The Journal of Foot & Ankle Surgery 54 (2015) 905–909

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Mechanical Comparison of Headless Screw Fixation and Locking Plate Fixation for Talar Neck Fractures

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ARTICLE INFO

Level of Clinical Evidence: 5

Keywords:
headless screw
locking plate
talar neck fractures

ABSTRACT

For talar neck fractures, open reduction and internal fixation have been thought to facilitate revascularization and prevent osteonecrosis. Newer screw systems allow for placement of cannulated headless screws, which provide compression by virtue of a variable pitch thread. The present study compared the biomechanical fixation strength of cannulated headless variable-pitch screw fixation and locking plate fixation. A reproducible talar neck fracture was created in 14 fresh cadaver talar necks. Talar head fixation was then performed using 2 cannulated headless variable-pitch 4-mm/5-mm diameter (4/5) screws (Acutrak; Acumed, Hillsboro, OR) and locking plate fixation. Headless variable-pitch screw fixation had lower failure displacement than did locking plate fixation. No statistically significant differences were found in failure stiffness, yield stiffness ($p = .655$), yield load ($p = .142$), or ultimate load between the 2 fixation techniques. Cannulated headless variable-pitch screw fixation resulted in better failure displacement than locking plate fixation in a cadaveric talus model and could be considered a viable option for talus fracture fixation. Headless, fully threaded, variable-pitch screw fixation has inherent advantages compared with locking plate fixation, because it might cause less damage to the articular surface and can compress the fracture for improved reduction. Additionally, plate fixation can increase the risk of avascular necrosis owing to the wider incision and dissection of soft tissues.

Fractures of the neck of the talus are relatively rare, accounting for roughly 1% of all fractures and 3% of all foot fractures; however, they account for 50% of all talar fractures (1). The talus has a unique anatomic shape and function. Without direct muscle attachments, it provides the junction between the lower leg and the foot (2,3). Displacement of the fragments leads to subluxation of the subtalar joint, and most researchers have recommended open reduction and internal fixation for displaced fractures (2,4–6). The process of open reduction and internal fixation has historically been thought to facilitate revascularization and prevent osteonecrosis (2–5). Variable-pitch screws have some biomechanical advantages compared with conventional screws in talus fracture fixation. Posteroanterior-directed fixation was reported to be stronger than conventional anteroposterior fixation using 2 screws (7).

Posteroanterior fixation is more likely to cross the fracture site in a perpendicular orientation, which might facilitate compression better than anteroposterior screw fixation. However, posteroanterior screw fixation has some potential disadvantages, including nerve and cartilage damage (8). Anteroposterior screws had an approximately 20% lower yield point and 20% less stiffness than did posteroanterior screws and the blade plate technique, but the difference was not statistically significant (8). Also, variable-pitch screws have biomechanical advantages compared with conventional screws in talus fracture fixation.

Biomechanical testing has shown that headless variable-pitch screws improve fixation of the talar head compared with conventional screws (9). Locking plate fixation provides suboptimal stability. Thus, the technique was developed to increase the stability of fixation in the treatment of bone fractures (10–12). The published data contain a limited number of biomechanical studies on talus fractures and have not included any studies comparing locking plate fixation and

Financial Disclosure: None reported.
Conflict of Interest: None reported.

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1067-2516/$ - see front matter
http://dx.doi.org/10.1053/j.jfas.2015.04.002

Fig. 1. The experimental setup showing the cup-shaped impactor applying a force to the talar head at 45° to the long axis of the talus.

headless screw fixation. As such, the present study compared headless screw fixation and locking plate fixation in the treatment of talus fractures in terms of the failure yield point and stiffness. We hypothesized that locking plate fixation would yield stronger construct and better biomechanical parameters than headless screw fixation. The present study was designated as a level of clinical evidence of 5, because this was a bench top cadaver study.

Materials and Methods

The study was performed using 14 fresh human cadaveric tali that were harvested from lower extremity surgical amputations. All specimens were free of ankle pathologic features. The mean age of the donors was 59 (range 36 to 82) years. Nine specimens were harvested from male donors and five from female donors. For each specimen, the talus was dissected free and cleared of soft tissue. Next, each talus was osteotomized across the talar neck, 1.5 cm proximal to the talonavicular cartilage using an oscillating

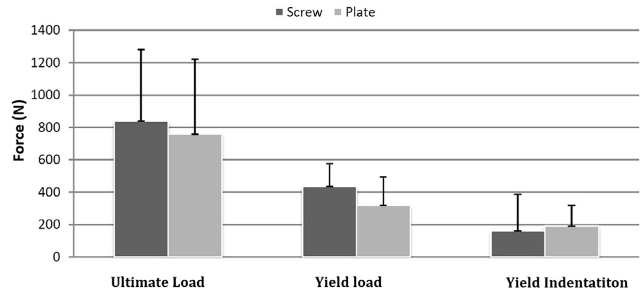

Fig. 3. Ultimate load, yield load, and yield indentation graphs for screw and plate fixation (screw, n = 7; plate, n = 7).

saw. Talar neck fractures were created in the intact specimens as previously described to achieve consistent fractures (7).

The body of each intact talus was rigidly fixed within acrylic cement in an aluminum potting box, with the head and neck exposed. Each potting box was rigidly attached to the load cell of an electromechanical universal testing machine (5 kN AG-X; Shimadzu, Kyoto, Japan; Fig. 1). The tali were positioned such that the anterior and middle subtalar facets made contact with the testing actuator fixed with a 15-mm diameter concave tip molded from the casting compound. A shearing force was directed dorsally at a displacement rate of 25 mm/min until the talar head was completely separated from the body. In the first group, for each talus, the fracture was reduced under direct visualization using the fracture pattern to achieve an anatomic reduction and then stabilized with 2 anteriorly inserted screws—1 medial and 1 lateral, fully threaded, variable-pitch headless Acutrak 4/5 screws (Acumed, Hillsboro, OR) 32-mm long that taper in diameter from 5.0 to 4.0 mm. The length of the screws used in fixation was not consistent across all specimens; instead, the screws were matched to the size of the specimen to provide the most clinically accurate fixation. Next, 2 guide pins were inserted into the talus through the pin guide to hold the fracture reduction. Screw holes were drilled over the pins using cannulated drill bits provided with each screw fixation set. A manual driver was used to insert both screws and complete the fixation. In the plate group, a medially applied 2.7-mm locking plate (Acumed, Hillsboro) with two 23-mm-long locking screws was used (Fig. 2). Surgery was performed by an orthopedic surgeon.

After fixation, radiographs of each specimen were obtained to confirm the accuracy of fixation placement. In the present study, the lowest profile plate with the longest available locking screw was used. It seemed logical that if an anatomic plate, designed specifically for the talar head or neck (e.g., T or L plates), with a lower profile and longer locking screw, was produced, it would be possible to fix the head and neck with >1 screw, purchasing the contralateral cortex, disclosing the biomechanical advantage of the locking plate screw system. Additionally, we aimed to compare the most simple configuration (1 plate and 2 screws versus 2 screws) to test the sole strength of the locking plate.

The potting box was repositioned the same as were the intact specimens on the mechanical testing machine. The specimens were again tested using a dorsally applied shearing force at a displacement rate of 25 mm/min until complete fixation failure. The observed mode of fixation failure was noted. The Shimadzu test machine recorded the force and displacement data from which the load-displacement curves were generated. The failure load and failure displacement were taken from the first inflection in the load-displacement curves, representing the clinical failure of fixation that would require subsequent repair.

The stiffness and energy absorbed (the area under the load-displacement curve to the point of failure) were also calculated for each specimen. After testing, the implants were removed, and the mechanical properties of the specimens were analyzed using a previously described cancellous bone impaction technique (13,14). The talar neck of

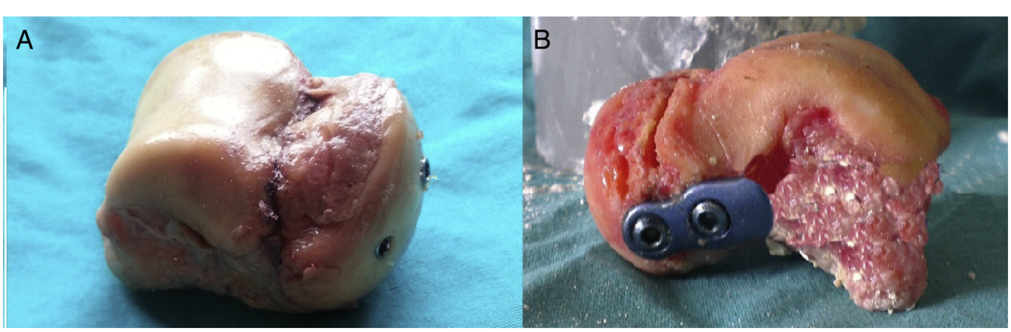

Fig. 2. (*A*) Headless screw fixation. (*B*) Talar neck fracture fixation with locking plate and 2 locking screws.