Introduction: Multiple surgical procedures are available to correct posterior tibial tendon deficiency, including medial displacement calcaneal osteotomy, lateral column lengthening, and subtalar fusion. While procedures can offload the plantar surface of the first and second metatarsal heads, complications include postoperative foot pain and development of arthritic changes in adjacent joints.[3,5] Talonavicular (TN) fusion is another common procedure done in the midfoot to correct particularly for posterior tibial tendon deficiency and isolated talonavicular arthritis. Overall fusion rates of isolated TN fusion range from 36-100% depending on the technique used.[1,2,4,5] Consequently, the TN joint can be difficult to fuse because of instability when subjected to shear and torsional forces. [1, 2]

Currently, this procedure is performed in multiple ways including use of a variety of plates, screws, and staples.

The purpose of this study was to compare the biomechanical differences between the contoured ACE reconstruction plate and screw fixation for TN fusion on plantar foot pressures. Three fusion techniques were investigated: 1) three cannulated screws; 2) contoured ACE reconstruction plate secured via two screws placed in the talus and one screw in the navicular; 3) one cannulated screw added to the previously described ACE reconstruction plate.

Materials and Methods: Eight matched pairs of cadaveric lower extremities were axially loaded to 100lbs in a custom compression apparatus while a TekScan HR Mat measured plantar pressures. The measured plantar pressures were divided into 3 forefoot regions, 2 midfoot regions, and 2 hindfoot regions. Following intact testing, each specimen underwent TN fusion via either an ACE reconstruction plate, ACE plate+screw, or screw fixation. The TN/fixation construct was then isolated and stiffness determined by cantilevered bending in two planes by alternating load to failure. Each repetition involved loading at 0.5mm/s until 225N of compressive load was achieved, then cycling between this position and 0.5mm of compression for 15 cycles. Bending stiffness was determined from the 15th cycle of the fourth repetition. This was followed by loading the navicular's plantar surface at 0.5mm/s until construct failure.

Results: Relative to the intact state, maximum pressure significantly decreased in the medial forefoot for all constructs (p<0.05). (Fig1)

Increases in maximum pressure were observed for the screw construct in the lateral forefoot (LF, p<0.001) and lateral midfoot (LM, p<0.02) and tended towards significance for the plate and plate/screw constructs in the lateral forefoot (LF, p=0.09 and p=0.06, respectively). Maximum pressures in the central forefoot (CF), medial midfoot (MM), and heel were unaffected. Average pressure decreased in the medial forefoot (p<0.02) and increased in the lateral forefoot (p<0.005) for all constructs (data not shown). Only the screw construct showed a significant effect on the average pressure of other regions, with a significant increase in the lateral midfoot (p<0.03), increase in the lateral heel (LH, p=0.02), and decrease in the medial heel (MH, p<0.05). Average pressures in the central forefoot and midfoot were unaffected. No significant differences were observed between plate and screw constructs in maximum (p>0.4) or average pressure data (p>0.5).

No significant difference was observed between the plate/screw and screw constructs for bending stiffness in either loading direction (p>0.5) (data not shown). Additionally, plantar failure data showed no significant difference between plate/screw and screw construct displacement at failure (p=0.5) or load at failure (p=0.2). (Fig2)

Discussion: Talonavicular fusion is currently used predominantly for patients with isolated post-traumatic TN arthritis, acquired flatfoot, and inflammatory arthritis of the talonavicular joint. The transfer of pressures to the lateral border of the forefoot as found in this study could account for the lateral foot pain and concomitant joint arthritis that is seen in patients following midfoot and hindfoot fusions. In a gait analysis of two patients by Fishco and colleagues of three TN fusions, they found an overall increase in pressure area along the lateral forefoot. However, the data was not broken into specific regions, and maximum and average pressures were not measured. [6] Our data does support Fisher's results of lateralization of the foot pressures.

While success rates have varied dependent on etiology, in general it can be a difficult joint to fuse the TN joint due to plantar stress across the fused joint. [3,5] Increased rates of nonunion have been reported, however, with fixation methods that did not extend across the joint. Our study displayed that there is very little difference in stiffness and load to failure between both the plate with screw and three screw fixation, suggesting that either procedure would be similarly effective in fusing the TN joint. The key to achieving fusion in the TN joint may be fixation across the joint that minimizes shear and rotational stresses.


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Figure 1: Maximum plantar pressures (MPa) in foot regions for each of the four states tested

Figure 2: Bending properties for load to failure for two TN fusion techniques