THE ROLE OF FOOT STRUCTURES IN CONTROL OF MIDFOOT MOTION

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Introduction: The talonavicular and calcaneocuboid joints of the foot act together to absorb shock and adapt to the complex forces imparted during ambulation. It has been observed clinically that the midfoot is more mobile with subtalar (calcaneal) eversion, and less so with inversion. Elftman (1) proposed that the mechanism for this change was related to the independent axes of the talonavicular and calcaneocuboid joints aligning in subtalar eversion and diverging with inversion, however no data was presented to support this thesis. In this study, the contributions of various structures to midfoot mobility were determined by sequential sectioning.

Methods: Specimens: The sample consisted of 8 human cadaveric feet, all free of overt pathology, which were disarticulated intact at the tibiotalar joint. Steinmann pins were placed through the base of the second metatarsal dorsal to plantar, and through the calcaneus, approximately 22 deg off the long axis of the foot. Loading apparatus: The foot was mounted to an apparatus with the talus as the fixed point. The calcaneus was positioned in either maximum achievable inversion or eversion for that particular specimen and was locked by an adjustable arm in that position. The midfoot was loaded to maximum dorsi flexion (combined with eversion) or planar flexion (combined with inversion) using a 22N weight suspended 10 cm from the center of the second metatarsal on the midfoot pin. An inclinometer was mounted first on the pin through the calcaneus to record its position, and then on the pin through the midfoot to record its motion under load. Experimental sequence: The calcaneus was placed in maximum inversion, locked, and its angular position recorded. The angle achieved by the loaded midfoot in dorsi flexion, and then plantar flexion, was measured with the inclinometer. The calcaneus was then positioned in maximum inversion and midfoot motion remeasured. Then the calcaneocuboid joint capsule was dissected perpendicular to the articulation and the posterior 4 mm of the cuboid bone removed, leaving the calcaneocuboid ligament intact. Following retesting, the plantar fascia, the short calcaneocuboid ligament, the spring ligament, and the bifurcate ligaments were sectioned in that order, with measurements of midfoot motion taken at each sectioning step. Data analysis: A repeated measures ANOVA with post hoc comparisons was used to detect differences in midfoot motion. CT scans of the intact foot were taken to visualize the congruity of the midfoot bones.

Results: Intact joint motion: Positioning the calcaneus in full inversion resulted in 32.9 deg (sd = 11.7 deg) of midfoot motion (dorsi to plantar flexion) under the load. In contrast, with the calcaneus positioned in full eversion, midfoot range of motion increased to 41.7 deg (sd = 11.7 deg) (p = 0.001, n =7). CT scans showed that the calcaneocuboid joint becomes close packed with calcaneal inversion, and incongruous with midfoot dorsi flexion.

Effect of sectioning: There was a progressive increase in overall midfoot range of motion with progressive sectioning of components as shown in Fig 1. With the calcaneus everted, midfoot motion increased from 52.5 deg to 55.3 deg with cuboid removed, to 64.6 deg with fascia sectioned, (p<0.05, n =5) 69.2 deg with the spring ligament sectioned, and 74.5 deg with the bifurcate ligament removed.

Conclusions: (i) When the calcaneus is positioned in inversion, midfoot motion decreases, probably due to close packing of the subtalar and midfoot bones, and conversely increases with eversion. (ii) The cuboid and soft tissues, when resected, progressively allowed greater midfoot dorsi-plantar flexion (up to 142% of that of the intact midfoot).


Supported by a grant from the Dept of Veterans Affairs.