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Analysis of Rotary Ankle Instability and Taping Restraint in a Cadaver Specimen

Gary B. Wilkerson, EdD, ATC • University of Tennessee at Chattanooga; Jesse F. Doty, MD • University of Tennessee College of Medicine – Chattanooga; Larry R. Gurchiek, DA, ATC and J. Marcus Hollis, PhD • University of South Alabama

ANKLE instability associated with an inversion injury mechanism has primarily been related to excessive inversion displacement of the foot segment in relation to the leg segment, excessive lateral tilt of the talus within the tibio-fibular mortise, and excessive anterior translation of the talus from beneath the tibio-fibular mortise. Rehabilitation exercises, external ankle supports, and surgical reconstruction techniques tend to focus on restraint of excessive ankle motion within the frontal plane, but the literature contains considerable evidence that antero-lateral rotary instability (ALRI) within the transverse plane leads to chronic ankle dysfunction and progressive chondral degeneration. The subtalar sling (ST sling) ankle taping procedure has been advocated as a means to restrain ALRI (Figures 1 & 2).1 The purpose of this report is to present the findings of a study that quantified internal rotation of the foot segment of a cadaver specimen with ankle ligaments intact, after sequential sectioning of three selected ligaments, with the presence of a Gibney tape configuration, and with the addition of ST sling component to a Gibney tape configuration.

Procedures

A single fresh-frozen human-cadaveric lower extremity that had been disarticulated at the hip was thawed and selectively dissected to expose the ankle ligaments for sequential sectioning. Soft tissue removal was limited to that which would provide access to the anterior talo-fibular ligament (ATFL), the posterior tibio-talar ligament (PTTL), and the interosseus talo-calcaneal ligament (ITCL). After completion of the dissection, holes were drilled through the tibia of the cadaver specimen to securely fix the leg segment in a horizontal position with vertically-oriented bolts that were passed through the tibia and anchored to a table (Figure 3). Flexion of the knee joint allowed the proximal end of the thigh segment to rest on the table. The foot segment was positioned beyond the table edge, which allowed for unconstrained three-dimensional movement in relation to the fixed leg segment.

The ankle arthrometer that was used has been shown to provide highly reliable and precise measurement of both frontal plane rotation and anterior-posterior translation of the foot in relation to a stationary leg segment. The arthrometer was modified to apply torque around an axis coinciding with the long axis of the leg and to quantify internal-external rotational displacement of the foot within the transverse plane (Figure 4). The foot segment was securely fixed to the arthrometer in a manner that did not interfere with displacement of either the talo-crural joint (TCJ) or the subtalar joint (STJ). Manual torque was applied to a maximum level of 5 Nm to induce rotation of the foot, while a neutral position of the TCJ was maintained within the sagittal plane. A customized software program recorded load and displacement data throughout the manually induced foot motion. Data were collected for 3 motion cycles of each of the following conditions: (a) ligaments intact, (b) ATFL cut, (c) PTTL cut, (d) ITCL cut, (e) Gibney taping, and (f) ST sling taping superimposed on Gibney taping.

Findings

Cubic regression analyses of torque versus internal rotation were performed on data derived from the 18 separate trials, each of which demonstrated exceptionally strong correlation ($R = 0.98 – 0.99$). Composite displacement curves were generated and 95% confidence intervals were calculated for each of the 6 conditions (Table 1). Internal rotation at 5 Nm progressively increased from 17.62 degrees in the intact state to a maximum value of 25.85 degrees after all 3 ligaments had been sectioned (Figure 5). The Gibney taping reduced displacement of the unstable ankle by 6.32 degrees at 5 Nm. The addition of the ST sling taping component to the Gibney taping procedure provided another 11.99 degrees of restraint, which provided a 71% total reduction in displacement of the unstable ankle (Figure 6). The results indicate that the ST taping procedure provided a statistically significant restraint of ankle displacement in the transverse plane ($p < .05$).
Clinical Relevance

Because the deltoid ligament is located on the medial aspect of the ankle, many clinicians assume that it is only damaged by an eversion injury mechanism; however, the deep posterior portion of the deltoid ligament (PTTL) has a mediolateral fiber orientation that can be ruptured by the internal rotation of the talus.
Surgically confirmed injury to both the ATFL and PTTL has been associated with a 98% prevalence of articular cartilage damage in the TCJ. STJ ligament injury may be present in as many as 75% of individuals with TCJ instability. Among patients presenting MRI evidence of ATFL injury, 56% also had evidence of damage to the ITCL. The resulting STJ instability is associated with subluxation of the calcaneus beneath the talus, which is very hard to distinguish from ALRI of the TCJ.

An important limitation of this study was a lack of axial loading of the articular surfaces of the TCJ and STJ. Compression of the joint surfaces under weight-bearing conditions would almost certainly enhance stability, thereby limiting the amplitude of displacement. With regard to the effect of ankle taping, lack of a mechanism to induce tape loosening represents another important limitation. Some clinicians believe that tape loosening severely limits the value of ankle taping, but a previous study of the effect of the ST sling on forced passive inversion demonstrated that a 42% restriction of the maximum unsupported displacement remained after prolonged activity (25 degrees versus 40 degrees). A previous study of the effect of the ST sling on anterior translation of uninjured subjects demonstrated that a 48% restriction of maximum unsupported displacement remained after 15 minutes of physical activity (4.9 mm vs. 9.4 mm). A previous study that quantified closed-chain external rotation of the leg segment during a 35-degree inversion displacement of the foot segment demonstrated that the ST sling provided an 18% post-exercise restriction of unsupported displacement (7.5 degrees vs. 9.1 degrees), and that the Gibney taping procedure did not provide a significant amount of post-exercise restriction. Despite the limitations of this cadaver study, the ST sling provided a 57% restriction of internal rotation of the unsupported intact specimen, and a 71% restriction of the unsupported unstable specimen (3 ligaments sectioned). Clearly, substantial tape loosening would not be likely to eliminate the restraining effect on internal rotary displacement.

**Conclusions**

The modified ankle arthrometer clearly has value as a diagnostic tool for identification of ALRI. Sectioning the PTTL (i.e., the deep posterior deltoid ligament) and the ITCL increased internal rotary displacement of the foot segment. Restraint of internal rotary displacement within the transverse plane was significantly increased after the ST sling was superimposed on the Gibney taping procedure. Because ALRI has been related to progressive degeneration of chondral lesions, the ST sling taping procedure should be used to protect the unstable ankle during functional activities.

**References**


