The Scandinavian Total Ankle Replacement (STAR) (Small Bone Innovation, Inc., Morrisville, PA, USA) was designed in order to provide high congruity between implant surfaces in the transverse plane. Owing to its unique shape, the mobile bearing is rotationally constrained by the talus but not the tibial component. The STAR system has demonstrated encouraging clinical results in several clinical series. 1-3

Total ankle arthroplasty provides an excellent alternative for many patients for the treatment of end-stage arthritis of the ankle. Accurate component position and functional ligament tensioning with proper mobile bearing thickness are thought to be critical factors when performing total ankle arthroplasty.2,4 However, the kinematic consequences and tolerances of total ankle component malposition have not been fully defined or researched.

The anteroposterior placement of the talus component and the functional slope of the tibial component are critical variables in the operative technique. We hypothesized that both factors potentially affect baseline ligament function and malposition necessitates greater energy input to function along an arc of excursion. The purpose of this study is to establish the effects of multiple iterations of these two factors with direct pressure monitoring under dynamic weight-bearing conditions in a cadaver.

Methodology & Study Design
Five fresh-frozen ankle specimens (4 males, 1 female mean age 59.2) were stored at room temperature and dissected free of soft tissue, keeping all major supporting ligaments intact. The specimens were prepared for deformities, contusions, ligament injuries, or areas of articular degeneration with visual and manual inspection. A threaded pin was placed in the talus shaft to allow for mounting on the test apparatus (Figure 1). The specimens were tested intact (except for one) prior to being implanted into each ankle and position controlled with fluoroscopic guidance.

Figure 1: implantation. A modified STAR prosthesis was used for each specimen. Arrows show the proper alignment.

Results
Each specimen was placed on a one of a kind robotic multi-axis gait simulator that was custom built at the University of Washington. (Figure 2) The foot was mounted to the simulator and a jig was applied to the leg throughout the simulated gait cycle. A mechanical spring was applied to simulate passive Achilles loads as the foot ranged into ankle dorsiflexion. The STAR talar component was firmly attached to a plate which allowed for reproducible talar positions along the AP axis of the ankle. (Figure 3)

Figure 2: Three separate STAR tibial components were also affixed to a series of jigs that allowed for apparatus alignment and precisely placed the components at variable angles of anterior facing slope. (Figure 4) The jigs allowed for reproducible talar positions of 5mm posterior, 5mm posterior, neutral, 5mm anterior, and 0mm anterior which were confirmed with digital calipers.

Figure 3: These talar positions were repeated for each tibial slope position (zero, 5 and 10 degrees anterior facing slope). There were three separate tibial positions and 5 separate talar positions that were tested (a total of 15 different position for each specimen). Load cell data was collected continuously. Since the positions were repeated on the same specimen, each specimen acted as its own control.

Figure 4: Statistical analysis of the data was performed with Analysis of Variance (ANOVA) with repeated measures. Significant differences were found. Tibial slope increased with dorsiflexion as talar position was moved posterior to anterior (p<0.05). Conversely, load and area decreased with ankle joint plantarflexion with movement in talar position, also significant.

Furthermore, malposition force showed significant load increase on the lateral aspect during ankle dorsiflexion and neutral, also with posterior to anterior component positioning. Tibial slope increase from 0° to 10° positive slope caused an increased (not significant) trend in lateral pressure on the talar component throughout movement range.

Figure 5: Statistical analysis of the data was performed with Analysis of Variance (ANOVA) with repeated measures. Significant differences were found. Tibial slope increased with dorsiflexion as talar position was moved posterior to anterior (p<0.05). Conversely, load and area decreased with ankle joint plantarflexion with movement in talar position, also significant.

Furthermore, malposition force showed significant load increase on the lateral aspect during ankle dorsiflexion and neutral, also with posterior to anterior component positioning. Tibial slope increase from 0° to 10° positive slope caused an increased (not significant) trend in lateral pressure on the talar component throughout movement range.

• One of the most common intra-operative complications in TAR is component malpositioning.4-5 Such technical errors are considered medium grade complications that can lead to failure less than 50% of the time.9 There are no reliable data to report on the frequent component position variability that occurs within a series using STAR.3,4,10 These minor technical component malalignments can often function very well clinically, which seems to be in agreement with this investigation.

Future investigations of position variation with long-term outcome analysis will be needed to fully understand optimal component position. It is important that this era of ankle replacement in the United States that success be optimized with total ankle replacement, in order to ensure its place as a viable and dependable surgical option for patients with end stage ankle arthritis. A better understanding of the biomechanical consequences of component malalignment will assist surgeons in clinical decision making and improving surgical technique.

References