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Tibiocalcaneonavicular Ligament Reconstruction in Simulated Flatfoot Deformity with Medial Ligament Insufficiency

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Introduction/Purpose: Spring ligament tear is often present in advanced stages of the AAFD. Anatomic studies have demonstrated that the superficial deltoid ligament blends with the superomedial spring ligament to provide medial tibiotalar and talonavicular stability. Reconstruction of combined deltoid-spring ligament, or the Tibiocalcaneonvaicular ligament (TCNL) was proposed to augment medial stability in advanced AAFD with large spring ligament tears. A tendon allograft is placed to cross three peritalar (tibiotalar, talonavicular and subtalar) joints to augment medial stability. We aimed to 1) investigate the kinematic effects of TCNL reconstruction in cadaveric flatfoot model with medial ligament insufficiency, and 2) compare TCNL reconstruction with anatomic spring and anatomic deltoid ligament reconstructions (Figure 1). We hypothesized that TCNL reconstruction is effective in restoring peritalar kinematics.

Methods: Five fresh-frozen cadaveric foot specimens were employed. Advanced stage flatfoot model was created by sectioning the medial and inferior talonavicular interosseous ligament and extending the release 2cm proximally along the superomedial spring ligament. Cyclic axial load of 1150N under a hydraulic loading frame with constant 350N Achilles tendon load were applied until >15° talo-first metatarsal abduction was achieved. Bone tunnels were drilled for three reconstruction types, and the peroneus longus tendon was configured to reconstruct the 1) anatomic spring ligament, 2) anatomic deltoid ligament, and 3) TCNL. Reflective markers were mounted on the tibia, talus, navicula, calcaneus and first metatarsus. Each reconstruction type was loaded with 800N ground reaction force, and kinematics of the peritalar joints were captured by 4-camera motion capture system. Forefoot abduction angle, Meary's angle, and hindfoot valgus were calculated and compared to the severe flatfoot prior to reconstruction and to each using two-way ANOVA.

Results: In creating the flatfoot deformity, both the tibiotalar and subtalar joints demonstrated an increase in valgus deformity by 5.6+3.7° and 6.1+5.3°, respectively, compared to the initial measurements. When comparing to the flatfoot deformity, the TCNL reconstruction achieved a significant improvement in percent correction of total hindfoot valgus (59.7+21.1%, $p=0.017$) and forefoot abduction angle (83.4+17.7%, $p<0.01$). The spring ligament reconstruction also demonstrated a significant improvement in forefoot abduction correction compared to the flatfoot (52+10.6%, $p<0.05$). No other reconstruction technique achieved a statistically significant improvement in percent correction compared to the flatfoot model in forefoot or hindfoot alignments. Additionally, no statistical differences were noted in the percent correction when comparing the three reconstructive techniques to each other.

Conclusion: In advanced stage cadaveric flatfoot with spring ligament tear, we found increased valgus alignment at both the tibiotalar and subtalar joints. This kinematic changes reflects increased strain across the medial peritalar ligaments. The deltoid-spring ligament complex (TCNL) reconstruction demonstrated significantly improved alignment of hindfoot valgus and forefoot abduction compared to the severe flatfoot condition. This finding suggests that in addition to osseous correction and tendon transfer, the TCNL reconstruction may serve as an important component in augmenting medial stability in advanced AAFD with medial ligament insufficiency.

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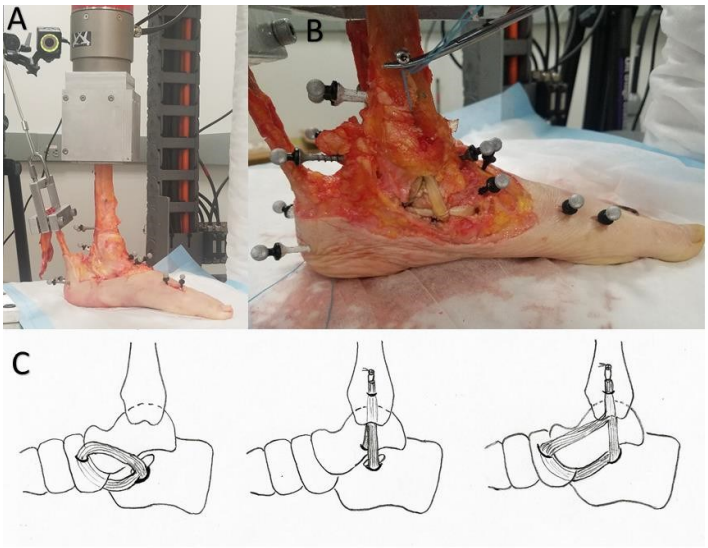


Figure 1: Measuring kinematic changes of cadaveric flatfoot model after three different techniques of medial ligament reconstruction.

A: Reflective markers are mounted on the tibia, talus, calcaneus, navicular and first metatarsus. Kinematic changes were captured by multiple camera motion capture system. Flatfoot model is created by sectioning talonavicular joint capsule and spring ligament followed by loading under 1150N axial force and 350N Achilles pull.

B: The TCNL reconstructed flatfoot loaded under ground reaction force of 800N.

C: Illustration of 3 different reconstruction methods tested: anatomic spring, anatomic deltoid and TCNL reconstruction.

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