 0.8 mm; p=.084). During the ramp to failure, no significant differences were found for force (GI: 38.3 ± 8.5 N vs. GII: 35.4 ± 9.6 N; p=0.429), stiffness (GI: 4.0 ± 0.9 N/mm vs. GII: 3.2 ± 1.3 N/mm; p=.0836) or displacement (GI: 17.4 ± 2.2 mm vs. GII: 16.5 ± 0.9 mm; p=.749).

DISCUSSION: The biomechanical performance of the suture tape arthrodesis was equivalent to the steel wire across all loading conditions except for flexion, where the steel wire was found to be stiffer and allowed less displacement. However, clinically these constructs would more likely fail due to extension or radial loading based on daily activities and functional use of the hands. These outcomes support our hypothesis that the use of suture tape for MCP joint fusion provides equivalent biomechanical performance to that of steel cable, making it a viable alternative clinically.

SIGNIFICANCE/CLINICAL RELEVANCE: The use of Suture Tape for MCP arthrodesis may provide adequate fixation to allow fusion to occur while minimizing the potential risk of irritation to the patient that is commonly experienced with surgical steel fusion techniques.

IMAGES AND TABLES:

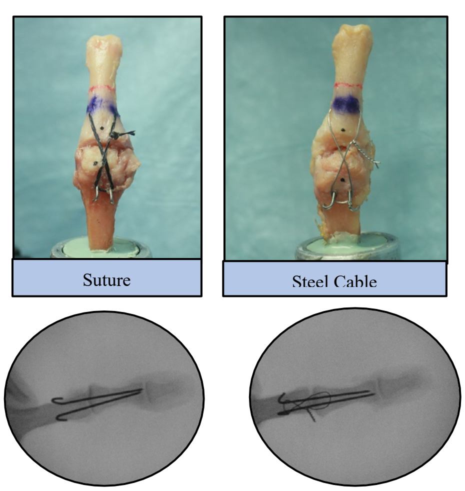

Figure 2. Examples of MCP arthrodesis testing groups and radiographs of each repair

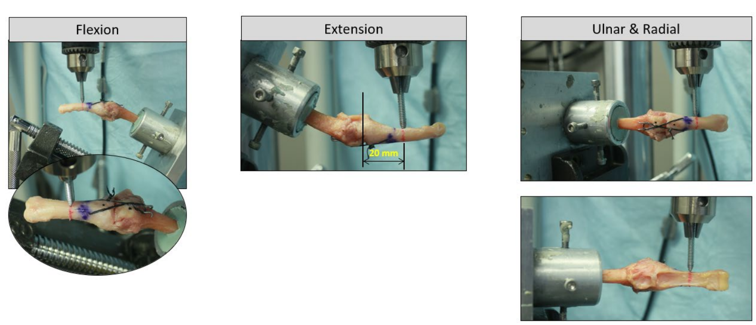

Figure 1. Biomechanical Testing setup for cantilever bending in the Flexion, Extension, Ulnar and Radial direction where the load applicator was placed 20 mm from the joint line.