The Journal of Foot & Ankle Surgery 58 (2019) 93–96

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Reliability, Surgeon Preferences, and Eye-Tracking Assessment of the Stress Examination of the Tarsometatarsal (Lisfranc) Joint Complex

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ARTICLE INFO

Level of Clinical Evidence: 5

Keywords:
diagnostic testing
dynamic stress testing
ligament rupture
Lisfranc ligament
tarsal-metatarsal

ABSTRACT

The primary objective of this investigation was to determine the level of agreement and reliability of the stress examination of the Lisfranc tarsometatarsal joint complex. Secondary objectives were to determine surgeon preferences with respect to this testing and to use gaze recognition software to perform an eye-tracking assessment during the performance of the test. Twelve foot and ankle surgeons, 12 residents, and 12 students were shown 2 intraoperative fluoroscopic still images and 1 video of the stress examination of the tarsometatarsal joint complex using stress abduction of the forefoot on the rearfoot. Participants were asked to evaluate the result as being "positive" or "negative" for tarsometatarsal joint stability. The overall reliability of the interpretation of the stress examination was a kappa of 0.281 (surgeons 0.182; residents 0.423; students 0.256) indicating "fair" agreement. Survey results indicated wide variability in the perioperative preferences and protocols of surgeons dealing with the evaluation and treatment of the tarsometatarsal joint. Eye-tracking results also demonstrated variability in the anatomic structures of interest focused on during performance of this testing. The results of this investigation provide evidence of reliability well below what would be expected of a gold standard test during stress examination of the Lisfranc tarsometatarsal joint complex. These results indicate that future scientific endeavors are required to standardize the performance and interpretation of this testing.

In addition to plain film radiographic characteristics and advanced imaging, manual stress examination by means of stress abduction of the forefoot on the rearfoot is a widely accepted and commonly performed diagnostic tool to determine stability of the medial Lisfranc tarsometatarsal joint complex following acute injury and to evaluate the need for operative intervention (1–4). Despite this however, there are relatively few published data on the performance and interpretation of this test. This might introduce the possibility of unwanted subjectively and variability during the performance of a purportedly objective diagnostic test likely important in surgical and functional outcomes.

The primary objective of this investigation was therefore to determine the frequency of agreement and reliability of the stress examination of the medial Lisfranc tarsometatarsal joint complex. Secondary objectives were to determine surgeon preferences and protocols with respect to this testing and to use gaze recognition software to perform an eye-tracking assessment during performance of stress examinations.

Financial Disclosure: None reported.

Conflict of Interest: A.J.M serves as a *JFAS* section editor.

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1067-2516/$ - see front matter
https://doi.org/10.1053/j.jfas.2018.08.015

Patients and Methods

Following approval by our institutional review board, 12 foot and ankle surgeons, 12 podiatric residents, and 12 podiatric medical students consented to participate. Surgeons were recruited from the faculty of a regional continuing medical education meeting of a national foot and ankle surgical organization. All were board-certified and reported feeling comfortable with the evaluation and treatment of injuries to the tarsometatarsal joint. Residents were recruited from a local board examination review meeting hosted by the senior author (A.J.M.). All were senior-level residents from Council on Podiatric Education–approved programs with the added credential in rearfoot and ankle reconstructive surgery. Students were recruited from the Temple University School of Podiatric Medicine. All were fourth-year students following completion of their externships, the residency interview process, and Part 2 examination of the National Board of Podiatric Medical Examiners.

Participants were shown 3 intraoperative fluoroscopic images (2 still images and 1 video) of the stress examination of the medial Lisfranc tarsometatarsal joint from different feet. During this test, 1 examiner hand is held on the lateral rearfoot while the other hand pushed the forefoot in a lateral direction and looking for diastasis and incongruity across the tarsometatarsal joint complex. This included 2 still images and 1 video. No images had evidence of clear fracture/dislocation and no images contained surgical implants of any kind. Participants evaluated each image/video and reported whether they felt the test was "positive" (indicating the medial Lisfranc tarsometatarsal complex was unstable and they would perform stabilization) or "negative" (indicating medial Lisfranc tarsometatarsal complex was stable and they would not perform stabilization). No time limit was enforced on examination of the images and the videos could be rewatched multiple times if requested.

The primary outcome measure was considered the level of agreement between board-certified surgeons with respect to the interpretation of the stress examinations.

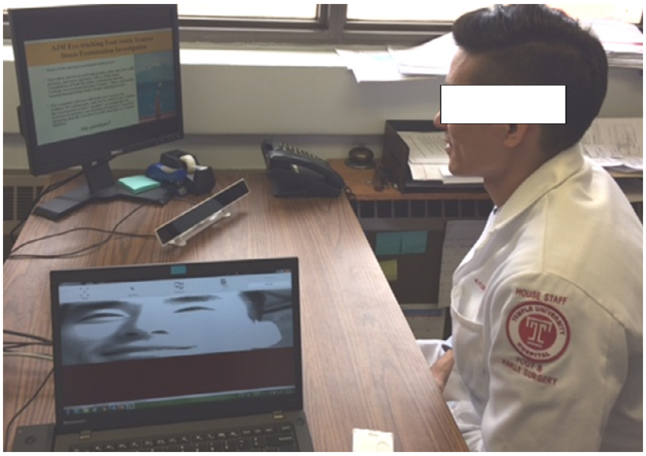

Fig. 1. Example of eye-tracking setup and calibration. Participants sat comfortably in a chair in front of a computer monitor. A separate monitor (which the participant could not visualize) was used to capture specific eye-tracking data. Following calibration, they were shown 2 still images and 1 video of the stress examination of the Lisfranc tarsometatarsal joint complex. Participants were asked to evaluate the images/videos as either “positive” or “negative” with respect to stability.

This was measured with a percent count; however, because there is a 50% likelihood that participants would agree on the interpretation simply as a result of chance within this design, reliability was also measured using Fleiss’ kappa. This is a measure of agreement between >2 raters when data are categorical; in this case, “positive” versus “negative.” An established value interpretation of the kappa statistic is as follows: kappas from 0.01 to 0.20 indicate “slight” agreement, from 0.21 to 0.40 indicate “fair” agreement, from 0.41 to 0.60 indicate “moderate” agreement, from 0.61 to 0.80 indicate “substantial” agreement, and from 0.81 to 1.00 indicate “almost perfect” agreement (5). Calculated kappa values <0.00 were considered 0.00.

Percent counts and kappa values were also calculated for residents, students, and the entire cohort; however these were considered secondary outcomes because the residents and students would be expected to have less clinical experience and expertise in the interpretation of these tests.

The surgeons additionally completed a survey following completion of their stress evaluations that attempted to elucidate their preferred perioperative testing protocols dealing with Lisfranc injuries. We also had the residents complete the survey but modified the questions to elucidate what they thought would be their preferences and protocols next year when in practice. We chose to not have the students complete the survey. It was our opinion that their level of clinical experience would not be to the point of perioperative preferences and protocols.

Further, eye-tracking and gaze recognition software (Gazepoint, Clemson, SC) was used to provide a subjective measure of what specific anatomy participants were looking at during performance of the stress examinations. A 2- computer monitor setup was used so that participants were unable to visualize their specific eye-tracking during performance of the testing (Fig. 1).

Data were stored in a password-protected personal computer for subsequent statistical analysis. All statistical analyses were performed using Statistical Analysis Systems software, version 9.2 (SAS Institute, Cary, NC), by the senior author (A.J.M.).

Results

Level of Agreement and Reliability

With respect to the first still image, 4 (33.3%) of the 12 surgeons, 1 (8.3%) of the 12 residents, and 3 (25.0%) of the 12 students considered it “positive” (Table). With respect to the second still image, 10 (83.3%) of

Fig. 2. Example of eye-tracking demonstrating a relatively distal focus. Although we observed that all participants primarily looked to the anatomy about the second metatarsal base during testing, some focused relatively distally. The green circles indicate where the subjects were looking, with larger circles indicating consistent focus and gaze.

the 12 surgeons, 7 (58.3%) of the 12 residents, and 11 (91.7%) of the 12 students considered it “positive.” With respect to the video, 10 (83.3%) of the 12 surgeons, 11 (91.7%) of the 12 residents, and 8 (66.7%) of the 12 students considered it “positive.” The overall reliability of the interpretation of the stress examination of the Lisfranc complex was a kappa of 0.281, indicating “fair” agreement (surgeons 0.182; residents 0.423; students 0.256).

Survey Results of Perioperative Protocols and Preferences

With respect to manual stress examinations, 12 (100.0%) of 12 surgeons and 8 (66.7%) of 12 residents reported performing the stress abduction test of the forefoot on the rearfoot as part of their protocol during testing for Lisfranc tarsometatarsal stability. Eight surgeons and 6 residents reported that this was their primary determinant of Lisfranc tarsometatarsal stability.

Nine (75.0%) of 12 surgeons and 9 (75.0%) of 12 residents reported using the mechanism of injury and preoperative radiographic characteristics as part of their protocol during testing for Lisfranc stability.

Table
Level of agreement of the stress examination of the medial Lisfranc tarsometatarsal joint complex

Frequency of Agreement With a “Positive” Result	Still Image 1, %	Still Image 2, %	Video 1, %	Reliability (Kappa Value)
Surgeons (n = 12)	33.3	83.3	83.3	0.182
Residents (n = 12)	8.3	58.3	91.7	0.423
Students (n = 12)	25.0	91.7	66.7	0.256
Total (n = 36)	22.2	77.8	80.6	0.281

Fig. 3. Example of eye-tracking demonstrating relatively proximal focus. Although we observed that all participants primarily looked to the anatomy about the second metatarsal base during testing, some focused relatively proximally.

Three surgeons and 6 residents reported that this was their primary determinant of Lisfranc stability.

With respect to testing interpretation, 10 (83.3%) of 12 surgeons and 11 (91.7%) of 12 residents reported looking to diastasis between the medial cuneiform and second metatarsal base during testing to assess for Lisfranc tarsometatarsal stability. Eight surgeons and 11 residents reported that they primarily looked to this area while making the determination of Lisfranc stability.

Five (41.7%) of 12 surgeons and 1 (8.3%) of 12 residents reported looking to instability and diastasis between the medial and intermediate cuneiforms during testing to assess for Lisfranc stability. One surgeon reported primarily looked to this area while making the determination of Lisfranc stability.

Five (41.7%) of 12 surgeons and 4 (33.3%) of 12 residents reported to additionally performing tarsometatarsal stability assessment in the frontal and/or sagittal planes.

Two (16.7%) of 12 surgeons reported looking to incongruity between the second metatarsal and intermediate cuneiform during testing, 1 (8.3%) of 12 residents reported looking to instability and diastasis between the first and second metatarsal bases during testing, and 3 (25.0%) of 12 surgeons further reported that they did not have a primary anatomic area that they looked to while determining Lisfranc stability.

Eye-Tracking and Gaze Recognition Results

We observed that all participants primarily looked to the anatomy about the second metatarsal base during testing. Although some participants focused somewhat relatively distally along the base of the metatarsal (Fig. 2) and some participants focused somewhat relatively proximally (Fig. 3), we observed that most participants focused along this entire anatomic area (Fig. 4).

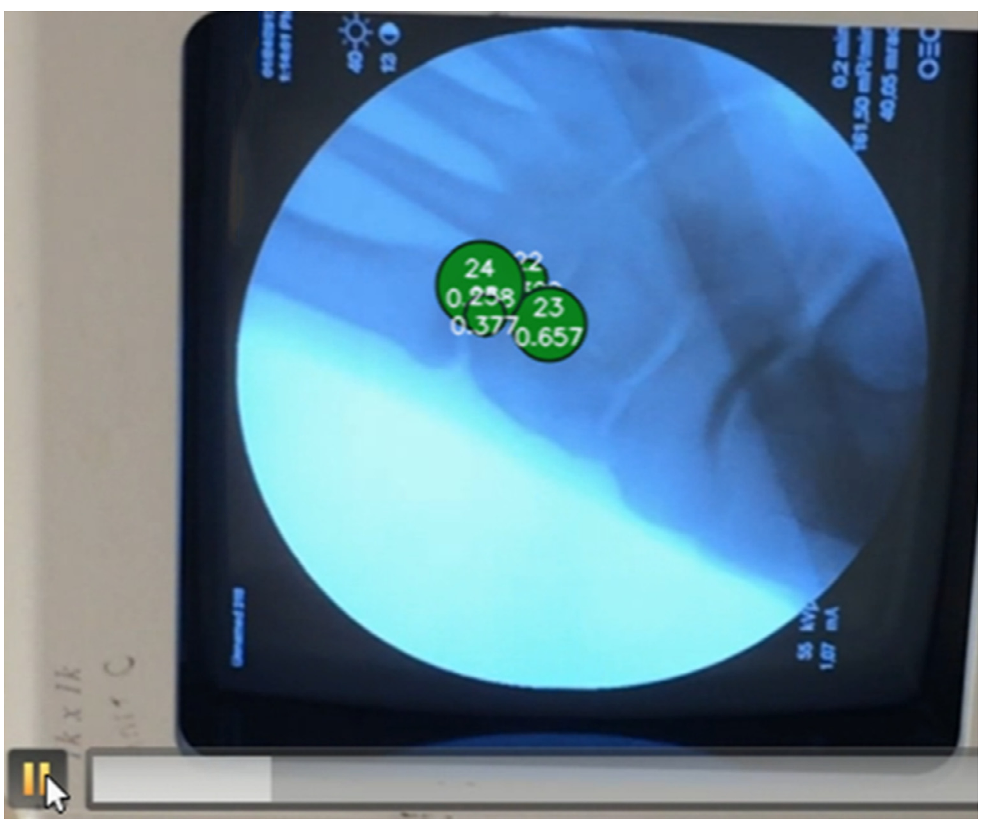

Fig. 4. Example of eye-tracking demonstrating an equal focus along the second metatarsal base. We observed that all participants primarily looked to the anatomy about the second metatarsal base during testing as demonstrated here.

Discussion

As with any scientific investigation, critical readers are encouraged to review and assess the study design and specific results to reach their own independent conclusions, whereas the following represents our conclusions based on the data. We also never consider data to be definitive, but do think there might be several findings worthy of clinical attention and future investigation. First, the observed levels of agreement were below what might be expected from a gold standard diagnostic test. The observed "fair" levels of agreement (as measured by the kappa coefficient) were not much better than what would be expected from agreement by chance. This indicates that the stress examination of the medial Lisfranc tarsometatarsal joint complex might benefit from the creation of an objective definition and standardized interpretation. The survey results and eye-tracking/gaze recognition patterns observed in this study might be useful as a starting point in defining just such an objectification.

Second, the results of the survey indicate variability in clinical practice and teaching with respect to the performance of these tests and perioperative protocols when dealing with the tarsometatarsal joint. Although it should certainly not be considered epidemiologic data representing contemporary clinical practice in the United States, it does at least show that a wide variety of perioperative preferences exist. The similar variability observed in residents about to enter clinical practice demonstrates that this might extend from training and not just clinical experience.

We also embrace that all investigations have limitations, and this had several important ones to consider. First, data were collected from a limited amount of subjects; therefore, these results may not be representative of a broader population sampling. Second, evaluating still images and intraoperative videos almost certainly does not recreate the intraoperative decision-making environment when surgeons typically have the ability to "feel" the performance of the tests. We are unable to infer how this might influence their results of interpretation of syndesmotic stability. And third, we did not evaluate every form of stress examination of the medial Lisfranc tarsometatarsal joint complex that surgeons might use in their practices. It is possible that other forms of assessment have different levels of agreement and reliability.

In conclusion, the results of this investigation provide evidence of reliability below what would be expected of a gold standard during stress examination of the medial Lisfranc tarsometatarsal joint complex. These results indicate that future research is required to standardize the performance and interpretation of this test. It is our hope that the survey questions and eye-tracking results might be used to do so.

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