Anatomy and Geometry of the Medial Interosseous Tarsometatarsal (Lisfranc) Ligament

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Statement of Purpose and Literature Review

Ligamentous injuries and articular fractures of the tarsometatarsal (Lisfranc) joint complex represent a relatively common lower extremity orthopedic trauma evaluated and treated by foot and ankle surgeons. However, subtle Lisfranc injuries, primarily those involving the medial interosseous tarsometatarsal ligament without associated fracture, often continue to represent a diagnostic challenge in the absence of advanced imaging [1-7]. These lower energy injuries are also more commonly treated with single percutaneous screw fixation across the Lisfranc ligament [1-7].

The objective of this investigation was to quantify the geometric anatomy of this ligament with the hopes of improving plain film radiographic diagnosis and surgical intervention technique.

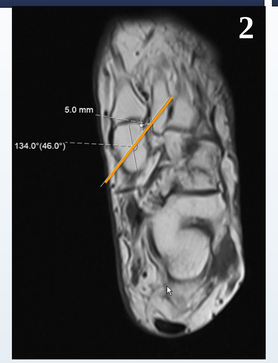
Methodology

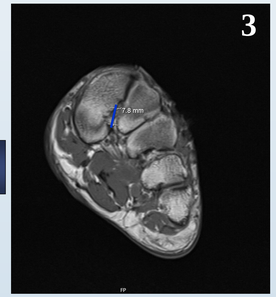
We evaluated a series of plain film radiographs, computed tomography (CT) images, and magnetic resonance image (MRI) images of the Lisfranc ligament in feet both with and without tarsometatarsal injury. We specifically measured the length/width of the ligament in the transverse plane, the height of the ligament in the frontal plane, and the angle of the ligament between the medial cuneiform and second metatarsal base in the transverse and frontal planes. We also measured diastasis between the medial cuneiform and second metatarsal base on all images, and correlated this measurement between imaging modalities. Descriptive statistics for each measurement are reported in terms of the mean ± standard deviation (range).

Results

First, from a transverse plane cut of CT (n=10) and MRI (n=10) scans of subjects without tarsometatarsal injury where the Lisfranc ligament was most visible, we measured the length (Figure 1 orange line defined as the oblique length between the center of the medial 2nd metatarsal base and the center of the distal lateral medial cuneiform) and width (Figure 1 blue line defined as the most distal and proximal tangential bisection of the ligament's midportion) of the Lisfranc ligament. **The length of the ligament in the transverse plane was 7.0 ± 0.45mm (6.3-7.8) and the width of the ligament was 4.4 ± 0.27mm (3.9-4.8) on CT scans, and 7.6 ± 0.27mm (7.2-8.1) and 4.8 ± 0.57mm (4.2-5.9) on MRIs.**

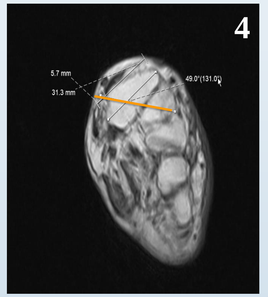
We then also attempted to determine an "ideal" anatomic angle for hardware insertion in the transverse plane. This was done by extending a line parallel to the midsubstance length of the ligament into the center of the 2nd metatarsal base and through the medial cuneiform (Figure 2 orange line). We measured the angle of this line relative to the long axis of the medial cuneiform, as well as where this line intersected the medial cortex of the medial cuneiform relative to its overall length. **From these measurements we calculated that the "ideal" starting location for a Lisfranc screw recreating the anatomy would be to start at 24.5% of the length of the medial cuneiform from the NC articulation and aimed 50 degrees distally to the long axis of the medial cuneiform.**





Second, from a coronal plane cut of CT (n=10) and MRI (n=10) scans of subjects without tarsometatarsal injury where the Lisfranc injury was most visible, we measured the height (Figure 3 blue line defined as the midsubstance height of the ligament's midportion) of the Lisfranc ligament. **The height of the ligament in the coronal plane was 7.5 ± 0.2mm (7.2-7.8) on CT scans, and 7.2 ± 0.9mm (5.0-7.9) on MRIs.**

We then also attempted to determine an "ideal" anatomic angle for hardware insertion in the coronal plane. This was done by extending a line created between the center of the Lisfranc ligament and the dorsal-lateral corner of the 2nd metatarsal base. This line was then extended medially out the medial cortex of the medial cuneiform. We measured the angle of this line relative to the long axis of the medial cuneiform, as well as where this line intersected the medial cortex of the medial cuneiform relative to its overall height. **From these measurements we calculated that the "ideal" starting location for a Lisfranc screw recreating the anatomy would start 17.1% up the height of the medial cuneiform from its inferior border and aimed 43.7 degrees superiorly.**



Finally, from a series of MRIs, CT scans and plain film radiographs of subjects both with and without tarsometatarsal injury we measured the amount of diastasis between the lateral aspect of the medial cuneiform and the medial aspect of the base of the 2nd metatarsal (Figures 5 and 6 yellow lines). **In normal feet without injury we found this distance to be 3.3 ± 0.97mm (0.8-5.3; 95% confidence interval 2.76-3.76mm), 5.0 ± 0.6mm (4.1-6; 95% confidence interval 4.56-5.48mm) and 4.53 ± 1.4mm (2.1-7.3; 95% confidence interval 3.45-5.62mm) on plain film radiographs, MRIs, and CTs, respectively. In feet with tarsometatarsal joint injury we found this distance to be 7.37 ± 3.49mm (5.3-14.4; 95% confidence interval 3.70-11.03mm) and 7.9 ± 3.0mm (4.5-13.1; 95% confidence interval 4.76-11.04).**

We further observed a Pearson correlation of -0.311 (p=0.415) between plain film radiographs and MRIs, and 0.807 (p<0.001) between plain film radiographs and CTs.

Discussion

As with any scientific investigation, critical readers are encouraged to review the study design and specific results in order to reach their own conclusions, while the following represents our conclusions based on the data. As scientists, we also never consider data to be definitive, but do think that these results are worthy of attention and future investigation:

The results of this investigation provide both normal and abnormal descriptive data of the anatomy and geometry of the Lisfranc ligament, as well as a quantitative measurement of the presence/absence of diastasis:

-First, the length/width/height descriptive statistics provided herein might be useful in determining an appropriate screw diameter for the most accurate anatomic recreation of the ligament. **The smallest mean measurement we observed was the width of the ligament in the transverse plane at 4.4mm, for example.**

-Second, we also observed that in order to most accurately anatomically recreate the geometry of the ligament, **one might consider starting a percutaneous screw at approximately 25% of the length of the medial cuneiform from the NC joint in the transverse plane and 17% up the height of the medial cuneiform from the most inferior border.** From this starting point, **the screw would theoretically be aimed 50 degrees distally in the transverse plane and 44 degrees superiorly in the frontal plane**.

-Third, we presented descriptive statistics of diastasis measurements in feet with and without tarsometatarsal injury **that might be useful in the development of an objective diagnostic criteria.** As one might expect, we also observed **high levels of correlation between plain film radiographs and CT scans with respect to diastasis**, but poor levels of correlation between plain film radiographs and MRIs with respect to diastasis.

It is our hope that the results of this investigation increase the body of knowledge with respect to injuries of the tarsometatarsal joint complex and lead to future avenues of investigation improving our profession's diagnosis and treatment of this anatomic area.

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