Neither Inversion nor Everson Locks the Midtarsal Joint: A Biomechanical Evaluation
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Summary:
The influence of inversion/eversion of the subtalar joint on the locking of the midtarsal joint has not yet been quantified.
The kinematics of the talonavicular joint was collected in inversion and eversion of the subtalar joint during 10-700N tibiotalar loading. Contrary to Elfman’s theory, our results showed that inversion of the subtalar joint did not significantly restrict the talonavicular joint motion.

Abstract:
Introduction:
It is presumed that the midtarsal joint locking mechanism plays an important role in the pathomechanism of the adult acquired flatfoot deformity caused by posterior tibial tendon dysfunction: During the stance phase of gait the posterior tibialis muscle fails to invert the subtalar joint and hereby the midtarsal joint remains unlocked. The unlocked midfoot absorbs the high loads across the midfoot during push off. Over time the secondary ligamentous static supporters of the midtarsal joint stretch, the longitudinal arch flattens, and the forefoot moves into an abducted position [Mann and Thompson, 1985].
The midtarsal joint locking mechanism has been described by Elfman [1960], however the influence of inversion/eversion of the subtalar joint on the locking of the midtarsal joint has not yet been quantified.

Methods:
Eight fresh-frozen specimens were mounted onto a Material Testing System (MTS 858, MTS Corp, Eden Prairie, MN) and put under tibiotalar loading. A 6 dimensional (3 rotations and 3 translation) relative position sensor constructed with 6 low friction hall-goniometers (QP-2H-C-SW4, Pewatron AG, Zürich, Switzerland) was attached to the talus and the navicular bone in order to collect the kinematics of the talonavicular joint during 10-700N tibiotalar loading. The plantigrade placement of the foot with the tibia perpendicular to the loading platform was referred to as the neutral trial. The tibia was then repositioned in increments of five degrees with a maximum of fifteen degrees of inversion and ten degrees of eversion. For each position the tibiotalar loading was repeated and the kinematics of the talonavicular joint was collected. The goal of the experimental setup was to control and change only the eversion/inversion of the subtalar joint leaving the remaining joints of the foot in their original position at neutral trial. Therefore the eversion/inversion motion of the calcaneus was immobilized in its position at neutral trial, allowing for movement in all other directions. To monitor consistent loading of the foot during eversion and inversion of the tibia, a digital pressure distribution film was placed underneath the forefoot.
The kinematics of the talonavicular joint is presented in a spherical coordinate system. The tip of the navicular bone pin is the origin of the coordinate system and the x-axis is parallel to the longitudinal axis of the foot. Therefore the zenith angle (zeta) represents the angle in the frontal plane of the foot and the azimuth angle (epsilon) represents the angle in the sagittal plane. The radial distance is defined as the distance between the tips of the bone-pins driven into the talus and the navicular. Δzeta, Δepsilon and Δdistance are the differences between the values at 10N and 700N of tibiotalar loading.

Results:
Neither in- nor eversion of the subtalar joint significantly influenced $\Delta \varepsilon$, $\Delta d$ or $\Delta \zeta$. $\Delta \varepsilon$ (10°ev:6.09°/5°ev:6.70°/neutral:8.17°/5°inv:9.20°/10°inv:9.53°/15°inv:7.98°) and $\Delta d$ (0.48mm/0.46mm/0.54mm/0.57mm/0.71mm/0.74mm) showed a tendency to be higher in inversion than in eversion. $\Delta \zeta$ showed a tendency to be lower in inversion than in eversion (1.19°/1.28°/1.25°/1.10°/1.02°/0.97°).

Conclusion:
Contrary to Elfman’s theory, our results showed that inversion of the subtalar joint did not restrict the talonavicular joint motion during tibiotalar loading.