Spring Ligament Tear Decreases the Ankle and Talonavicular Joint Reaction Forces: Biomechanical Study of the Tibiocalcaneonavicular Ligament Reconstruction

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Category: Other

Keywords: Tibiocalcaneonavicular ligament, Deltoid ligament, Spring ligament, Adult acquired flatfoot deformity

Introduction/Purpose: Spring ligament tear is often noted in advanced stages of the adult acquired flatfoot deformity (AAFD). Previous anatomic studies demonstrated that the spring and deltoid ligaments are not separate structure, but form a confluent ligament in which the tibiocalcaneonavicular ligament (TCNL) comprises the largest component. A biomechanical study which utilized stage IIB AAFD model demonstrated inferior result of the anatomic spring ligament reconstruction compared to the tibionavicular ligament reconstruction. Therefore, the TCNL reconstruction has been proposed for effective restoration of the ankle and talonavicular joints stability in AAFD with a large spring ligament tear. We aimed to investigate if spring ligament tear of greater than 1.5cm decreases the ankle and talonavicular joint reaction forces (JRF), and if they could be restored by the TCNL reconstruction.

Methods: Ten fresh-frozen human cadaveric lower legs were obtained and disarticulated at the knee joint. Steinmann pins were percutaneously placed across the distal tibia, center of the talus and navicular while preserving adjacent soft tissues. A distraction force was applied across the ankle and talonavicular joints to determine the baseline force displacement curve to generate a best-fit polynomial equation to determine normal JRF. A spring ligament injury model was created by releasing the medial capsuloligamentous complex of the talonavicular joint and extending the resection 1.5cm proximally. The TCNL reconstruction was performed with a forked semitendinosus allograft. The folded portion of the graft was fixed to the medial malleolar inter-colliculus. One limb of the separated part of the allograft was fixed to the navicular tuberosity and the other limb was fixed to the calcaneus below the sustentaculum tali. The resultant JRFs across the tibiotalar and talonavicular joints were measured after each step.
**Results:** The mean baseline JRFs of the ankle and talonavicular joints were 8.36 N +/- 1.8 N and 3.01 N +/- 0.9 N, respectively. The spring ligament tear resulted in 29% decrease in tibiotalar JRF (5.97 N +/- 1.1 N, p< 0.05) and 13% decrease in talonavicular JRF (2.63 N +/- 0.8 N, p>0.05). Although the tibionavicular ligament reconstruction partially restored JRFs of the tibiotalar (7.83 +/- 2.4 N, p> 0.05) and talonavicular joints (4.08 N +/- 1.8 N, p> 0.05), they were not statistically significant. Addition of the tibiocalcaneal ligament reconstruction resulted in significantly increased JRFs of the tibiotalar (9.17 +/- 3.93 N, p> 0.05) and talonavicular joints (4.35 +/- 2.04 N, p> 0.05) compared to the spring ligament injury model.

**Conclusion:** This is the first biomechanical study to demonstrate that a large size (>1.5cm) spring ligament tear results in decreased JRF of the ankle joint. The decreased ankle and talonavicular JRFs were effectively restored by the novel TCNL reconstruction. This technique utilizes a forked allograft with two limbs for the tibionavicular and tibiocalcaneal ligaments reconstructions. Advanced AAFD with a large size spring ligament tear may have medial ankle instability that should not be overlooked. The novel TCNL reconstruction should be considered to prevent progression of valgus deformity. The biomechanical and clinical efficacies of the TCNL reconstruction warrant further investigation.