THE EFFECT OF ANKLE ARTHRODESIS ON FOOT BONE KINEMATICS IN GAIT

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INTRODUCTION
Tibiotalar joint arthrodesis (ankle fusion) is used to alleviate pain in the ankle from osteoarthritis after conservative treatment has failed. Arthrodesis is often selected over arthroplasty (joint replacement) for younger patients, as the limited lifespan of current arthroplasty devices will require revision, which may eventually put the patient at risk of amputation. Arthrodesis of the tibiotalar joint, which is responsible for the majority of sagittal plane motion of the foot, can alter the kinematics of distal foot joints during gait. Additionally, a misaligned fusion may further alter the foot joint kinematics. The goal of this study is quantify distal foot joint kinematics after simulation of properly aligned and misaligned ankle fusions using a cadaveric stance phase gait simulation. The misalignments will include transverse plane and frontal plane rotational misalignment, and anterior-posterior translation misalignment. To date only one specimen has been tested using a custom transverse plane misalignment device, but the other two devices are ready for testing.

METHODS
Three different devices were designed for the three fusion misalignments, and each is adjustable from neutral alignment to a range of misalignments. The transverse plane misalignment device (Figure 1A) consists of two plates that rotate up to ±25° about a center axis and can be fixed together with two machine screws and nuts. The frontal plane misalignment device (Figure 1B) uses a three-plate system in which the middle plate can be replaced with wedges up to ±15°, allowing for eversion and inversion in 5° increments. These plates are held together using screws and custom brackets. The anterior/posterior translation misalignment device (Figure 1C) uses a two-plate system that slides along a center track and fixes the plates together with 50mm screws that allow up to 15mm of translation in each direction. All three of these designs use four oblique bone screws to connect to both the tibia and talus, and create a fusion between these bones (Figure 2). Additionally, implant of these custom devices will be performed by an orthopedic surgeon using the same surgical hardware used to perform Salto ankle arthroplasty (Tornier, Inc). In short, a precise section of bone will be removed at the ankle (including part of the tibia and part of the talus) with the same dimensions as the custom devices. For all misalignments, testing will performed using the robotic gait simulator (RGS) [1]. Target ground reaction forces (GRF) and tibia kinematics used by the RGS will be based on eight one-year post-operative ankle fusion patients. The GRF will be scaled to 25% of the donor’s body weight to prevent failure of the fusion device in the fragile cadaver bone. Bone kinematics will be collected using an eight-camera Vicon System and 10-segment foot model [2]. Range of motion (ROM) for distal foot joints, as well as the fused ankle, will be quantified and compared to previous data of normal, unfused feet tested in the RGS. A pilot study of the transverse plane misalignment device was performed on one specimen.

RESULTS AND DISCUSSION
Statistical analysis from the transverse plane misalignment pilot study was not conducted, and all results are preliminary. Sagittal plane ROM data was compared to normal feet from a previous study of natural cadaver feet [3] (Table 1). Tibiotalar joint fusion was achieved, as sagittal plane ROM was reduced to less than 10% of the normal ROM. Increase in the distal foot joint ROM only occurred at the first metatarsocuneiform joint, and was not seen in any other joint as expected. Results from the 5° of internal rotation misalignment were similar to the neutral fusion (Table 1). Some joints had a decreased ROM, which would be expected with the fusion; however, with only one specimen, few conclusions can be drawn.

CONCLUSIONS
These preliminary results demonstrate an effective method for simulating ankle fusion and misalignment with the RGS. Additional testing will include more kinematic parameters, plantar pressure data, and the two additional misalignment devices.

REFERENCES