

Clinical Outcomes and Development of Symptomatic Osteoarthritis Two to Twenty-Four Years After Surgery for Tarsometatarsal Joint Complex Injuries

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1 **Clinical Outcomes and Development of Symptomatic Osteoarthritis Two to Twenty-**
2 **Four Years After Surgery for Tarsometatarsal Joint Complex Injuries**

3 **Abstract**

4 **Background:**

5 Lisfranc injuries have been reported to result in osteoarthritis (OA) following surgical
6 treatment. Good outcomes in short- and medium-term results have been reported. However,
7 long-term results are limited, specifically clinical outcome and development of symptomatic
8 OA. The objectives of this study were to assess (1) clinical outcomes, (2) incidence of
9 symptomatic OA, and (3) risk factors for OA two to twenty-four years after Lisfranc joint
10 injuries treated surgically either with open reduction internal fixation (ORIF) or primary
11 arthrodesis.

12 **Methods:**

13 This was a retrospective study concerning 128 patients surgically treated at our institution
14 between 1988 and 2009 for a tarsometatarsal (TMT) joint injury. Surgery was either ORIF
15 with transarticular screws or primary fusion when joint comminution at the TMT line was
16 such that ORIF was not possible. Functional outcomes were assessed with the American
17 Orthopaedic Foot and Ankle Society (AOFAS) score, Foot Function Index (FFI), and VAS
18 pain score. Global health was evaluated with the SF-12 Health Survey physical component
19 score (SF-12 pcs).

20 **Results:**

21 Sixty-one patients were available for a clinical, questionnaire and radiological evaluation at a
22 mean of 10.9 years (range, two to twenty-four years) postoperative. The mean scores were:
23 AOFAS 79, FFI 16.9, and VAS pain 2.5. Radiographic OA was noted in 44 patients (72.1%),
24 and symptomatic OA in 54%, the latter having worse outcomes. Risk factors for OA were
25 non-anatomic reduction, fracture classification of Myerson type C, and a history of smoking.

26 **Conclusions:**

27 Two to twenty-four years following Lisfranc injury operative treatment restoring and
28 maintaining joint anatomy results in satisfactory clinical outcome scores, and a large number
29 of patients return to their previous level of functioning and employment, with little need for
30 secondary procedures. However, there is substantial posttraumatic OA on radiographs, albeit
31 less symptomatic OA.

32 **Level of Evidence:** Diagnostic Level 4

Introduction

Treatment of injuries to the tarsometatarsal (TMT) joint complex, called Lisfranc injuries, has evolved from closed reduction and cast immobilization with or without percutaneous Kirschner wires^{1, 2} to anatomic open reduction internal fixation (ORIF) with transarticular screws^{3, 4} and recently bridge plate joint sparing techniques⁵⁻⁸. Additionally there are proponents of primary arthrodesis for more severe injuries with extensive bony comminution or those purely ligamentous^{9, 10} (CME 1). A recent systematic analysis revealed that stable anatomic reduction and alignment offers the best opportunity for satisfactory outcome¹¹. Good outcomes in short- to mid-term results have been reported^{4, 9-12}. However, long-term results are limited, specifically relating to clinical outcome and presence of symptomatic osteoarthritis (OA). The objectives of our study were to assess (1) clinical outcomes, (2) incidence of symptomatic OA, and (3) risk factors for symptomatic OA at two to twenty-four years after Lisfranc joint injuries treated surgically either with ORIF and transarticular screws or primary arthrodesis. To the best of our knowledge this comprises the largest group of patients with the longest follow-up.

Materials and Methods

We performed a retrospective study of all patients with a TMT joint injury surgically treated at our institution between 1988 and 2009. Patients were identified from the hospital database. During this time a consistent protocol was used, with the indication for surgery based on clinical evaluation and radiological signs of instability, and/or in cases of displacement of at least one millimeter on radiological studies. The surgical plan in all patients was anatomic reduction and stable fixation with screws for TMT joints I-III, and Kirschner wires (K-wires) for joints IV and V. During the period of study we didn't change our operative technique. Primary fusion was based on surgeon decision where TMT joint comminution was such that

ORIF was not possible. This was performed for TMT joints I-III; for cuboid-MT joints IV and V primary fusion was not performed. Postoperatively, patients were placed in a below-knee cast with limited weight-bearing (10 kg.) for eight weeks. Following cast removal patients began progressive weight-bearing to achieve full weight-bearing after three months. Following ORIF, implants were removed four months postoperatively. This was a general protocol followed with clinical decision-making.

Outcomes of interest were: (1) Clinical scores evaluating pain, function, and general health; (2) Incidence of symptomatic OA; and (3) Risk factors for symptomatic OA. Information on the following variables was collected from medical records, operative reports and radiographs: age, gender, body mass index (BMI), injury mechanism, fracture type,, fixation method, anatomic reduction, and any additional procedure except routine hardware removal. Data was also collected about presence or absence of polytrauma, defined as concomitant musculoskeletal and/or other system injury (e.g. pulmonary, abdominal, head, etc.) . Smoking information (never-smoker vs. ever-smoker) was obtained at follow-up visit. Preoperative radiographs, and computed tomography (CT) scans when available, were reviewed to classify the type of Lisfranc injury according to Myerson et al². Post-operative radiographs were analyzed for quality of reduction according to following radiological parameters¹³: On the anteroposterior (AP) view whether the medial border of the second metatarsal (MT) was in line with the medial border of the middle cuneiform; **on the oblique view** whether the medial border of the fourth MT and the medial border of the cuboid were aligned; **and on the lateral view** whether the dorsal and plantar aspects of the MTs corresponded with the cuneiform and cuboid. Alignment was considered anatomical if this relationship was intact and non-anatomical if it was off by greater than two millimeters. (CME 3) All radiographic assessments were performed by two independent examiners

83 blinded to outcome scores. Differences between the two blinded examiners (***) Blinded by
84 JBJS ***) were resolved by asking a third blinded senior examiner (*** Blinded by JBJS
85 ***). Any complications or additional surgeries except routine hardware removal were noted
86 on the medical reports. Time to return to work and resumption of physical activity were
87 collected from follow-up records.

88
89 Patients eligible for the study, alive and living in the area, were contacted by mail and/or
90 telephone for a follow-up visit. Information on residency change and death was obtained
91 from the State population registry. All patients living and registered with an address were
92 contacted. **According to the population registry for those who had left the area or in**
93 **most cases the country, with no current address known to the registry, an additional**
94 **search for a current address was performed on the internet.** Patients were seen for a
95 clinical, questionnaire and radiological evaluation two to twenty-four years postoperative.
96 Functional outcomes were assessed using a frequently employed instrument, the American
97 Orthopaedic Foot and Ankle Society (AOFAS) score¹⁴ (higher score = better result), and a
98 validated instrument, the Foot Function Index (FFI)^{15, 16} (higher score = greater
99 disability/decreased function). Patients rated their pain levels on a visual analog pain scale
100 (VAS) from 0 (no pain) to 10 (worst pain). Global health was evaluated with SF-12 Health
101 Survey physical component score (SF-12 pcs; higher score=better result)¹⁷. Weight-bearing
102 radiographs were evaluated for assessment of alignment and evidence of degenerative
103 changes. The latter was considered present if there was radiographic evidence of osteophytes,
104 joint space narrowing, subchondral cysts and/or sclerosis. Radiographic degenerative changes
105 together with the presence of any pain (occasional, mild, moderate, or severe daily pain), was
106 considered as symptomatic posttraumatic OA. Correlation of radiological findings to pain
107 was done by analyzing the radiographic data obtained by the blinded reviewers and the

clinical outcome data obtained during follow-up evaluation.

Physicians involved in follow-up evaluation played no part in the surgery. All patients gave informed consent for participation. We received institutional review board approval (***) **Blinded by JBJS (***)**.

STATISTICAL ANALYSIS:

Baseline characteristics of patients seen at follow-up vs. those not seen were compared using Pearson's chi-square test for categorical variables and independent samples t-test for the continuous variable.

To evaluate clinically important (significant) differences between the clinical scores of patients with vs. without OA, score differences were assessed using effect sizes¹⁸. Effect sizes were calculated as mean unadjusted difference divided by the pooled SD of the corresponding mean scores. Effect sizes of 0.2, 0.5, and 0.8 are regarded as small, medium, and large degrees of difference, respectively¹⁹. To evaluate statistical differences between scores the Mann-Whitney U test was used. The association between patient-, fracture- and surgery-related variables and presence of symptomatic OA was evaluated with unadjusted and adjusted risk ratios, their 95% confidence intervals (CI) and corresponding p-values obtained using the general linear model (GLM) for the binomial family in STATA, version 11.1.(Stata Corp., College Station, Texas). A p-value of 0.15 was used as cut-off for the multi-variate risk factor evaluation as is recommended²⁰.

Source of Funding:

No outside funding supported our study.

Results

Demographics:

One hundred and twenty-eight patients (101 men and twenty-seven women) were surgically treated at our institution between 1988 and 2009 for a TMT joint injury, and contacted for follow-up. Fifty-five had moved out of the area or country without a known current address and were lost to follow-up, ten had died, and two were unwilling to participate (Fig. 1) **This left sixty-one patients (61 of 118 alive, 51.7%), forty-eight men and thirteen women, for clinical and radiological evaluation. At baseline, patients seen at follow-up as compared to those not seen did not significantly differ with respect to age, sex distribution, type of fracture, fracture classification, and method of fixation (Table 1).** At the time of injury the mean age of the sixty-one patients included was 37.5 years (range, sixteen to seventy years). Injuries were mostly due to high-energy trauma; in thirty-one patients (50.8%) the cause was a motor vehicle accident. Nine patients were polytraumatized. Fifty-four patients (88.5%) had combined ligamentous injury and fractures, and seven (11.5%) a purely ligamentous injury. According to the classification of Myerson², sixteen patients (26.2%) had fracture type A, twenty-seven (44.3%) type B, and eighteen patients (29.5%) fracture type C. Type A represented total incongruity of the TMT joint in any plane or direction; type B partial incongruity; and type C a divergent pattern with the first MT displaced medially and the lateral four in any other concomitant pattern of displacement.

Treatment:

Fifty patients (82%) underwent ORIF and eleven patients (18%) had primary arthrodesis. Postoperative radiographs revealed anatomical reduction in fifty-four patients (88.5%) overall.

Complications:

Postoperative complications occurred in two patients. One with secondary loss of fixation nine months after surgery required open reduction and arthrodesis of TMT joints I-III. The second patient had a superficial infection six weeks postoperative treated with débridement and antibiotics with good resolution.

Outcome:

Mean time between initial injury and study follow-up was 130.9 months (10.9 years) (range, 29-287 months; 2.4-23.9 years). Median and mean scores of clinical outcomes overall are in Table 2. Thirteen patients (21%) had to change their physical activity due to pain. At time of follow-up, 39 patients could wear regular shoes, 19 had inserts in their shoes, and 3 had modified shoes. Information regarding return to work for forty-one patients revealed that all had returned to their previous work with mean time between injury and return of 4.7 months (range, 1-16 months). All patients were able to walk more than 6 blocks without difficulty. The SF-12 pcs score was similar to the mean general population value (mean population value=49.8)²¹. Similar clinical results were found among those with polytrauma (n=9) compared to those without (n=51) with the mean AOFAS total score of 76.2 (± 15.0) vs. 79.5 (± 16.0), effect size 0.15, $p=0.382$; and the mean FFI of 17.1 (± 6.6) vs. 16.9 (± 7.3), effect size 0.02, $p=0.647$. With regard to pain there was also no difference (VAS pain score 2.6 (± 2.1) vs. 2.5 (± 1.9), effect size 0.01, $p=0.995$). Similarly, the outcome scores in patients after primary arthrodesis compared to the ORIF group did not significantly differ (mean AOFAS midfoot score 77.8 (± 14.8) vs. 79.7 (± 16), effect size 0.07, $p=0.520$; mean FFI 17.1 (± 4.3) vs. 16.9 (± 7.6), effect size 0.02, $p=0.332$; and mean VAS pain score 2.7 (± 1.1) vs. 2.5 (± 1.6), effect size 0.09, $p=0.747$).

Radiographs revealed degenerative changes in forty-four patients (72.1%). Radiographic signs of malalignment were observed in fifteen patients (24.6%), 100% with degenerative

changes (Fig 2). However, among the forty-six patients with good alignment degenerative changes were observed in twenty-eight patients (62%) (Fig 3). Symptomatic posttraumatic OA was frequent and noted in thirty-three of the sixty-one patients (54.1%). Patients with symptomatic OA had significantly lower mean values, both clinically and statistically, on all scores except for the SF-12 pcs (Table 3). Risk factors for symptomatic OA identified in uni- and multivariable analyses (Table 4) were failure to obtain anatomic reduction (adjusted risk ratio 1.95 (95% CI 1.27-2.98)) (Fig. 4), Myerson classification of C as compared to A (adjusted risk ratio 1.80 (95% CI 0.97-3.34)), and history of former or current smoking at time of surgery (adjusted risk ratio 1.35 (95% CI 0.93-1.97)). Four patients (6.5%) required secondary arthrodesis due to symptomatic posttraumatic OA at a mean of eighty-four months.

Discussion

To our best knowledge this report concerns the largest number of patients with the longest follow-up after surgical treatment of a Lisfranc injury. Our principal findings include: (1) Overall, after a mean follow-up of 10.9 years (range, 2.4-23.9 years) mean AOFAS score was 79, mean FFI was 16.9, and mean VAS pain scale was 2.5; about half of the patients had no pain; (2) Incidence of radiographic OA was noted in about two of three patients, and symptomatic OA in about one-half with the latter reporting worse outcomes; and (3) Risk factors for OA were failure to achieve an anatomic reduction (Fig 3), fracture classification type C, and a history of smoking.

Our results are consistent with most studies in the literature regarding clinical outcome. In a systematic review of eleven studies involving 257 patients with mean follow-up of forty-four months, Stavlas et al.¹¹ noted that most patients were treated with ORIF and screw fixation. More than half (58%) of injuries were fracture/dislocations while 43% were pure

dislocations. In six of these studies (146 patients) mean AOFAS score was 78.1. One-half of patients had radiographic evidence of posttraumatic OA, from slight degenerative changes to complete loss of joint space. No mention is made as to degree of symptomatology. In another study Kuo et al.⁴ reported on forty-eight patients treated with ORIF, and at average of fifty-two months noted an average AOFAS score of 77, with better results with anatomic reduction. Richter et al.²² reported on sixty-two patients at mean follow-up of nine years and a mean AOFAS score of 72. They described both Lisfranc and Chopart injuries unlike our study including only Lisfranc injuries. Reinhardt, et al.¹² noted an average AOFAS score of 81 with average VAS pain scale of 1.8 in twenty-five patients followed for an average of forty-two months, with as well good patient satisfaction treating both pure dislocation and fracture/dislocation types with primary arthrodesis. In a report of thirty-two patients at a mean of fourteen years follow-up, Marin Pena et al.²³ noted a mean AOFAS score of 91.7 despite all patients being treated with much older techniques. No patients were treated with screw fixation, half were treated with closed reduction, K-wires and cast, and eight were treated with only closed reduction and cast. It is surprising to see such good AOFAS scores with techniques that lost favor many years ago.

The FFI was designed to measure impact of foot pathology on function¹⁶. SooHoo reported a mean FFI of 28.19 in patients with a range of chronic foot/ankle disorders¹⁵. Budiman et al. noted an average FFI of 28.09 in patients with rheumatoid arthritis. In our study, the average FFI was 16.9, corresponding to better functional outcome. To our knowledge the FFI score has never been described in evaluating outcome of Lisfranc injuries.

Mulier et al.²⁴ reported on thirty-one patients with a 2.9 year mean follow-up..The study is complicated because 45% of patients had associated injuries involving Chopart or subtalar

joints. Our study reported solely on TMT joint injuries. They noted only 52% excellent or good results as evaluated by the Baltimore Painful Foot Score with radiographic changes of OA in 94% of patients. The determining factor in developing OA was the extent of the initial injury. They commented that an initial anatomic reduction did not guarantee excellent results but minimized likelihood of OA. The positive result achieved by anatomic reduction and proper alignment has been noted by others³. Adib et al.²⁵ performed ORIF in ninety-four patients with forty-four available for follow-up. They reported a 45% incidence of OA. In ten patients with non-anatomic reduction, eight (80%) developed OA, while in thirty-four patients with anatomic reduction, twelve (35%) experienced OA. They concluded that the only important factor affecting development of OA was anatomic reduction.

Presence of OA, even if symptomatic, does not necessarily mean treatment is necessary,. In our study, of thirty-three patients with symptomatic OA four underwent a secondary procedure. Of twenty-eight patients who had radiographic OA without symptoms, one underwent a secondary procedure. In contrast, in the previously mentioned study by Richter et al.²² twenty patients underwent secondary arthrodesis with little information as to symptomatic OA and indication for surgery.

Reports of risk factors in developing OA following surgery for TMT joint injuries cite the failure to achieve an anatomic reduction, but little else. Our study is consistent with this factor but demonstrates that fracture classification and smoking are two additional significant factors. A Lisfranc injury classified as type C in comparison to type A was significant, similar to what we have reported for OA following ankle fractures²⁶. And we found a third significant risk factor - a history of smoking. This is in accordance with a recent review on

smoking and OA which reported that smokers may have a moderately increased risk of painful OA²⁷.

Most reports have substantially limited follow-up and small numbers of patients. We have a considerably longer follow-up and larger number of patients, but are also limited with respect to sub-group analyses (e.g., outcomes according to ORIF vs. arthrodesis). **Another limitation is that only 51.7% of the patients still alive were seen at follow-up. However, they did not substantially differ with respect to their baseline characteristics from those who were not seen. The high number of patients lost to follow-up is related to the relatively young age of patients at the time of operation and the very long follow-up time in our study, factors known to increase loss to follow-up. Except for two patients, who refused to come and in whom the decision to participate might have been influenced by their outcome, the other 55 patients were not seen because they had moved out of the area/country. We believe that their decision to move was unrelated to the outcome of their foot surgery and that they were most likely missing at random.** While we do not have information on preoperative OA, it has been noted that primary (not posttraumatic) Lisfranc joint OA is rare, especially in patients under forty years of age²⁸. Lastly, the risk factors identified in our study require validation in other patient populations (external validation).

We conclude that two to twenty-four years following TMT joint injury, operative treatment restoring and maintaining joint anatomy results in satisfactory clinical outcome scores (CME 2), and a large number of patients return to their previous level of functioning and employment, with little need for secondary procedures. There is substantial posttraumatic OA on radiographs, albeit less symptomatic OA.

References

1. Hardcastle PH, Reschauer R, Kutscha-Lissberg E, Schoffmann W. Injuries to the tarsometatarsal joint. Incidence, classification and treatment. J Bone Joint Surg Br. 1982;64:349-56.
2. Myerson MS, Fisher RT, Burgess AR, Kenzora JE. Fracture dislocations of the tarsometatarsal joints: end results correlated with pathology and treatment. Foot Ankle. 1986;6:225-42.
3. Benirschke SK, Meinberg E, Anderson SA, Jones CB, Cole PA. Fractures and dislocations of the midfoot: Lisfranc and Chopart injuries. J Bone Joint Surg Am. 2012;94:1325-37.
4. Kuo RS, Tejwani NC, Digiovanni CW, Holt SK, Benirschke SK, Hansen ST, Jr., et al. Outcome after open reduction and internal fixation of Lisfranc joint injuries. J Bone Joint Surg Am. 2000;82-A:1609-18.
5. Aronow M. Joint preserving techniques for Lisfranc injury. Tech Orthop. 2011;26:43-9.
6. Panchbhavi V. Current operative techniques in Lisfranc injury. Oper Tech Orthop. 2008;18:239-46.
7. Wilson M, Gomez-Tristan A. Medial plate fixation of Lisfranc injuries. Tech Foot & Ankle. 2010;9:107-10.
8. Assal M, Stern R. Dorsal Multiple Plating Without Routine Transarticular Screws for Fixation of Lisfranc Injury. Orthopedics Accepted for publication doi: 103928/01477447-2014. 2013.
9. Henning JA, Jones CB, Sietsema DL, Bohay DR, Anderson JG. Open reduction internal fixation versus primary arthrodesis for lisfranc injuries: a prospective randomized study. Foot & ankle international. 2009;30:913-22.

- 305 10. Ly TV, Coetzee JC. Treatment of primarily ligamentous Lisfranc joint injuries: primary
306 arthrodesis compared with open reduction and internal fixation. A prospective,
307 randomized study. *J Bone Joint Surg Am.* 2006;88:514-20.
- 308 11. Stavlas P, Roberts CS, Xypnitos FN, Giannoudis PV. The role of reduction and internal
309 fixation of Lisfranc fracture-dislocations: a systematic review of the literature. *Int Orthop.*
310 2010;34:1083-91.
- 311 12. Reinhardt KR, Oh LS, Schottel P, Roberts MM, Levine D. Treatment of Lisfranc
312 fracture-dislocations with primary partial arthrodesis. *Foot & ankle international.*
313 2012;33:50-6.
- 314 13. Stein RE. Radiological aspects of the tarsometatarsal joints. *Foot Ankle.* 1983;3:286-9.
- 315 14. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical
316 rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot & ankle*
317 *international.* 1994;15:349-53.
- 318 15. SooHoo NF, Samimi DB, Vyas RM, Botzler T. Evaluation of the validity of the Foot
319 Function Index in measuring outcomes in patients with foot and ankle disorders. *Foot &*
320 *ankle international.* 2006;27:38-42.
- 321 16. Budiman-Mak E, Conrad KJ, Roach KE. The Foot Function Index: a measure of foot pain
322 and disability. *J Clin Epidemiol.* 1991;44:561-70.
- 323 17. Ware J, Jr., Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of
324 scales and preliminary tests of reliability and validity. *Med Care.* 1996;34:220-33.
- 325 18. Parsons N, Griffin XL, Stengel D, Carey Smith R, Perry DC, Costa ML. Standardised
326 effect sizes in clinical research: how to compare shoulder surgeons with hip surgeons.
327 *Bone Joint J.* 2014;96-B:853-4.
- 328 19. Cohen J. *Power Analysis for the Behavioral Sciences*, 2nd ed. Hillsdale, New Jersey:
329 Lawrence Erlbaum Associates; 1988.

- 330 20. Hosmer D, Lemeshow S. Applied Logistic Regression, 2nd ed. Toronto, Ontario: John
331 Wiley & Sons; 2000.
- 332 21. Perneger TV, Burnand B. A simple imputation algorithm reduced missing data in SF-12
333 health surveys. J Clin Epidemiol. 2005;58:142-9.
- 334 22. Richter M, Thermann H, Huefner T, Schmidt U, Krettek C. Aetiology, treatment and
335 outcome in Lisfranc joint dislocations and fracture dislocations. Foot and Ankle Surg.
336 2002;8:21-32.
- 337 23. Marin-Pena OR, Vilorio Recio F, Sanz Gomez T, Larrainzar Garijo R. Fourteen years
338 follow up after Lisfranc fracture-dislocation: functional and radiological results. Injury.
339 2012;43 Suppl 2:S79-82.
- 340 24. Mulier T, Reynders P, Sioen W, van den Bergh J, de Reymaeker G, Reynaert P, et al. The
341 treatment of Lisfranc injuries. Acta Orthop Belg. 1997;63:82-90.
- 342 25. Adib F, Medadi F, Guidi E, Nirschl R, Ochiai D, Wolff A, et al. Osteoarthritis following
343 open reduction and internal fixation of the Lisfranc injury. 12th EFORT Congress 2011.
- 344 **26. *** Blinded by JBJS *****
- 345 27. Felson DT, Zhang Y. Smoking and osteoarthritis: a review of the evidence and its
346 implications. Osteoarthritis Cartilage. 2015;23:331-3.
- 347 28. Iagnocco A, Rizzo C, Gattamelata A, Vavala C, Ceccarelli F, Cravotto E, et al.
348 Osteoarthritis of the foot: a review of the current state of knowledge. Med Ultrason.
349 2013;15:35-40.

350 **Figure Legends**

351 Figure 1: Flowchart

352 Figure 2:

353 Figures 2A and 2B: Anteroposterior and oblique radiographs at a follow-up of 48 months
354 showing a malalignment of the second metatarsal in a patient with a good outcome (AOFAS
355 score of 85).

356 Figure 3:

357 Figures 3A and 3B: Anteroposterior and oblique radiographs at a follow-up of 164 months
358 showing no malalignment in a patient with a poor outcome (AOFAS score of 47).

359 Figure 4:

360 Figures 4A and 4B: Anteroposterior and oblique radiographs at a follow-up of 114 months
361 showing a malalignment in a patient with a poor outcome (AOFAS score of 47).

CME Questions

1. The options for management of a Lisfranc injury include all but one of the following:
 - (a) Closed reduction with percutaneous wire fixation.
 - (b) Open reduction and internal fixation.
 - (c) Primary arthrodesis
 - (d) Naviculo-first cuneiform arthrodesis.**
2. The best opportunity for a satisfactory outcome is which of the following?
 - (a) Stable anatomic reduction with maintenance of the reduction and alignment.**
 - (b) Primary arthrodesis.
 - (c) ORIF with screw fixation.
 - (d) Secondary arthrodesis.
3. Several radiographic parameters are analyzed for satisfactory alignment postoperative repair of Lisfranc injury. They include all but one of the following:
 - (a) On the anteroposterior (AP) view, the medial border of the second metatarsal (MT) should be in line with the medial border of the middle cuneiform.
 - (b) The oblique view should show alignment of the medial border of the fourth MT and the medial border of the cuboid.
 - (c) On the lateral view, the dorsal and plantar aspects of the MTs should correspond with the cuneiform and cuboid.
 - (d) On the AP view, the medial border of the first MT should be in line with the medial border of the middle cuneiform.**

Table 1. Baseline characteristics of the patients seen vs. those not seen at follow-up

	Seen at FU n=61	Not seen at FU n=67	p-value*
Men (%)	48 (78.7)	48 (71.6)	0.358
Age at operation, mean (\pmSD)	37.5 (\pm 14.7)	40.7 (\pm 16.8)	0.662
Fracture type (%)			0.557
Fracture	7 (11.5)	12 (17.9)	
Fracture-dislocation	47 (77.0)	49 (73.1)	
Dislocation	7 (11.5)	6 (9.0)	
Fracture classification (%)**			0.781
A	16 (26.2)	12 (21.4)	
B	27 (44.3)	28 (50.0)	
C	18 (29.5)	16 (28.6)	
Method of fixation			
Primary arthrodesis	11 (18.0)	10 (14.9)	0.635
ORIF	50 (82.0)	57 (85.1)	

*Pearson's chi-square test for categorical variables and Mann-Whitney U test for continuous variable

**Fracture classification was not available for 11 of the 67 patients not seen at FU

Table 2. Clinical outcomes 2-24 years after tarsometatarsal joint complex injuries

	n	AOFAS score	FFI total	FFI pain	FFI disability	FFI activity	VAS pain	SF-12 pcs
All, mean, SD	61	79.0 (±16.0)	16.9 (±7.1)	19.7 (±9.0)	17.7 (±9.9)	10.6 (±3.0)	2.5 (±1.9)	49.8 (±8.0)
Median, IQR		80 (70; 90)	15.2 (12.6; 18.1)	18.9 (11.1; 27.8)	14.4 (10; 21.1)	10 (10; 10)	3 (1; 4)	51.2 (46.7; 56.6)

FFI= Foot Function Index
SD= Standard deviation
IQR= Interquartile range
VAS= Visual Analog Scale
pcs= physical component score

Table 3. Clinical outcomes according to presence or absence of symptomatic osteoarthritis (OA)

	n	Mean AOFAS	Mean FFI total	Mean FFI pain	Mean FFI disability	Mean FFI activity	Mean VAS pain	Mean SF-12 pcs
Symptomatic OA								
No	28	84.7 (±16.2)	15.4 (±7.5)	17.1 (±9.7)	16.5 (±10.0)	10.4 (±2.9)	1.7 (±1.8)	50.8 (±6.7)
Yes	33	74.1 (±13.9)	18.2 (±6.6)	22.0 (±7.8)	18.7 (±9.8)	10.7 (±3.0)	3.2 (±1.8)	48.5 (±9.1)
Effect size*		0.72	0.41	0.56	0.23	0.08	0.86	0.30
p-value**		0.005	0.035	0.011	0.157	0.337	0.002	0.461

FFI= Foot Function Index
VAS= Visual Analog Scale
pcs= physical component score
*Effect sizes (for independent samples) calculated as mean unadjusted difference divided by the pooled standard deviation of the corresponding mean scores. Effect sizes of 0.2, 0.5, and 0.8 are regarded as small, medium, and large degrees of difference.
**p-values obtained with use of Mann-Whitney U test

Table 4. Association between each risk factor and the presence of symptomatic osteoarthritis

	Symptomatic OA yes	Symptomatic OA no	Unadjusted risk ratio (95% CI)	p-value	Adjusted risk ratio (95% CI)	p-value
Men (%)	28 (58.3)	20 (41.7)				
Women (%)	5 (38.5)	8 (61.5)	0.66 (0.32-1.37)	0.262	0.60 (0.27-1.32)	0.203
Age at operation, mean, SD	37.7 (±13.7)	37.3 (±16.2)	1.0 (0.98-1.02)	0.922		
BMI at follow-up, mean, SD	26.3 (±2.3)	26.6 (±3.6)	0.99 (0.91-1.08)	0.806		
Smoking status (%)						
Never-smoker	14 (45.2)	18 (54.8)				
Ever-smoker	19 (63.3)	11 (36.7)	1.40 (0.87-2.25)	0.162	1.35 (0.93-1.97)	0.115
Fracture classification (%)						
A	6 (37.5)	10 (62.5)	Ref.		Ref.	
B	17 (63.0)	10 (37.0)	1.68 (0.84-3.37)	0.144	1.44 (0.81-2.58)	0.218
C	10 (55.6)	8 (44.4)	1.48 (0.70-3.15)	0.308	1.80 (0.97-3.34)	0.062
Dislocation	2 (28.6)	5 (71.4)				
Fracture/Fracture-dislocation	31 (57.4)	23 (42.6)	2.01 (0.61-6.63)	0.252	1.59 (0.51-4.96)	0.425
Method of fixation						
Primary arthrodesis	5 (45.5)	6 (54.5)				
ORIF	28 (56.0)	22 (44.0)	1.23 (0.62-2.46)	0.555	1.31 (0.69-2.49)	0.402
Anatomic reduction (%)						
Yes	27 (50.0)	27 (50.0)				
No	6 (85.7)	1 (14.3)	1.71 (1.15-2.57)	0.009	1.95 (1.27-2.98)	0.002
Secondary procedure (%)						
No	29 (51.8)	27 (48.2)				
Yes	4 (80.0)	1 (20.0)	1.54 (0.93-2.56)	0.092	1.03 (0.71-1.50)	0.879

Unadjusted and adjusted risk ratios, their 95% confidence intervals (CI) and corresponding p-values were obtained using the general linear model (GLM) for the binomial family.

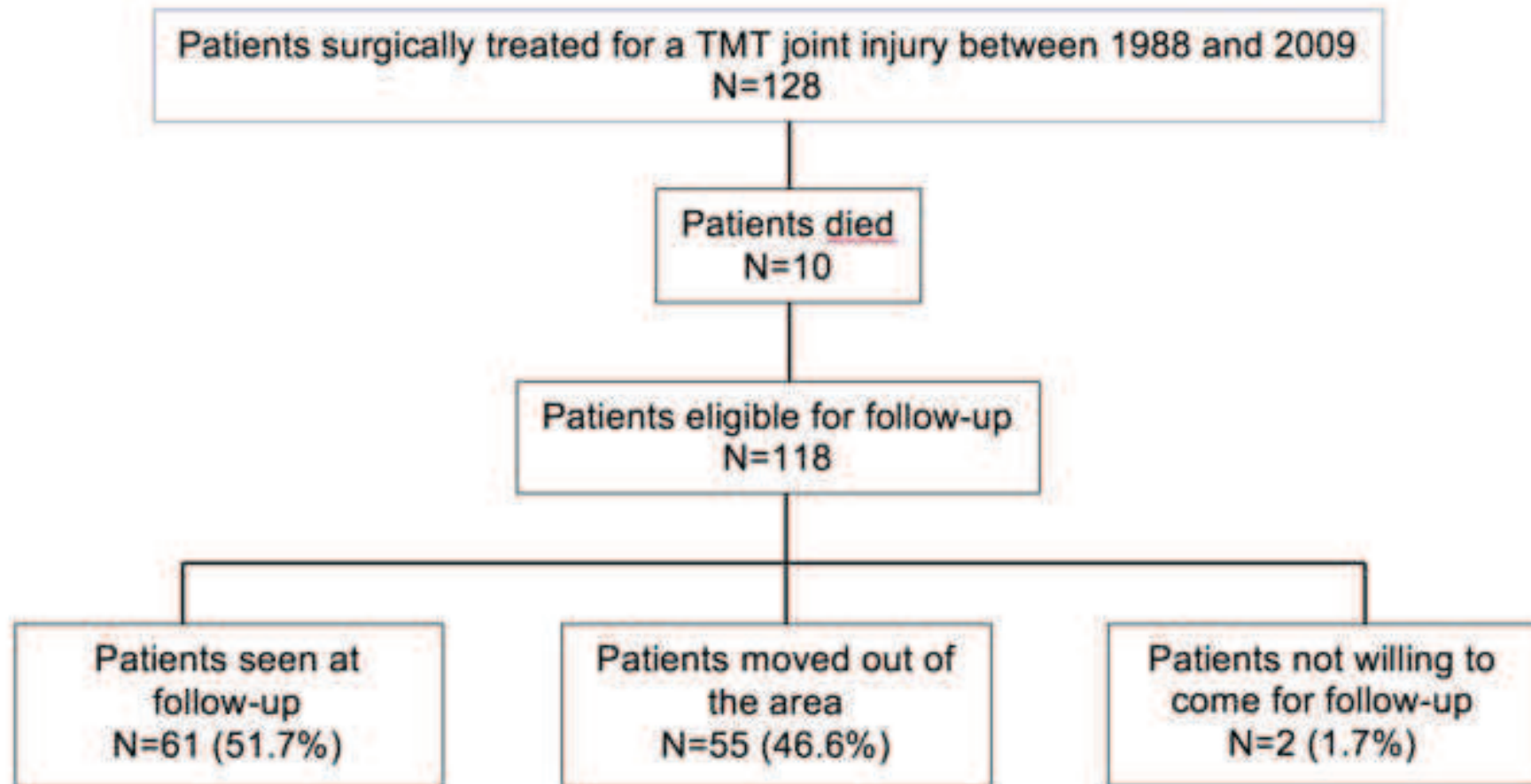
Figure 1 : Flowchart

Figure 2A

[Click here to download Figure Figure2A.tif](#) 



Figure 2B

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Figure 3A

[Click here to download Figure Fig_3A.tif](#) 



Figure 3B

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Figure 4A

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Figure 4B

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