Foot and Ankle Surgery xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

# Outcome after nonoperative treatment of stable Lisfranc injuries. A prospective cohort study

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ARTICLE INFO

*Article history:*
Received 22 February 2021
Received in revised form 15 March 2021
Accepted 23 March 2021
Available online xxx

*Keywords:*
Lisfranc injury
Tarsometatarsal joint injury
Midfoot injury
Stable
Nonoperative

ABSTRACT

*Background:* The aim of this study was to evaluate the outcome after nondisplaced and stable Lisfranc injuries.
*Methods:* 26 patients with injuries to the Lisfranc joint complex detected on CT scans, but without displacement were tested to be stable using a fluoroscopic stress test. The patients were immobilized in a non-weightbearing short leg cast for 6 weeks. The final follow-up was 55 (IQR 53–60) months after injury.
*Results:* All the Lisfranc injuries were confirmed to be stable on follow-up weightbearing radiographs at a minimum of 3 months after injury. Median American Foot and Ankle Society (AOFAS) midfoot score at 1-year follow-up was 89 (IQR 84–97) and at final follow-up 100 (IQR 90–100); The AOFAS score continued to improve after 1-year (P=.005). The median visual analog scale (VAS) for pain was 0 (IQR 0–0) at the final follow-up. One patient had radiological signs of osteoarthritis at 1-year follow-up.
*Conclusion:* Stable Lisfranc injuries treated nonoperatively had an excellent outcome in this study with a median follow-up of 55 months. The AOFAS score continued to improve after 1 year.


## 1. Introduction

The Lisfranc joint complex comprise of the tarsometatarsal, intercuneiform and naviculocuneiform joints with their associated ligaments [1,2]. Lisfranc injuries can vary from severe fracture-dislocations to stable nondisplaced injuries [3–8]. The incidence is previously reported to be 1/60 000 person-years, but recent studies report a higher incidence ranging from 9.2 to 14/100 000 person-years [8–10]. Up to 24% of Lisfranc injuries are missed on initial radiographs [8,11,12]. The increase in reported incidence seems to be related to an increased awareness of this entity, together with more advanced diagnostic tools such as CT scan, MRI, weightbearing radiographs and fluoroscopic stress test [7,8,10].

Operative treatment with anatomic reduction and stable fixation are the most important factors in achieving a favorable outcome in the unstable Lisfranc injuries [1,13–15]. A stable Lisfranc injury has been defined as an injury to the Lisfranc joint complex with displacement < 2 mm on weightbearing radiographs and/or no obvious displacement on stress fluoroscopy, when compared to the non-injured foot [3,7,8,16–18]. For stable Lisfranc injuries nonoperative treatment is recommended, although only few studies with small patient numbers exist [5,19,20]. Also, only one study verifies stability by obtaining follow-up weightbearing radiographs, and none have routinely obtained CT scans to rule out minor displacements [19,21].

The aim of the present study was to evaluate the outcome after nonoperative treatment of stable Lisfranc injuries.

## 2. Materials and methods

A prospective cohort study including stable Lisfranc injuries was conducted at Oslo University Hospital (a level one trauma center) and Oslo Accident and Emergency Department. The patients in the present study were also included in a previously published study reporting on incidence, mechanism of injury and predictors of instability [8]. The study was approved by The Regional Committee for Medical and Health Research (2014/849/REK) and approved by the data protection officer at the university hospital. An informed consent form was signed by the patients prior to enrollment. Patients presenting with an isolated stable Lisfranc injury between September 1, 2014 and August 31, 2015 were invited to participate.

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https://doi.org/10.1016/j.fas.2021.03.017

An acute, stable Lisfranc injury was defined as acute trauma (Lisfranc injury diagnosed within 4 weeks) presenting with midfoot pain on weightbearing and manipulation of the midfoot. In addition, radiographs verified injury to the tarsometatarsal joint line with intraarticular or avulsion fractures, but no displacement of ≥2 mm on radiographs or CT scans or obvious displacement on stress test under fluoroscopy (Fig. 1).

Exclusion criteria were unstable Lisfranc injuries, concomitant lower extremity injuries, Charcot arthropathy, isolated fifth metatarsal fracture, non-compliant patient and patient not available for follow-up.

Patient characteristics and mechanism of injury were registered at enrollment. Injured feet were tested for occult instability by a stress test under fluoroscopy [22,23]. As this test was performed 7–14 days after injury, anesthesia was unnecessary in most patients. If needed, the foot was tested under general anesthesia. The stress test was positive if joint displacement was detected, and the opposite non-injured foot was tested for comparison.

The patients were treated with immobilization in a non-weightbearing short leg cast for 6 weeks. If no pain on weightbearing at 6 weeks they started full weightbearing in normal shoes, whereas if pain was present they were offered a Walker boot with full weightbearing for the next 4 weeks.

Weightbearing AP, oblique and lateral radiographs of both the injured and non-injured feet were obtained at 6 weeks, 3 months and 12 months follow-up. 4–5 years after injury the patients were interviewed by phone and invited to a final follow-up.

Radiographs and CT scans were evaluated using Syngo Studio VB36E (Siemens Healthcare GmbH, Erlangen, Germany). Two orthopaedic surgeons specialized in foot and ankle surgery and one musculoskeletal radiology consultant evaluated the images.

Injuries to the tarsometatarsal joints were categorized as avulsion fractures or intraarticular fractures and located to the medial, middle and lateral column according to the columnar theory as described by Chiodo and Myerson, and later revised by Schepers and Rammelt [16,24].

The primary outcome measure was the American Orthopaedic Foot and Ankle Society midfoot score (AOFAS score), consisting of three main components (pain, function, and alignment), ranging from 0 to 100 with best score being 100 [25]. Secondary outcome measures were the 36-Item Short Form Health Survey (SF-36) and the visual analog scale for pain (VAS pain) at rest and during walking.

Patients not able to attend final follow-up were interviewed by phone and the AOFAS score, Numeric rating scale (NRS) for pain at rest and during walking, as well as return to activities were addressed. With regards to gait abnormality and alignment parts of the AOFAS score, the patients interviewed by phone were asked about any gait abnormality or if the alignment of their foot had changed (compared to the non-injured foot). The NRS pain has been shown to highly correlate to the VAS pain [26].

Secondary displacement and signs of posttraumatic osteoarthritis (OA) were evaluated on the radiographs obtained at the follow-ups. Radiographs were not routinely obtained at the final follow-up.

## 3. Statistics

Statistical analyses were conducted using SPSS version 26 (SPSS Inc, IBM, Chicago, IL). Data were tested for nor mality and normally distributed data are presented with a mean value and standard deviation (SD). The one sample t-test was used for statistical analysis. Non-parametric data are presented with median values and the interquartile range (IQR) and the Wilcoxon signed rank test was used for statistical analysis. The significance level was set to $P < 05$.

**Fig. 1.** (a, b, c) 36 years old male who fell during jogging, was unable to weightbear on his forefoot and had midfoot pain and plantar ecchymosis. A CT scan revealed a nondisplaced intraarticular fracture at the base of the 2nd metatarsal (a and b). A dorsolateral avulsion fracture of the third cuneiform and extraarticular non-displaced fractures of the proximal third and fourth metatarsal was present (not shown). The foot was stable when stress tested under fluoroscopy. No displacements were detected on weightbearing radiographs of both feet at the 3-month follow-up (c).

When examining the change in AOFAS score over time, a one-sample T-test was conducted to determine whether the average slope (change in AOFAS score per one-month time unit) was different from zero (no change). To be able to evaluate change in

AOFAS score over the whole study period, only patients who had AOFAS score measured at 3 and/or 12 months and at the final follow-up were included. The slope was computed between either "final follow-up – 3 months", or "final follow-up – 1 year", depending on what data was available for each subject and then divided by the number of months occurring between these two measurements.

## 4. Results

Eighty-nine Lisfranc injuries were registered during the one year inclusion period, 48 of these injuries were stable. Sixteen patients did not meet the inclusion criteria due to other lower extremity injuries ($n = 11$), presentation later than 4 weeks after injury ($n = 2$), residency outside Norway ($n = 3$). Six patients did not want to participate in the study. Twenty-six patients with isolated stable Lisfranc injuries were included. Patient characteristics at enrollment and mechanisms of injury are presented in Tables 1a and 1b. A plantar ecchymosis was registered in 20/26 patients.

Twenty-three of the patients had initial non-weightbearing radiographs and nine of these radiographs were evaluated as normal. CT scans were obtained of all injured feet prior to inclusion, all of which showed avulsion fractures or intraarticular fractures in the TMT joint line, indicating a Lisfranc injury. No displacement of 2 mm or more were detected in any joints of the Lisfranc joint complex. Radiological findings are presented in Table 2.

A stress test under fluoroscopy was performed in 25 of the 26 patients at median 10 (IQR 8–14) days after injury, to evaluate stability. All stress tests were negative. One patient did not have a stress test (an 80-years old female). On the follow-up weightbearing radiographs, none of the patients had any subsequent displacement in the Lisfranc joint complex. When comparing the injured foot to the non-injured foot, none of the 26 patients had a difference of ≥2 mm or more in the C1-M2 interval or the M1-M2 interval on the follow-up weightbearing radiographs at 6, 12 and 52 weeks. Only one patient had radiological signs of degenerative joint disease at the 1-year follow-up, the joint degeneration was located to the TMT-1 joint where the patient had an intraarticular fracture on presentation. The patient presented no symptoms from the injured foot at the final follow-up.

The AOFAS score, VAS pain scores and SF-36 are listed in Tables 3 and 4.

14/26 patients attended the final follow-up, eight patients were interviewed by phone and four patients were lost to follow-up. Median follow-up time was 55 (IQR 53–60) months. Of the eight patients interviewed by phone, seven patients reported no pain or discomfort from their injured foot. One patient reported mild pain at rest (NRS 1/10) and during walking (NRS 1/10). None of the patients interviewed by phone on the final follow-up reported limitations during activities, walking distance, footwear or walking surface. No patients reported any gait abnormality or were able to detect any change in appearance or alignment of their injured foot compared to the non-injured foot.

Twenty patients had at least one earlier AOFAS score in addition to the AOFAS score at the final follow-up. The scores from these patients were used to calculate the slopes of the AOFAS score over time. The slopes were normally distributed as assessed by Shapiro-Wilk's test of normality ($p = 0.228$). Mean slope (0.24, SD = 0.17) was statistically different from zero, $t(19) = 6.57$, $p < .001$, indicating a positive change in AOFAS score over time. With regard to the time period from 1 year after injury until the final follow-up (median 55

**Table 1a**
Patient characteristics at time of inclusion.

| Patient characteristics | |
|---|---|
| Number of patients | 26 |
| Gender (Male/Female) | 15/11 |
| Side (Right/Left) | 14/12 |
| Age (mean, SD) | 40.0 (15.7) |
| Time injury-diagnosis in days (mean, SD) | 2.2 (5.7) |
| Plantar ecchymosis | 20 |

**Table 1b**
Mechanisms of injury.

| Mechanism of injury | |
|---|---|
| Fall from own height/twisting injury of foot | 7 |
| Fall down stairs | 1 |
| Bike accident | 2 |
| Kicked into an object | 1 |
| Sports related injury | 4 |
| Motor vehicle accident | 2 |
| Fall > 3 meters | 2 |
| Crush injury | 7 |

**Table 2**
None of the patients had isolated lateral column injuries.

| Radiological findings | |
|---|---|
| Initial non-WB radiographs (pos/neg)[a] | 14/9 |
| Positive CT scans[b] | 26 |
| Medial column | |
| Negative | 8 |
| Avulsion fx | 10 |
| Intraarticular fx | 8 |
| Middle column | |
| Negative | 5 |
| Avulsion fx | 5 |
| Intraarticular fx | 13 |
| Lateral column | |
| Negative | 15 |
| Avulsion fx | 1 |
| Intraarticular fx | 7 |

WB = weightbearing. Fx = fracture.
[a] Positive = Fractures detected on initial non-weightbearing radiographs.
[b] Intraarticular fractures or avulsion fractures TMT joints.

**Table 3**
American Foot and Ankle Society (AOFAS) midfoot score and the visual analog scale for pain. (VAS pain). The median and interquartile range (IQR) are reported.

| | 3 months (19 patients) | 1 year (20 patients) | Final FU[a](22 patients [b]) |
|---|---|---|---|
| AOFAS midfoot score | 85 (77–87) | 89 (84–97) | 100 (90–100) |
| VAS pain score | | | |
| At rest | 0 (0–2) | 0 (0–1.1) | 0 (0–0) |
| During walking | 3 (2–5) | 0.5 (0–2.4) | 0 (0–0) |

[a] Final follow-up (FU) = Median 55 (IQR 53–60) months.
[b] 8 of the 22 patients were interview by phone.

**Table 4**
36-Item Short Form Health Survey (SF-36) score at 1 year. The median and interquartile range (IQR) are reported.

| SF-36 | 1 year (20 patients) |
|---|---|
| Physical function | 95 (86.3–100) |
| Role physical | 100 (75–100) |
| Bodily pain | 78.8 (60–90) |
| General health | 70 (57.5–80) |
| Vitality | 65 (47.5–70) |
| Social function | 100 (78.1–100) |
| Role emotional | 100 (41.7–100) |
| Mental health | 80 (66–88) |
| Physical component summary (PCS) | 51.8 (46–54.6) |
| Mental component summary (MCS) | 52.9 (40.9–58.4) |

months), there was also an improvement of the AOFAS score (median 89 vs 100, $P = .005$) indicating a positive change in the AOFAS score between 1 year and final follow-up.

None of the patients reported work-related limitations due to their Lisfranc injury at final follow-up, but 2/22 patients reported some limitations in recreational sports activities (skateboarding and skiing). None of the patients had undergone any surgeries to their foot at final follow-up.

## 5. Discussion

The outcome of nonoperatively treated stable Lisfranc injuries in 26 patients are presented in this study. All injuries had CT verified avulsion fractures or intraarticular fracture in the tarsometatarsal joint line. The stability was verified using fluoroscopic stress test and follow-up weightbearing radiographs at a minimum of 3 months after injury. The outcome after a median follow-up time of 55 (IQR 53–60) months was excellent with a median AOFAS midfoot score of 100 (IQR 90–100), improving from 89 (IQR 84–97) at 1 year ($P = .005$). Osteoarthritis does not seem to be frequent after a stable Lisfranc injury as degenerative joint disease was only detected radiologically at 1-year in one patient. Only 2/22 patients reported limitations in recreational sports activity caused by their Lisfranc injury at the final follow-up. Stable Lisfranc injuries are easily overlooked as 9/23 injuries were not detected on initial non-weightbearing radiographs.

Most previous papers on Lisfranc injuries focus on the unstable fracture-dislocations and only few report on the stable and nondisplaced Lisfranc injuries [3,5,19,20]. Stable injuries are best treated nonoperatively, while the unstable injuries should be treated operatively [5,7,16,27–29]. One of the most challenging issues concerning Lisfranc injuries is to adequately evaluate stability of the nondisplaced Lisfranc injuries and thereby properly select the right patients for nonoperative treatment. Minor displacements of the TMT joints indicating instability are best evaluated using CT scans as they are often missed on radiographs [21]. To detect occult instability in the nondisplaced Lisfranc injuries, the feet can be examined using either weightbearing radiographs or a fluoroscopic stress test [5,17,22,23,27,30,31]. MRI has also been shown to have a high accuracy in detecting instability in ligamentous Lisfranc injuries [18,32]. When evaluating both weightbearing radiographs and fluoroscopic stress tests the injured foot should be compared to the non-injured foot, as the M1-M2 and C1-M2 distances show variance between individuals and also between the non-weightbearing and weightbearing state [2,5,7,18,27,29]. The fluoroscopic stress test has been criticized for lack of reliability in detecting unstable Lisfranc injuries, even though it is reported to be more sensitive compared to weightbearing radiographs in cadaver studies [22,23,33,34].

In a study by Chen et al. on minimally displaced Lisfranc injuries evaluated by weightbearing radiographs at presentation, 14/26 patients showed subsequent displacement at follow-up, where 9/14 were detected within 14 days [19]. Preidler et al. showed that obtaining weightbearing radiographs on the day of injury did not add any information to non-weightbearing radiographs [35]. This emphasizes that the assessment of stability in these nondisplaced injuries is difficult, especially during the first days after injury. Hence, testing the stability of the midfoot should be postponed until 7–14 days, when pain is reduced [8,16,19,27]. The patients should also be reassessed with weightbearing radiographs at follow-ups to detect any subsequent displacement [19,27]. In the present study, the Lisfranc injuries were tested for instability using a fluoroscopic stress test at a median of 10 (IQR 8, 14) days. Weightbearing radiographs were obtained at 6 and 12 weeks and 1 year. None of the injured feet showed any subsequent displacement.

Although the stable Lisfranc injuries are uniformly recommended nonoperative treatment, only few authors have reported on the outcome of nondisplaced Lisfranc injuries after evaluating the stability using weightbearing radiographs or fluoroscopic stress tests [3,5,19,20]. Nunley et al. reported excellent outcome after Lisfranc injuries that were tested to be stable using weightbearing radiographs [5]. In their study only one of the seven patients with a stable Lisfranc injury presented within the first 4 weeks, in contrast to the present study, where all patients presented within the first 4 weeks.

Chen et al. reported on 12/26 patients with a stable Lisfranc injury treated nonoperatively.[3] The patient reported AOFAS score at mean follow-up of 54 months was 78.0 (95% CI, 68.6–87.4) and Manchester-Oxford Foot Questionnaire (MOXFQ) 24.8 (95% CI, 11.1–38.5). The AOFAS score was poorer than the excellent results we present at a median of 55 months, median 100 (IQR 90–100). This may be explained by a difference in the nature of the Lisfranc injuries included in the two studies. In Chen's study, the inclusion criteria were less than 2 mm diastasis between the bases of the first and second metatarsal (M1-M2) and no displacement in the third, fourth and fifth tarsometatarsal joint. Thus, an increased diastasis between the medial cuneiform and the base of the second metatarsal (C1-M2) in addition to displacement of the first and second tarsometatarsal joint could be present. In our study only injuries with less than 2 mm difference in the C1-M2 interval and the M1-M2 interval, and no displacement in any tarsometatarsal joints were included. All the injured feet in our study were also initially evaluated by CT scans. Injuries with displacements of 2 mm or more were considered unstable and thereby excluded from the study. In the study by Chen et al. multiplanar imagining was not routinely obtained, but left to the discretion of the treating surgeon [19].

Crates et al. reported the outcomes of 36 patients with subtle Lisfranc injuries, including patients with 2 mm or less diastasis in the M1-M2 interval on weightbearing radiographs. 16/36 patients were treated successfully nonoperatively, while 20 patients failed nonoperative treatment. Failed nonoperative treatment were based on judgement by the senior author, and neither timing of initial weightbearing radiographs, nor the time from injury to failed nonoperative treatment or the use of weightbearing radiographs on follow-up were specified [20]. Furthermore, the injuries in that study were not evaluated by CT scans to detect minor displacements, indicating unstable injuries. These factors and the poor AOFAS score in the group who failed nonoperative treatment (mean AOFAS score of 63.5) compared to the group with successful nonoperative treatment (mean AOFAS score = 90.2, calculated from the subgroups reported) suggest that the injuries failing nonoperative treatment were in fact unstable injuries.

The AOFAS score in the present study continued to improve even after 1 year (median 89 versus 100, P= .005), implying that the rehabilitation period can be prolonged over years.

The VAS pain score at rest and during walking at final follow-up were both 0 (IQR: 0–0), corresponding well with an excellent outcome. Also, the median SF-36 physical component summary score (PCS 51.8) and mental component summary score (MCS 52.9) at the 1-year follow-up were equivalent to the scores of the general population (40–49 years old, PCS mean 50.8 (SD 9.1) and MCS mean 52.6 (SD 9.1)) indicating return to the same quality of life as the Norwegian general population [36]. Only 2/22 patients reported limitations in recreational sports activities (skiing and skateboarding) at final follow-up. We have not encountered any other study reporting VAS pain score or SF-36 after stable Lisfranc injuries.

A high incidence of radiographic post traumatic OA is reported in patients treated for unstable Lisfranc injuries [14,37–40]. The frequency of post traumatic OA after stable Lisfranc injuries is largely unknown. Chen et al. reported on 12 stable Lisfranc injuries treated conservatively with a follow-up of 54 months and follow-up radiographs at minimum 24 weeks; None of the stable injuries showed signs of degenerative joint disease [19]. In the present study only one patient had radiological signs of posttraumatic OA at 1 year and no patients had clinical signs of OA at 5 years.

The present study has some strengths, firstly the prospective design with a median follow-up of 55 months. All but one patient were tested for stability and all patients had weightbearing radiographs obtained at a minimum of 3 months. The injuries were all assessed using CT scans to verify injury to the Lisfranc joint complex (fractures, including avulsion fractures) and rule out any subtle displacements often not detected on conventional radiographs [41]. All patients followed the same nonoperative treatment protocol. Although the study included only 26 patients, it is to our knowledge the largest study on stable Lisfranc injuries treated nonoperatively throughout the entire study period.

The study also contains some inherent weaknesses. Only 14 patients were available for the final follow-up visit, the further 8 patients were interviewed by phone and 4 patients were lost to follow-up. As 8 patients were interviewed by phone at the final follow-up, any gait abnormality or malalignment not detected by the patients themselves might have been missed, even though this was not detected in these patients on previous follow-ups. The patients did not routinely have radiographs obtained at final follow-up and any radiological OA without clinical manifestation at that point was thereby not detected. The AOFAS midfoot scale has been shown to have a ceiling effect and therefore a limited ability to differentiate between patients with high outcome scores [42]. We used fluoroscopic stress test for the initial evaluation of stability of non-displaced Lisfranc injuries and weightbearing radiographs at follow-ups. In the future, weightbearing CT scans might be an even more precise method to detect any occult instability [43].

## 6. Conclusion

Stable Lisfranc injuries treated nonoperatively had an excellent outcome 55 months after injury in this prospective cohort study. The AOFAS midfoot score continued to improve even after 1 year. Assessment of stability in Lisfranc injuries should preferably be done 7–14 days after the injury. None of the patients had clinical symptoms of posttraumatic osteoarthritis at the final follow-up, one patient had radiologically detected degenerative joint disease at the 1-year follow-up.

## Conflict of interest

None

## Acknowledgements

We would like to thank Maiju Pesonen for statistical support. This study has not received any funding.

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