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Foot & Ankle

Deltoid Ligament: An Anatomical Evaluation of Function

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ABSTRACT

A cadaver study done to evaluate function of the deltoid ligament and its major subdivisions, the superficial and deep components, revealed that the deltoid ligament is the primary restraint against valgus tilting of the talus, with superficial and deep components being equally effective in this regard. The deep deltoid ligament appeared to be the secondary restraint against both lateral and anterior talar excursion, with the lateral malleolus and supporting ligaments being the primary restraint.

Stability of the ankle is related to its osseous configuration and associated ligamentous structures, with the deltoid ligament constituting the medial ligamentous support. There is general agreement that discrete superficial and deep portions of the deltoid ligament exist and that the deep layer is more important, but little documentation exists as to the role of the deltoid ligament as a whole or in terms of its subdivisions in maintaining ankle stability. In an effort to further elucidate the function and need for surgical repair of this structure, a series of cadaver dissections was done with associated stress testing following disruption of both medial and lateral supporting structures.

MATERIAL AND METHODS

Twenty-four fresh cadaver lower extremities were dissected free of all skin, muscle, and subcutaneous tissue, leaving the fascial and ligamentous support of the ankle intact. Only specimens free of any gross abnormality and exhibiting a relatively normal range of motion were used. The anterior capsule, which was not considered to be a major restraining structure, was routinely excised to directly measure talar displacement. The fascial and ligamentous tissue planes on the medial side of the ankle were carefully dissected and defined, after which specimens were vertically mounted with the foot and ankle being supported at a position of neutral flexion. In all specimens, intact except for the anterior capsule, the maximum amount of direct anterior talar excursion, lateral talar shift, and valgus talar tilting with manual stressing was measured and recorded. Anterior talar excursion was determined by measuring with calipers (0.5-mm increments) the amount of anterior displacement of the talus relative to the anterior edge of the plafond, which occurred when forceful anterior pressure was applied to the hindfoot. Similarly, maximum lateral talar shift was determined by applying forceful pressure medially about the midfoot and hindfoot and measuring any widening of the medial joint space with metal spacers 0.5 mm in width. Tilting of the talus was attempted by applying a strong valgus force to the hindfoot and midfoot with any angulation between the dome of the talus and the plafond being measured with a goniometer (1° increments). Although manual stressing has some inherent variability in terms of the amount of force applied, it is a method that is useful clinically and that was felt to yield useful information in a similar fashion in this study.

An effort was then made to evaluate any instability resulting from disruption of either division or both divisions of the deltoid ligament. In four specimens the superficial ligament was divided, and in another four specimens the deep ligament was divided, leaving intact the lateral malleolus, lateral ligaments, and posterior capsule. Manual stressing as described above was then performed and repeated in all eight specimens following division of both components.

Next, in an effort to compare the restraining influence of the lateral malleolus and lateral ligaments as a unit with that of the deltoid ligament, the lateral malleolus was removed at the level of the plafond in 16 additional specimens, followed again by manual stressing.

For all 24 ankles, any increase in talar mobility from that noted in the intact specimens was related to loss of the supporting structures that had been divided. This was interpreted as an indication of the restraining influence of those structures.

Next, an effort was made to compare the superficial and deep components of the deltoid ligament as restraining structures. In eight of the above-mentioned

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ankles in which the lateral malleolus had been removed, the superficial ligament was completely detached from its distal insertion onto the talus, navicular, calcaneonavicular ligament, and calcaneus, taking care to maintain the deep deltoid ligament intact. In the other eight specimens in which the lateral malleolus had been removed, the deep ligament was divided from within the joint, taking care to preserve the integrity of the superficial layer. Again, manual stressing was done.

RESULTS

Identification of the fascial and ligamentous structures about the medial ankle was found to agree with a recent detailed description by Sarrafian.[13] Worthy of emphasis is the observation that the deep layer is a short (approximately 6 mm in length), transverse, subsynovial, relatively inaccessible structure.

Manual stressing for maximum anterior talar excursion in 24 specimens, intact except for the anterior capsule, revealed an average anterior excursion of 0.9 mm (range, 0 to 2.5 mm). No lateral displacement or valgus tilting of the talus was possible in any intact specimen.

In the eight specimens in which either the superficial or deep ligament was divided and then both portions were divided with the lateral structures and posterior capsule remaining intact, division of the superficial ligament in four specimens, the deep ligament in four specimens, and subsequently both the superficial and deep ligaments in all eight specimens resulted in no increase in anterior excursion and no lateral shift of the talus in any specimen. Valgus tilting of the talus was not possible in any specimen in which only the superficial or deep ligament was divided but was possible to an average of 14° (range, 13° to 16°) (Fig. 1) following division of both superficial and deep components. Further valgus tilting was limited by the posterior capsule, the division of which resulted in complete eversion of the talus.

Fig. 1. Cadaver specimen demonstrating talar tilt possible with manual valgus stressing following division of the deltoid ligament.

Following removal of the distal fibula in 16 specimens, anterior talar excursion was noted to increase to an average of 5.6 mm, with a range of 4 to 8 mm. At this time lateral talar shift also was noted to be possible to an average of 1.9 mm, with a range of 1.5 to 3 mm (Fig. 2*A*). Again, no tilting of the talus with valgus stressing was noted in any specimen. In eight of these ankles, in which the superficial deltoid ligament was then divided, maximum anterior talar excursion was noted to increase in only one specimen by 1 mm. In none of the eight ankles was maximum lateral talar shift noted to increase (Fig. 2*B*); and, again, no talar tilt was noted in any specimen with valgus stressing. In the eight additional specimens in which the deep deltoid ligament was divided, leaving the superficial ligament intact, maximum anterior talar excursion increased to an average of 8 mm (range, 7 to 9 mm). Maximum lateral talar shift also was noted to increase to an average of 3.8 mm (range, 3 to 4.5 mm) (Fig. 2*C*). Once again, no tilting of the talus was observed in any specimen with valgus stressing.

DISCUSSION

The results of this study would indicate that up to 2.5 mm of anterior talar excursion may be possible in an ankle that is intact except for the anterior capsule. This is in agreement with prior clinical and experimental studies in which 2 to 3 mm of anterior talar displacement with stressing was felt to be normal.[1,2,10–12]

The deltoid ligament was noted to be the primary restraint against tilting of the talus secondary to a valgus stress. This finding differs from the results of cadaver experiments by Yablon et al.[15,16] in which division of the deltoid ligament was said to result in no instability of the ankle, whereas resection of the lateral malleolus produced marked valgus instability.

The lateral supporting structures of the ankle are the primary restraint against anterior talar excursion. If the lateral malleolus and the lateral ligaments were intact, no increase in anterior excursion was noted following division of either or both layers of the deltoid ligament. Following removal of the lateral malleolus and its attached ligaments, however, anterior talar excursion was noted to significantly increase even if the deltoid ligament was completely intact. Although division of the superficial deltoid ligament appeared to have essentially no additional effect on anterior instability, the deep

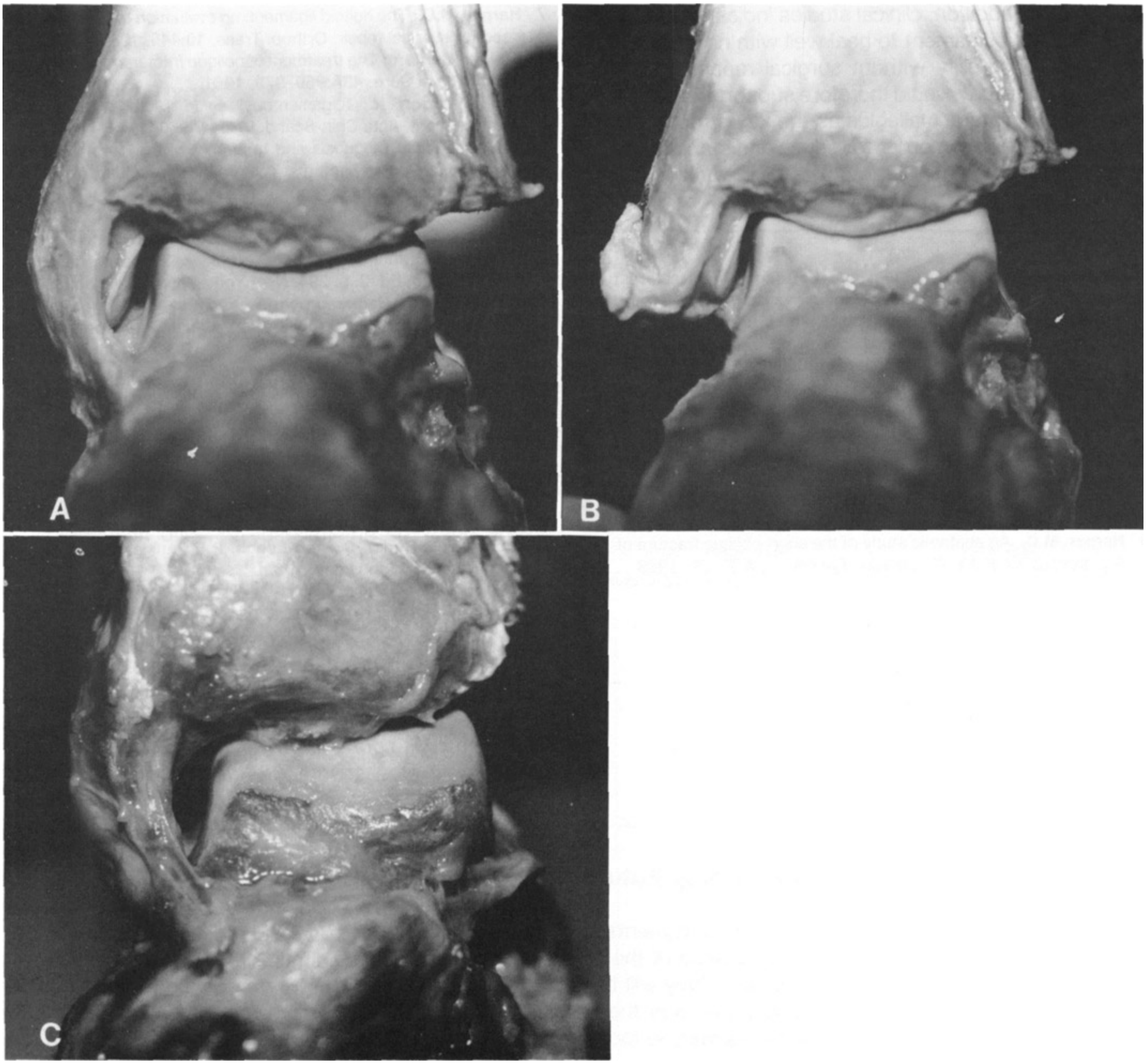

Fig. 2. Cadaver specimens following osteotomy of the lateral malleolus demonstrating maximum lateral talar shift possible with manual stressing. *A*, talar shift possible with deltoid ligament intact. *B*, talar shift possible following division of superficial deltoid ligament. *C*, talar shift possible following division of deep deltoid ligament.

deltoid ligament did function as a secondary restraint against anterior talar excursion, with anterior excursion again increasing following division of this structure.

With regard to lateral talar shift, the lateral malleolus is the primary restraining structure. As noted by other authors, the deltoid ligament will allow up to 3 mm of lateral talar displacement in the absence of the lateral malleolus.[3–5,6,9] Of the two divisions of the deltoid ligament, the deep layer was noted to be the secondary restraint against lateral talar shift. Division of the superficial layer resulted in no further displacement, but division of the deep layer resulted in a further lateral displacement averaging 1.9 mm (a 100% increase). This is in agreement with findings described by Grath.[5]

The poor results involving fracture dislocations of the ankle are commonly associated with residual lateral displacement of the lateral malleolus.[3,8,11,14,15] In contrast, talar instability secondary to laxity of the deltoid ligament is said to occur infrequently as reflected in a paucity of reports describing late reconstruction of this structure.[15] In addition, clinical studies indicate the ability of the deltoid ligament to heal well with no resultant valgus talar instability without surgical repair.[7,11] The findings in this study would therefore support the clinical concept of the lateral malleolus as the key structure to reduce and stabilize in order to reduce and stabilize the talus in the management of fractures of the ankle.

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