Biomechanical Assessment of Flexible Flatfoot Correction: Comparison of Techniques in a Cadaver Model

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Author(s):
Diego H. Zanolli, MD
Richard Glisson, BS
James A. Nunley, II, MD
Mark E. Easley, MD

Introduction
Introduction: Using a cadaver flatfoot model, we evaluated the ability of a range of current surgical methods to correct the deformity and resist flattening during ensuing mechanical challenges. Emphasis was placed on determining whether spring ligament repair contributes appreciably to the integrity of the surgical correction.

Methods
Methods: Flatfoot deformity was created in ten fresh frozen lower legs through ligament attenuation and repetitive axial loading coupled with extrinsic tendon loading. In the intact, flat, and corrected conditions the angular positions of key bones were documented during post-surgical load cycles 100, 500, 1000 using electronic clinometers attached to the talus, navicular, and first metatarsal. The talus-first metatarsal angle was measured in the sagittal plane, and the talus-navicular angle was measured in the coronal plane. Six corrective procedures were sequentially evaluated, and repeated measures ANOVA with Bonferroni post-hoc tests were used to determine differences among the treatments: 1. Lateral column lengthening using an 8 mm wedge. 2. Medial displacement calcaneal osteotomy and flexor digitorum longus (FDL) transfer. 3. Medial displacement calcaneal osteotomy and FDL transfer plus lateral column lengthening. 4. Treatment 3 plus "pants-over-vest" spring ligament repair. 5. Treatment 3 plus "distal posterior tibialis stump to spring" ligament repair. 6. Treatment 3 plus "sutures and anchors" spring ligament repair.

Results
Results: The mean sagittal plane flattening, reflected by the talus -1st MT angle, was 8.3 degrees. As indicated by the graph, all treatments achieved some degree of correction, which gradually decreased during post-operative cyclic loading. Correction afforded by Treatments 1, 3, 4, 5 and 6 exceeded that of Treatment 2 (medial displacement calcaneal osteotomy and FDL transfer) at all evaluated time points (p < 0.05). Treatment 2 corrected significantly less than all other treatments (p < 0.05). No initial sagittal correction differences were distinguishable among treatments 1, 3, 4, 5 and 6. In the coronal plane, flattening produced mean navicular eversion of 6.0 degrees relative to the talus. Treatment 2 talus-navicular angle correction was inferior to all other treatments at all time points (p<0.001). Treatments 1, 3, 4, 5 and 6 maintained near-normal talus-navicular angles throughout cyclic loading, with no differences evident among treatments.
Conclusion
Discussion and Conclusion: FDL tendon transfer with a medial displacement calcaneal osteotomy was markedly inferior to all other evaluated treatments. Lateral column lengthening is a powerful technique that allows correction in both sagittal and coronal planes, and consistently achieved the most talus-1st MT angle correction. Addition of spring ligament repair to combined medial displacement calcaneal osteotomy/FDL transfer/lateral column lengthening resulted in only minor improvements to the correction in each plane, too small to be statistically significant. Thus, including spring ligament repair in association with the “All American” procedure may have limited value.