Reconstruction of the Superior Aspect of the Midfoot Provides Greater Correction than an Anatomic Reconstruction of the Spring Ligament in a Simulated Flatfoot Deformity

Josh R. Baxter, PhD, Jeremy M. LaMothe, MD, PhD, Raymond J. Walls, MD, Marcelo P. Prado, MD, Susannah Gilbert, MS, Jonathan T. Deland, MD.
Hospital for Special Surgery, New York, NY, USA.


Introduction: Adult acquired flatfoot deformity is the manifestation of compromised constraints of the medial arch [1]. Calcaneal osteotomies and midfoot fusions are commonly performed to alleviate the deformity but often result in overcorrection and pain. Reconstructing the passive constraints of the talonavicular joint may correct the deformity; however, the functions of reconstructed midfoot ligaments are not well understood. Therefore, the purpose of this study was to demonstrate the efficacy of different talonavicular joint reconstruction techniques in a simulated standing task. Our hypothesis was that an anatomic reconstruction of the spring ligament would provide the best correction of the simulated flatfoot deformity while other reconstruction techniques of the medial arch would provide less correction.

Methods: Flatfoot deformity was created in 12 cadaveric lower limbs. The spring ligament complex, superficial deltoid, and interosseous talocalcaneal ligaments were sectioned and a ground reaction force of 800 N was cyclically applied to the specimen while an Achilles load of 350 N was maintained. The medial talonavicular joint was reconstructed using a peroneus longus tendon autograft by fellowship trained surgeons. Three reconstructions were performed on each specimen in a randomized order and shared a common bone tunnel in the medial third of the navicular body while the insertion points of the graft varied. Anatomic reconstruction of the spring ligament (Fig. 1A) passed both ends of the graft through bone tunnels made in the calcaneus to approximate the lines of action of the spring ligament complex. Talo-navicular reconstruction (Fig. 1B) passed the graft through the body of the calcaneus and talus to approximate parts of the spring ligament complex and talonavicular joint capsule. Tibio-navicular reconstruction (Fig. 1C) secured the ends of the graft to the dorsal aspect of the navicular and medial side of the tibia to approximate the superficial deltoid ligament and superomedial talonavicular joint.

Alignment of the talonavicular and hindfoot (tibio-calcaneal) joints were measured while the foot was loaded with a ground reaction force of 400 N and Achilles load of 350 N. Prior to creation of the flatfoot, normative data was collected.

Deformity correction resulting from the three reconstruction techniques were compared using repeated measures analyses of variance models and Tukey post-hoc tests with a significance level of α = 0.05. To confirm that the reconstructions corrected the flatfoot condition, 95% confidence intervals were calculated for the deformity correction values for each condition and joint angle. These confidence intervals are represented by the error bars in the results figures.

Results: Talonavicular abduction and dorsiflexion deformities were corrected by each of the three reconstruction techniques (Fig. 2); however, twice as much of the abduction deformity was corrected by
the tibio-navicular reconstruction compared to the anatomic spring ligament reconstruction (Fig. 2). The reconstructions had a graded effect on talonavicular eversion; the tibio-navicular reconstruction provided the most correction while the anatomic spring ligament reconstruction did not provide any (Fig. 2).

Both the tibio-navicular and talar-navicular reconstructions corrected the hindfoot eversion deformity (Fig. 3), while the anatomic spring ligament reconstruction only corrected the hindfoot one-quarter as much as the tibio-navicular technique (Fig. 3).

Discussion: These results demonstrate that reconstructing the soft-tissues of the medial arch can correct a simulated flatfoot deformity. Reconstructing the tibio-navicular portion of the midfoot provided the greatest amount of correction, not only at the talonavicular joint but at the hindfoot as well (Figs. 2 and 3). While an anatomic reconstruction of the spring ligament did improve alignment in sagittal and transverse planes, coronal plane deformities were unaffected. These findings suggest that proximal fixation of grafts are most effective in correcting alignment of the mid- and hindfoot in simulated flatfoot deformities.

Although the current surgical paradigm is to treat flatfoot deformity with osseous procedures [2], our findings suggest that midfoot correction can be achieved with reconstruction of the medial arch. Midfoot stability provided by soft tissue reconstruction could also reduce the extent to which osseous procedures are needed, potentially decreasing joint stresses [3] and patient reported pain [4]. This study is limited to simulated standing and these reconstructions may not stabilize the midfoot during functional tasks like walking or stair climbing.

In conclusion, soft tissue reconstruction of the medial arch corrects a simulated flatfoot deformity. The lines of action of the tendon graft play an important role in the type and amount of deformity correction, where proximal insertion of the tendon graft results in greater deformity correction compared to distal fixation. Reconstructing the superomedial talonavicular capsule may be necessary to correct both the midfoot and hindfoot deformity commonly associated with flatfoot deformity.

Significance: Reconstruction of the medial arch soft tissues is highly dependent on the graft lines of action. Clinically significant correction can be achieved without osseous procedures that have been linked to patient reported pain and increased joint contact stress.
Figure 1: Schematic of the anatomic spring ligament (A), talonavicular (B), and tibio-navicular (C) reconstructions.
Figure 2. Correction of talonavicular deformity provided by the anatomic spring ligament (white box), talo-navicular (gray box), and tibio-navicular (black box) reconstructions. * $P < 0.05$ compared to tibio-navicular reconstruction.
Figure 3. Correction of hindfoot eversion provided by the anatomic spring ligament (white box), talo-navicular (gray box), and tibio-navicular (black box) reconstructions. * $P < 0.05$ compared to tibio-navicular reconstruction.