Biomechanical Performance of Headless Compression Screws in Medial Malleolar Fracture Fixation

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Disclosures:

INTRODUCTION: Ankle fractures are the second most common lower extremity fracture accounting for approximately 9% of fractures in adult patients. These fractures commonly involve the medial malleolus and surgical fixation is the treatment of choice. The majority of patients recover well post-operatively, however, adverse outcomes include pain, infection, malunion, nonunion, arthritis, wound complications, painful or prominent hardware, and need for revision surgery. Although there is no standardized technique for the fixation of medial malleolus fractures, these fractures have traditionally been treated with cancellous lag screws or tension band technique. More recently, surgeons have begun using headless compression screws. Studies have commented on patient complaints of hardware prominence and pain with traditional screws and tension bands[1]. Biomechanical studies comparing the different techniques have shown either no statistical difference in fracture displacement or superior fixation of the headless compression screw technique. Further studies comparing headless compression screws with the other traditional methods of fixation are still needed for more common types of medial malleolus fractures using different loading conditions that more closely simulate the normal motion and loading of the ankle. This study aims to assess the biomechanical properties of surgical fixation of medial malleolus fractures using headless compression screws when compared to fixation with traditional partially threaded screws.

METHODS: Five pairs of cadaveric ankle specimens (distal tibia and foot) were procured from two male and three female donors (mean age 45.6 yrs, range 30-70 yrs). The foot was disarticulated through the calcaneocuboid joint and navicular-cuneiform joints. Soft tissues surrounding the ankle joint were dissected except for the deltoid ligaments. Osteotomies of the medial malleolus were made transversely at the level of the tibial plafond (Muller type B) using a power saw. Each pair of specimens was randomly assigned to receive fixation using two 4.0 mm headless compression screws (Fixos™, Stryker, Kalamazoo, MI) or 4.0 mm partially threaded headed screws (Asnis® III, Stryker, Kalamazoo, MI) (Figure 1). The specimens were then potted and tested on a servo-hydraulic material testing system (Landmark 370, MTS Systems, Eden Prairies, MN). A ½-inch threaded rod was drilled through the distal tibia and was coupled with a pair of eyebolts mounted on the actuator of the testing system. Torsional load in the direction of foot external rotation, which is a loading mode commonly associated with medial malleolar injury[2], was applied in combination with a 100 N axial compression (to simulate partial weight bearing) and repeated with a 100 N of tension (to engage the deltoid ligament to distract the fracture fragment). The torsional test was run under displacement control (1 degree/sec) with a maximum torque limit set at 2 Nm to avoid tissue damage[3]. Following these two non-destructive tests, the specimen was again in combined torsion and compression but with the rotational limit doubled. Marker triads from a motion analysis system (Optotrak Certus, NDI, Waterloo, Canada) were mounted onto the distal fragment and the tibia. Euler angles in sagittal (Z), transverse (Y), and frontal (X) planes and the distance between triad origins were derived to evaluate the inter-fragment movement. Nonparametric paired comparisons were carried out for construct (ankle) stiffness and inter-fragment movement.

RESULTS: At lower torque (<2 Nm) both the headless compression screws and control groups showed minimal inter-fragment movement. This was the case for both tensile and compressive preload testing. At higher torque with compressive preload test, the inter-fragment movement at peak load was 0.60±1.00 degrees in the sagittal plane, 0.34±0.27 degrees in the frontal plane, and 0.37±0.60 degrees in the transverse plane for the headless screw group. In comparison, the control group demonstrated much larger movement in all three planes (1.79±1.66, 1.51±1.49, and 0.84±1.08 degrees respectively). The differences reach statistical significance for the sagittal and frontal plane movements (Figure 2). The mean (SD) stiffness of the repaired ankle was also significantly higher in the headless group (0.71±0.18 Nm/deg vs. 0.57±0.14 N/deg, $p<0.04$) (Figure 3). Linear displacement of the fragment was small in all three tests and no difference was found between the two groups.

DISCUSSION: Results from this cadaveric paired comparison demonstrated superior fracture site stability and ankle stiffness in external rotation provided by the headless compression screws over the headed partially threaded screws. Limited sample size of the study prevents drawing generalized conclusions, however, age-stratified data from the specimens of two older donors (59 yrs & 70 yrs) showed greater differences between the two groups while both screws performed similarly well in the three younger donors (ages). This suggests that elderly patients may receive greater benefit from fixation using headless compression screws. Further study is needed to confirm this observation.

SIGNIFICANCE/CLINICAL RELEVANCE: Headless compression screws are less irritating and have less risk for painful hardware and hardware removal. The improved fixation stability also facilitates possible early ankle motion that benefits fracture healing. It may also allow for earlier weight bearing postoperatively. This study provides preliminary evidence to support headless compression screws as a viable option for fixation of medial malleolar fractures.

REFERENCES: 1. Barnes et al 2014, Injury, 45:1365-7. 2. Ebraheim et al 2014, Foot Ankle Surg, 20:276-80. 3. Patel et al 2013, Foot Ankle Int, 34:426:33.

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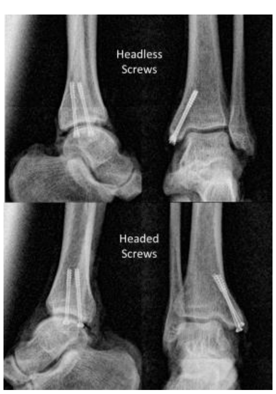

Figure 1. An instrumented pair.

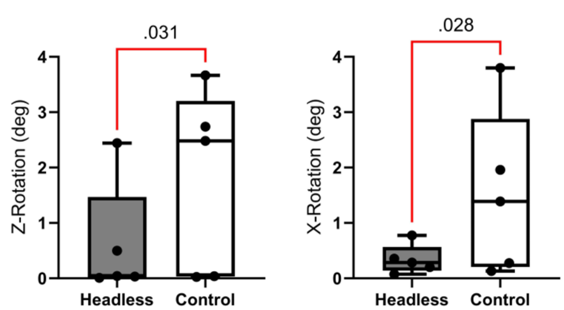

Figure 2. Sagittal (L) and frontal (R) inter-fragment motion.

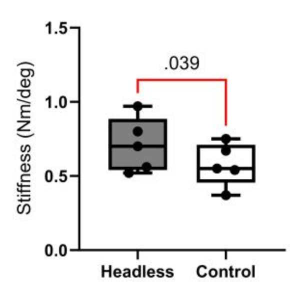

Figure 3. Ankle stiffness in external rotation.