# Systematic Quantification of Stabilizing Effects of Subtalar Joint Soft-Tissue Constraints in a Novel Cadaveric Model

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**Background:** Distinguishing between ankle instability and subtalar joint instability is challenging because the contributions of the subtalar joint's soft-tissue constraints are poorly understood. This study quantified the effects on joint stability of systematic sectioning of these constraints followed by application of torsional and drawer loads simulating a manual clinical examination.

**Methods:** Subtalar joint motion in response to carefully controlled inversion, eversion, internal rotation, and external rotation moments and multidirectional drawer forces was quantified in fresh-frozen cadaver limbs. Sequential measurements were obtained under axial load approximating a non-weight-bearing clinical setting with the foot in neutral, 10° of dorsiflexion, and 10° and 20° of plantar flexion. The contributions of the components of the inferior extensor retinaculum were documented after incremental sectioning. The calcaneofibular, cervical, and interosseous talocalcaneal ligaments were then sectioned sequentially, in two different orders, to produce five different ligament-insufficiency scenarios.

**Results:** Incremental detachment of the components of the inferior extensor retinaculum had no effect on subtalar motion independent of foot position. Regardless of the subsequent ligament-sectioning order, significant motion increases relative to the intact condition occurred only after transection of the calcaneofibular ligament. Sectioning of this ligament produced increased inversion and external rotation, which was most evident with the foot dorsiflexed.

**Conclusions:** Calcaneofibular ligament disruption results in increases in subtalar inversion and external rotation that might be detectable during a manual examination. Insufficiency of other subtalar joint constraints may result in motion increases that are too subtle to be perceptible.

**Clinical Relevance:** If calcaneofibular ligament insufficiency is established, its reconstruction or repair should receive priority over that of other ankle or subtalar periarticular soft-tissue structures.

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Approximately 30,000 ankle inversion sprains occur daily in the United States, and chronic lateral ankle instability subsequently develops in 20% to 40% of these cases[1-4]. Because injury to lateral subtalar joint ligaments is often associated with ankle sprains[5,6], patients presenting with a severe ankle injury should be evaluated for a concomitant subtalar sprain. This is particularly important because, if such an injury is left untreated, it can progress to chronic lateral ankle or subtalar instability[6-8]. Ten percent to 25% of patients with functional ankle instability exhibit subtalar joint instability[9].

Clinical distinction between ankle and subtalar joint instability is challenging[10], as the symptoms are similar, poorly defined, and subjective. It is generally accepted that the calcaneofibular, interosseous talocalcaneal, and cervical ligaments are primary

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stabilizers of the subtalar joint[7,11-13]. However, clinical diagnosis of subtalar joint ligament injury is hindered by (1) a lack of agreement regarding the relative contributions of normal ankle and subtalar joints to overall hindfoot motion, and (2) design and methodology weaknesses and limitations of scope among the many laboratory studies in which the investigators measured motion of normal and soft-tissue-compromised subtalar joints[7,8,12,14-21].

To address the lack of coherence and the methodology limitations of previous laboratory studies, we employed precise measurement techniques to quantify subtalar joint motion in response to tightly controlled rotational and translational forces following systematic sectioning of its soft-tissue constraints. The motion-provoking challenges to which the joint was subjected approximated those applied in a manual clinical examination. We hypothesized that subtalar joint motion would not change after detachment of the inferior extensor retinaculum but would increase as each ligamentous structure was sectioned regardless of the release order.

## Materials and Methods

### *Specimen Preparation*

Sixteen fresh-frozen cadaver legs from 14 donors (mean age at time of death, 56 years; range, 39 to 68 years; 8 left and 8 right) were used. After thawing, the tibial shaft was embedded in a metal tube to facilitate attachment to the testing apparatus. The distal syndesmosis and interosseous membrane were left intact, and the fibular shaft was isolated from the embedding material. After insertion of screws into its plantar surface to enhance anchoring, the calcaneus was embedded in a metal cup with the ankle and subtalar joints in neutral positions and lightly compressed, the tibia vertical, and the cup's base perpendicular to the tibia. This established the reference position from which all ensuing measurements were made.

### *Load Application Apparatus*

Hindfoot motion was provoked with use of a device that applied controlled forces to the ankle and subtalar joints via cables, pulleys, levers, and weights (Fig. 1). The tibia was attached to a carriage incorporating linear and rotary bearings that allowed internal-external rotation and superior-inferior translation. The carriage could be pivoted and locked in the desired degree of foot flexion, and it incorporated a mechanism for selectively blocking tibial rotation. Tibial rotation

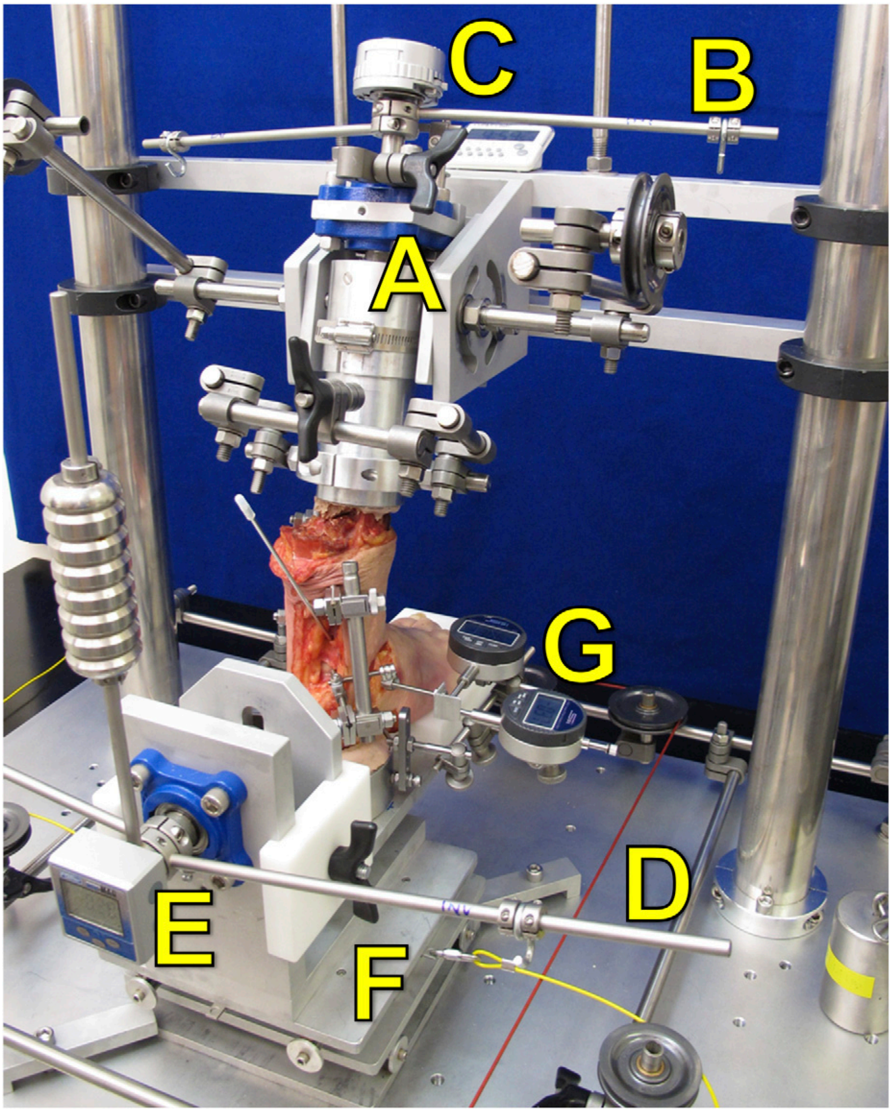

Fig. 1

Testing apparatus. A = carriage containing rotary and linear bearings allowing internal-external rotation and superior-inferior motion of the tibia, a mechanism for selectively locking rotation by adding a strut from a nonrotating portion of the carriage to the tibial tube and a means to set the desired foot dorsiflexion-plantar flexion; B = lever for application of internal-external rotation forces via a cable, a pulley, and hanging weights; C = digital internal-external rotation meter; D = lever for application of inversion-eversion forces via hanging weights; E = digital inversion-eversion meter and a device for locking neutral inversion-eversion (white blocks with black wing nut); F = X-Y translation platform; and G = digital medial-lateral and anterior-posterior displacement meters.

**TABLE I Ankle and Subtalar Joint Translation in Intact Specimens (N = 16)**

| | Anterior Drawer | | Posterior Drawer | | Medial Drawer | | Lateral Drawer | |
|---|---|---|---|---|---|---|---|---|
| Foot Position/Joint | Mean ± SD *(mm)* | % Attributable to Each Joint | Mean ± SD *(mm)* | % Attributable to Each Joint | Mean ± SD *(mm)* | % Attributable to Each Joint | Mean ± SD *(mm)* | % Attributable to Each Joint |
| 10° dorsiflexion | | | | | | | | |
| Subtalar | 1.2 ± 0.7 | 19 | 0.7 ± 0.3 | 30 | 1.0 ± 0.4 | 36 | 0.9 ± 0.3 | 38 |
| Ankle | 5.0 ± 2.7 | 81 | 1.6 ± 0.9 | 70 | 1.8 ± 0.8 | 64 | 1.5 ± 0.7 | 62 |
| Neutral | | | | | | | | |
| Subtalar | 1.3 ± 0.7 | 22 | 0.8 ± 0.3 | 33 | 1.5 ± 0.7 | 41 | 1.2 ± 0.4 | 39 |
| Ankle | 4.7 ± 2.9 | 78 | 1.6 ± 0.7 | 67 | 2.2 ± 1.1 | 59 | 1.9 ± 1.1 | 61 |
| 10° plantar flexion | | | | | | | | |
| Subtalar | 1.1 ± 0.6 | 23 | 0.8 ± 0.3 | 33 | 1.5 ± 0.7 | 39 | 1.1 ± 0.2 | 39 |
| Ankle | 3.6 ± 2.1 | 77 | 1.6 ± 0.6 | 67 | 2.3 ± 1.2 | 61 | 1.7 ± 0.6 | 61 |
| 20° plantar flexion | | | | | | | | |
| Subtalar | 0.8 ± 0.4 | 25 | 0.8 ± 0.2 | 26 | 1.4 ± 0.7 | 36 | 1.1 ± 0.3 | 39 |
| Ankle | 2.4 ± 1.5 | 75 | 2.3 ± 1.0 | 74 | 2.5 ± 1.6 | 64 | 1.7 ± 0.8 | 61 |

was measured by an angle meter with a resolution of 0.001°, derived from a digital protractor (model 54-440-750; Fred V. Fowler Company).

The calcaneus was attached to a cradle that could allow unconstrained subtalar joint inversion and eversion when desired or be locked in neutral inversion-eversion. The forefoot was elevated level with the heel, and the cradle's rotation axis was aligned with the center of the posterior margin of the subtalar joint, perpendicular to the coronal plane of the foot. A digital angle meter (model 54-422-450-1; Fred V. Fowler Company) displayed the inversion-eversion angle with a resolution of 0.05°. The cradle rested on a low-friction X-Y translation platform that permitted unrestricted transverse plane foot translation under the applied stresses and provided a means for applying precise drawer forces (Fig. 1).

Initially, the foot was positioned in neutral and the ankle was immobilized with bilateral uniplanar external fixation augmented by a threaded Steinmann pin crossing the joint. This ensured that subsequently measured calcaneal rotations and translations reflected subtalar joint motion only, rather than combined ankle and subtalar joint motion. A metal plate attached to the talus provided a point from which to measure calcaneal translation under drawer loads with use of digital displacement indicators (model 13-002-1; SPI), with a resolution of 0.01 mm, fastened to the calcaneal cup (Fig. 1).

The axial load applied during all measurements was the sum of the mass of the specimen superior to the subtalar joint plus the mass of the previously described carriage. This load, which averaged 36 N, maintained intimate subtalar articular surface contact and was deemed to approximate axial joint load during non-weight-bearing examination in the clinical setting[13].

## Application of Subtalar Joint Loads

*Internal and external rotation* of the calcaneus relative to the talus was recorded while torsional moments of 4 Nm were applied about the axis of the cylinder containing the tibia and fibula. Foot inversion-eversion was locked in neutral for these measurements, allowing isolation of the transverse plane rotational components of the subtalar joint's triplanar supination and pronation. The moments were achieved by attaching a weight and cable to a lever projecting from the shaft of the superior rotary bearing (Fig. 1). Zero degrees of rotation was defined as the subtalar joint rotational orientation occurring naturally from congruity of its articular surfaces under the 36-N axial load. The X-Y translation platform beneath the foot cradle allowed transverse plane translation of the calcaneus, ensuring that the subtalar joint's internal/external rotation axis was not constrained to that of the rotary bearing.

*Subtalar joint inversion and eversion* were measured under torsional moments of 4 Nm applied about an anterior-posterior axis traversing the center of the joint, produced by hanging weights directly on levers projecting horizontally from the rotary bearing shaft of the foot cradle (Fig. 1). Inversion and eversion were measured from the point at which the cradle was horizontal. The mass of the cradle and foot was counterbalanced by an opposing weight. Rotation of the cylinder in which the tibia was embedded was locked in neutral position during these measurements.

*Subtalar joint translation* was measured by applying a 67-N force sequentially to the calcaneus in the anterior, posterior, medial, and lateral directions using weights, pulleys, and cables attached to the X-Y translation platform (Fig. 1). This load was determined empirically to reproducibly translate the calcaneus to a discrete displacement end point in each direction as the restraining ligaments tensioned. Inversion-eversion and internal-external rotation of the foot were locked in neutral for these measurements.

## Evaluated Foot-Flexion Positions

Measurements were obtained from intact specimens with the foot in neutral position, and the entire measurement sequence was subsequently repeated with the foot in 10° of dorsiflexion, 10° of plantar flexion, and 20° of plantar flexion. These positions were achieved by removing the pin fixing the ankle joint, loosening the external fixation, and pivoting the carriage to which the tibia and fibula were mounted to the desired angle. The pivot mechanism was then locked, the external ankle fixation was tightened, and the pin was reinserted across the ankle.

## Contribution of Ankle Joint to Calcaneal Motion

To quantify the relative contributions of the subtalar joint and ankle joint to overall hindfoot motion, as a final step the entire measurement sequence was repeated with both the ankle joint fixation pin and external ankle fixation temporarily removed.

## Sequential Release of Inferior Extensor Retinaculum

After the intact specimens were tested, the effect of the integrity of the extensor retinaculum on subtalar joint stability was quantified. This and all subsequent tests were performed in each of the four foot-flexion increments described above, with the ankle joint fixed after foot positioning. The lateral, intermediate, and medial roots of the retinaculum were released in that order, and the entire sequence of subtalar joint motion measurements was performed after each sectioning increment.

## Sequential Transection of Primary Ligamentous Stabilizers

After the specimens were tested in their intact state and with the inferior retinaculum released, they were divided into two groups of eight. Each group underwent a different sequence of ligament sectioning to simulate several lateral ligament insufficiency scenarios. In Group 1 (mean age of donors, 52 years; 6 male and 2 female; 4 left and 4 right legs) the calcaneofibular ligament was

**TABLE II Ankle and Subtalar Joint Angulation in Intact Specimens (N = 16)**

| | Internal Rotation | | External Rotation | | Inversion | | Eversion | |
|---|---|---|---|---|---|---|---|---|
| Foot Position/Joint | Mean ± SD *(deg)* | % Attributable to Each Joint | Mean ± SD *(deg)* | % Attributable to Each Joint | Mean ± SD *(deg)* | % Attributable to Each Joint | Mean ± SD *(deg)* | % Attributable to Each Joint |
| 10° dorsiflexion | | | | | | | | |
| Subtalar | 4.9 ± 3.7 | 31 | 4.0 ± 1.2 | 30 | 3.8 ± 1.4 | 37 | 6.8 ± 3.5 | 48 |
| Ankle | 11.1 ± 6.2 | 69 | 9.4 ± 2.4 | 70 | 6.4 ± 2.2 | 63 | 7.4 ± 4.1 | 52 |
| Neutral | | | | | | | | |
| Subtalar | 5.1 ± 2.4 | 34 | 4.8 ± 1.1 | 32 | 7.2 ± 1.7 | 41 | 4.6 ± 3.3 | 43 |
| Ankle | 10.0 ± 4.8 | 66 | 10.0 ± 2.8 | 68 | 10.4 ± 3.1 | 59 | 6.1 ± 3.2 | 57 |
| 10° plantar flexion | | | | | | | | |
| Subtalar | 4.0 ± 1.3 | 32 | 4.5 ± 1.1 | 34 | 8.0 ± 2.2 | 38 | 4.3 ± 2.0 | 51 |
| Ankle | 8.5 ± 3.4 | 68 | 8.6 ± 2.9 | 66 | 13.1 ± 3.6 | 62 | 4.1 ± 1.8 | 49 |
| 20° plantar flexion | | | | | | | | |
| Subtalar | 3.9 ± 1.7 | 34 | 4.3 ± 1.6 | 35 | 10.8 ± 2.6 | 42 | 2.6 ± 1.4 | 46 |
| Ankle | 7.5 ± 3.0 | 66 | 7.9 ± 2.6 | 65 | 14.7 ± 3.4 | 58 | 3.1 ± 1.9 | 54 |

sectioned first, the cervical ligament second, and the interosseous talocalcaneal ligament last. The ligaments were accessed through a lateral approach, and sharp transection was used. In Group 2 (mean age, 60 years; 6 male and 2 female; 4 left and 4 right), the cervical ligament was sectioned first, the interosseous talocalcaneal ligament second, and the calcaneofibular ligament last. Internal-external rotation, inversion-eversion, and translation of the subtalar joint were measured in each foot flexion position as described above after each ligament was released.

### *Statistical Analysis*

Using results from all sixteen intact specimens, calcaneal motion with the ankle fixed was compared with calcaneal motion with both the ankle and the subtalar joint unconstrained to define the contribution of each joint to hindfoot motion. Repeated-measures analyses of variance (ANOVAs) were performed separately for Groups 1 and 2 to identify significant differences in subtalar joint stability among specimens with intact soft tissues, the three levels of compromise of the extensor retinaculum, and the ligament-deficient conditions. Post-hoc testing with Bonferroni correction for multiple comparisons was used, and $p = 0.05$ was the significance level.

The values below are presented as the averages for the specimens.

## Results

### *Relative Contributions of Intact Ankle and Subtalar Joints to Calcaneal Motion*

Depending on the foot flexion angle, the subtalar joint contributed 19% to 25% of calcaneal anterior drawer, 26% to 33% of posterior drawer, 36% to 41% of medial drawer, and 38% to 39% of lateral drawer (Table I). Also depending on the foot flexion angle, it accounted for 31% to 34% of calcaneal internal rotation, 30% to 35% of external rotation, 37% to 42% of inversion, and 43% to 51% of eversion (Table II).

### *Stabilizing Role of Inferior Extensor Retinaculum*

Sequential transection of the lateral, intermediate, and medial roots of the retinaculum did not significantly change any of the subtalar joint motion measurements in either experimental group. Complete retinaculum release resulted in drawer increases (compared with the intact condition) ranging (depending on the drawer direction and foot flexion angle) from 0 to 0.5 mm in Group 1 and 0 to 0.6 mm in Group 2 and increases in subtalar joint angulation ranging (depending on the angulation direction and foot flexion angle) from 0° to 2.3° in Group 1 and 0° to 0.8° in Group 2 (see Appendix).

### *Stabilizing Roles of Primary Ligamentous Constraints*

A significant interaction effect between the ligament condition and subtalar joint motion was found for inversion and external rotation in Group 1 ($p \leq 0.005$) and for inversion in Group 2 ($p \leq 0.005$). No other significant joint stability changes were identified. Consequently, although all measurements are shown in the Appendix, inversion and external rotation results are emphasized below.

#### Group 1

In Group 1 (ligament sectioning order: calcaneofibular, cervical, interosseous talocalcaneal), subtalar inversion increased significantly relative to the intact condition in all assessed foot flexion positions (Fig. 2 and Appendix). In 10° of dorsiflexion, an increase of 5.9 degrees occurred immediately on calcaneofibular ligament release ($p = 0.018$), also exceeding inversion measured after release of the retinaculum's lateral root ($p = 0.026$). Inversion after cervical and interosseous talocalcaneal ligament release did not significantly exceed that documented after calcaneofibular ligament release. Releasing all three ligaments resulted in 13.1° of inversion, an increase of 10.1° relative to the intact state, which also exceeded the inversion measured after partial or complete retinaculum detachment ($p = 0.001$).

In neutral foot flexion, inversion increased by 5.7° (relative to the measurement in the intact state) after the calcaneofibular and cervical ligaments were both transected ($p = 0.041$); there was no further increase after all three ligaments were released. After cervical ligament release, inversion surpassed that measured after detachment of the lateral ($p = 0.028$) and intermediate ($p = 0.023$) roots of the retinaculum.

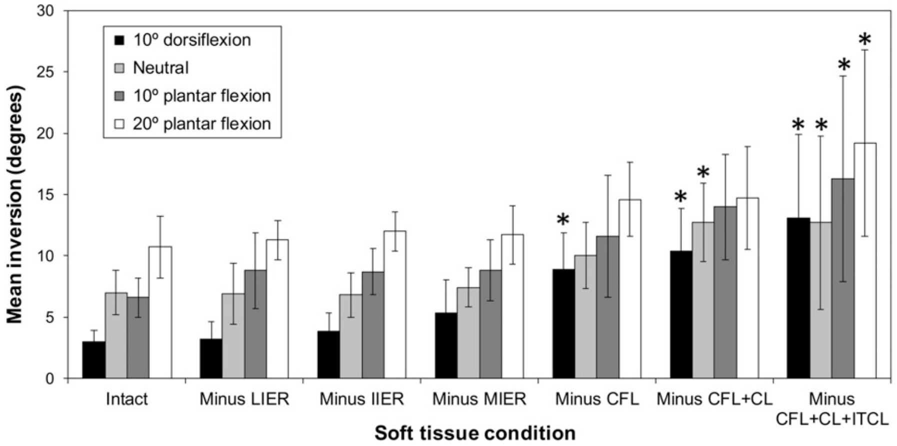

Fig. 2

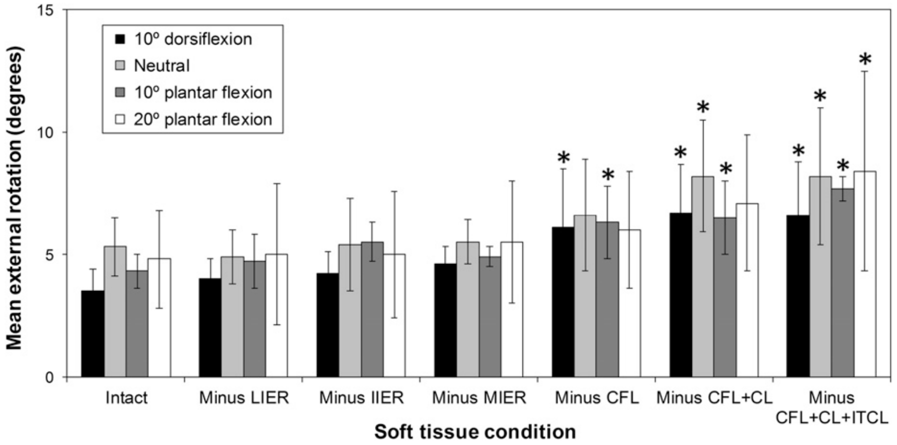

Fig. 3

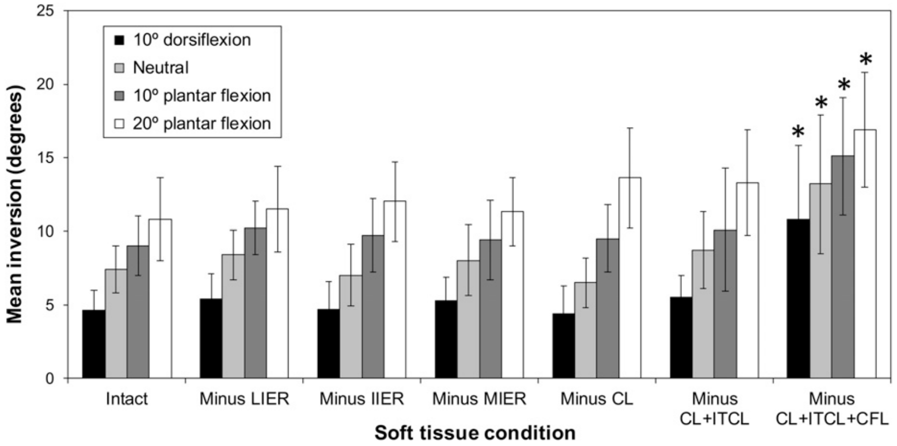

Fig. 4

**Figs. 2, 3, and 4** Subtalar joint inversion (**Fig. 2**) and external rotation (**Fig. 3**) in response to sequential soft-tissue release in Group 1 (ligament sectioning order: calcaneofibular [CFL], cervical [CL], interosseous talocalcaneal [ITCL]) and subtalar joint inversion in response to sequential soft-tissue release in Group 2 (ligament sectioning order: cervical, interosseous talocalcaneal, calcaneofibular) (**Fig. 4**). The I bars represent the standard deviation (SD). The asterisks indicate a significant increase in motion relative to one or more of the preceding soft-tissue conditions. LIER = lateral root of inferior extensor retinaculum, IIER = intermediate root of inferior extensor retinaculum, and MIER = medial root of inferior extensor retinaculum.

In 10° of plantar flexion, a significant inversion increase (9.7°, resulting in 16.3° of inversion) was documented only after release of all three ligaments (p = 0.009).

In 20° of plantar flexion, the first significant inversion increase (8.5°, resulting in 19.2° of inversion) also followed sectioning of all three ligaments (p = 0.001). This exceeded the inversion recorded in the intact state and after each increment of retinaculum release.

External rotation in 10° of dorsiflexion and 10° of plantar flexion increased significantly (p = 0.038 and p = 0.030, respectively) when the calcaneofibular ligament was transected, ultimately reaching 6.6° and 7.7°, respectively, after release of all three ligaments (Fig. 3 and Appendix).

### Group 2

In Group 2 (ligament sectioning order: cervical, interosseous talocalcaneal, and calcaneofibular), no significant inversion changes occurred until the calcaneofibular ligament was sectioned. After its release, inversion exceeded that measured in all preceding soft-tissue conditions with the foot dorsiflexed, in neutral, or plantar flexed 10° (p = 0.001 to 0.029). The increase ranged from 5.8° to 6.2° over intact-state values, depending on the foot flexion position, and was 4.5° to 5.3° greater than those in the preceding condition, in which the cervical and interosseous talocalcaneal ligaments were compromised (Fig. 4 and Appendix).

Unlike the specimens in Group 1, those in Group 2 did not exhibit a significant external rotation increase as soft-tissue sectioning progressed, despite an upward trend.

## Discussion

Clinical differentiation between ankle instability and subtalar joint instability is challenging for a number of reasons[10]. Both are typically the result of an acute inversion injury, they have similar symptoms, and the hindfoot motion perceived in a clinical examination is the sum of the motions occurring at both joints. Subtalar joint instability is particularly problematic because there is a lack of coherent information regarding the relative contributions of normal ankle and subtalar joints to hindfoot motion in response to stresses likely to be applied during diagnostic evaluations.

Normal subtalar joint motion and the contributions of soft-tissue constraints to subtalar stability have been investigated in numerous laboratory studies[7,8,12,14-21]. However, many of these studies have been poorly designed and controlled, and widely disparate and often suboptimal measurement methods have been employed. Furthermore, none examined the range of subtalar motions quantified in our study. Because of the large number of previous studies, an in-depth discussion of the contributions and limitations of each is beyond the scope of this report. Briefly, the most common flaws have been unknown, inadequate, or poorly controlled inversion and eversion moments and transverse plane rotational torques[7,8,12,14,19-21], reporting of range of motion rather than motion from a neutral position[7,12,19], lack of axial load to maintain joint congruity[7,8,12,14,16-21], artificial constraint of the fibula due to rigid fixation to the tibia[7,8,14,15,18], documentation of triaxial pronation and supination without isolation of their abduction-adduction and internal-external rotation components[12], inadequate control of dorsiflexion-plantar flexion[12,14,19,21], derangement of normal ligament tension and subtalar motion as a result of locking the ankle in neutral during subtalar motion measurements[7,8,18,20], and quantification of only one motion (typically inversion)[8,12,14,16,19].

While our study clearly demonstrated the importance of the calcaneofibular ligament in stabilizing the subtalar joint, the cervical ligament, interosseous talocalcaneal ligament, and inferior extensor retinaculum are certainly also stabilizers to a lesser degree. As can be seen most readily in Figures 2, 3, and 4, there generally were small increases in subtalar joint motion as each structure was successively compromised. Larger experimental group sizes might have resulted in identification of additional significant changes. The testing that was performed, however, entailed 3,584 individual motion measurements, making the number of additional measurements necessary to overcome the wide interindividual variability inherent in cadaver testing a daunting prospect. Furthermore, given the relatively small motion magnitudes documented in our study, any additional significant changes would likely be subtle and of limited clinical relevance.

It is improbable that human hands and eyes can detect 1° or 2° of difference in subtalar joint motion, let alone fractions of a degree or millimeter. To have enabled additional definitive conclusions regarding clinical relevance, our study would have had to have included many investigations outside of its current scope. These might include quantification of the average surgeon's ability to perceive small subtalar translation and angulation changes, determination of the magnitudes of motion corresponding to clinically noticeable instability, and whether that in turn corresponds to symptoms and decreased function.

We acknowledge a number of other study limitations. The subtalar joint loads applied were static and could not simulate the role of musculature as a dynamic stabilizer of the joint. We recognize that sharp transection of soft-tissue constraints may not accurately reproduce actual soft-tissue injuries, which can occur as a continuum rather than as abrupt failures of discrete structures. Also, while we preserved the distal syndesmosis and interosseous membrane and did not fix the fibula to the tibia in an effort to retain normal fibular mobility, fibular motion was unquantified and may not have been physiologic. Additionally, the measurements were intentionally performed with a modest axial load as a means of approximating a manual clinical examination, leaving effects under weight-bearing conditions unexplored. Despite the limitations, we believe that the study design is unprecedented in its elimination of subjective measurements and in its strict control of motion-provoking forces.

Because marked instability was documented only in inversion and external rotation after release of the calcaneofibular ligament, our results support the view that subtalar instability is primarily a rotatory problem[10,22] and may explain the inability of static two-dimensional radiographs to reliably indicate its existence[4,11,23]. However, the increase in inversion subsequent to calcaneofibular ligament disruption, on the order of 6° with the foot dorsiflexed, may be perceptible by an astute examiner during manual assessment. On the basis of our findings, we recommend assessing subtalar joint instability by holding the ankle in 10° of passive dorsiflexion (as was also suggested by Thermann et al.[24]) and, with one hand stabilizing the tibia, applying combined external rotation and varus stress to the calcaneus. If this maneuver indicates abnormal inversion, and the clinical scenario is compatible, a diagnosis of calcaneofibular ligament insufficiency should be considered. Attenuation of the calcaneofibular ligament can be verified by advanced imaging. In addition to directing diagnostic efforts toward determining the functionality of the calcaneofibular ligament in patients with suspected subtalar instability, our results suggest that, if calcaneofibular ligament insufficiency is established, its reconstruction or repair should be considered in preference to interosseous talocalcaneal or cervical ligament reconstruction. Moreover, there has been a trend toward repairing only the anterior talofibular ligament in patients with ankle instability[25-27], neglecting the important calcaneofibular ligament. Our results suggest that this approach may not be optimal.

## Appendix

eA Tables showing the effects of sequential soft-tissue sectioning on subtalar joint drawer and angulation measurements in Groups 1 and 2 are available with the online version of this article as a data supplement at jbjs.org. ■

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