INTRODUCTION: As the lower limb moves through the stance phase of gait, the tibiotalar joint is loaded up to 5 times bodyweight. Although there have been numerous studies of tibiotalar joint mechanics, there are relatively few noninvasive studies on cartilage contact [1]. Understanding tibiotalar joint cartilage contact during functional activities is relevant in the context of understanding joint mechanics, loading, and pathology. In this study we used a computational surrogate of cartilage contact – interbone spacing [2] – to evaluate how cartilage contact might change during gait. The specific purpose of the study was to assess movement of the tibiotalar subchondral joint space centroids with respect to bony motion, using data collected using an in vitro gait simulator.

METHODS: 7 cadaver right lower extremities (2M, 5F, 70 ± 7 yrs.) were prepared for use with a simple static gait simulator. Specimen preparation involved the dissection of the 9 extrinsic foot tendons (Achilles (calcaneal), tibialis posterior, flexor digitorum longus, flexor hallucis longus, combined peroneus longus and brevis, tibialis anterior, and combined extensor digitorum longus and extensor hallucis longus), and implanting ≥ 4 tantalum marker beads (1.0 mm diam.) into each of the tibia, fibula, calcaneus, talus, navicular, cuboid, medial cuneiform, and first, third, and fifth metatarsals. The proximal tibia and fibula of the specimens were then potted to yield a fixed fibular head height (and rotation axis) 34 cm above the lateral malleolus [3]. Gait was simulated using an adjustable track, which located the fibular head in 9 positions evenly spaced (with time) from heel contact to 90% of stance phase of gait (Fig. 1) [3].

Specimens were positioned in 0° ankle dors/plantar flexion and 0° subtalar inversion/eversion at the beginning of midstance, and loaded with approximately 35 kg in compression (roughly 50% body weight) [4] as measured by F-Scan (Tekscan, South Boston, MA). Specimens were then imaged in each of the 9 positions using a bi-plane videofluoroscopy system, with tendon loading via a low-friction cable assembly and dead weights, whose magnitudes were selected based on EMG data [5]. Specimen orientation was constrained between the adjustable track and radiolucent carbon fiber base plate. The talontalus markers were tracked and rigid body transforms were calculated between simulated positions using custom-written Matlab (MathWorks, Natick, MA) code (XRayProject, xromm.org). Digital models of the beaded bones were generated from clinical CT acquired at a voxel resolution of ~0.6 × ~0.6 × 0.625 mm. Kinematic analysis was performed within a talus-based coordinate system [6], constructed from the neutral foot position. Ankle dors/plantar flexion was defined by the position of the talus relative to the tibia (Fig. 2). A point on the surface of the talus was also tracked relative to the tibia across all positions and reported.

Inter-bone spacing between the tibia and talus was calculated for the articular surfaces included within a distance threshold distance of 4.0 mm, which approximated the summed thickness of the tibial and talar cartilage [1]. Joint space distance was defined as the distance from the centroid of a polygon on the talar surface to the closest point on the tibial surface (Fig. 3). The weighted average of these distances defined the joint contact centroid, which was calculated for each of the 9 positions (Fig. 4).

RESULTS: Mean dorsiflexion ranged between 0° and 12° (Fig 2). The surface area on the talus included by the 4.0 mm joint space threshold was consistent and similar across the 9 simulated positions for the 7 specimens (119 ± 16 cm²), with a boundary that shifted in the posterior direction as the talus plantar flexed with respect to the tibia.

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