The influence of approach and implant on reduction accuracy and stability in Lisfranc fracture-dislocation at the tarsometatarsal joint

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Abstract

Background Besides early diagnosis, an anatomical and stable reduction is paramount for obtaining favourable outcome. The current study looked at the influence of the type of approach and the type of fixation of tarsometatarsal injuries on the accuracy and stability of the reduction.

Material and methods Consecutive patients treated for an acute Lisfranc injury were included. All radiographs were re-assessed for accuracy and secondary displacement following either a closed or open approach and the type of fixation (Kirschner wires alone or a combination of screws plates and Kirschner wires).

Results A total of 28 patients were included. Six patients were treated with closed reduction and percutaneous fixation and 22 with open reduction internal fixation. Sixteen patients were treated with Kirschner wires only (six closed, 10 open), seven with screws with/without Kirschner wires, and five with medial plating with/without Kirschner wires. In the closed reduction group two out of six (33%) reductions were considered anatomical versus 19 out of 22 (86%) in the open group (p=0.021). All six secondary displacements occurred in the Kirschner wire fixation group (37.5%) versus none in the rigid fixation group (p=0.024).

Conclusion The results demonstrate that ORIF with screws or plate results in better reduction and better maintenance of reduction in both low and high energy Lisfranc injuries. These results should be further evaluated in light of functional outcome.

Keywords: Lisfranc, ORIF, accuracy, stability

Introduction

Tarsometatarsal injuries are well-known for their low incidence (1/55,000 per year and 0.2 % of all injuries) but high impact on functional outcome. [2,12]

With respect to the treatment there is no real consensus. Currently, injuries might be treated non-operatively when non-displaced. [27,38] In displaced injuries treatment options are closed reduction with or without fixation [5,14,15,25,30,31], or open reduction internal fixation with various methods of fixation (Kirschner wires [5,7,26,38], different types of screws [19,24,33,37], extra-articular plate fixation [3,32], or suture-button device [1,9]), and primary arthrodesis[22,23]. A current meta-analysis has shown substantial evidence that clinical and radiographic outcome is influenced by the accuracy of the reduction independent of the type of fixation. [4,10,15,19,24,34,35,39,42] Although there is some literature suggesting that the use of screws might provide a more stable fixation, the use of K-wires is still popular. [18,29,30]

The aim of this study was to assess whether or not the surgical approach (closed versus open) and the type of fixation (Kirschner wires versus screws or combination) had an effect on the accuracy of the reduction and the ability to maintain the reduction.

Material and methods

All consecutive patients who sustained a Lisfranc injury treated surgically between June 2004 and December 2011 were included in this retrospective case series. Patients were considered eligible if they had undergone operative treatment of an acute tarsometatarsal injury. Depending on the attending surgeons' preferences (eight different surgeons in total) the injuries were treated either via closed or open reduction and fixated either in a more flexible way (*i.e.*, Kirschner wires only) or more rigidly (*i.e.*, screws or plates with or without K-wires). Patients who were treated conservatively (N = 5), or that had a secondary arthrodesis following a non-operative treatment (N = 4) as well as patients with a follow-up of less than three months (N = 2) were excluded. The open approach was via a single incision between the first and second ray. In more recent cases where a bridging plate was used five out of six had two incisions (one medial and one between second and third ray). Aftertreatment was non-weightbearing for three months, of which the first six weeks in a below-knee cast. Implants were routinely removed between six to 16 weeks (median 10 weeks) depending on the surgeons' preferences and consolidation of additional fractures.

Clinical data

Patient characteristics (*i.e.*, gender and age), fracture characteristics (*i.e.*, date of trauma, trauma mechanism, and injury classification), and surgical characteristics (*i.e.*, open or closed approach, flexible or rigid fixation, accuracy of the reduction, secondary displacement, and re-operation) were obtained from the electronic patient charts. Major infectious wound complications (resubmission for intravenous antibiotics or surgical debridement with implant removal) were scored.

The fractures were retrospectively classified according to the descriptive system by Myerson, in which type-A represents total incongruity, a type-B injury a partial incongruity, and a type-

C a divergent injury. [24] In addition the injuries were classified according to the involvement of the medial, central, or lateral column. For each column, a distinction was made between not involved, pure ligamentary, simple fracture (or <50% joint surface involvement), and comminuted fracture of the joint, irrespectively of the direction and amount of the displacement.

The accuracy of the post-operative reduction was based upon the following criteria: 1) distance between the first and second metatarsal; 2) continuous line from the medial side of second metatarsal and intermediate cuneiform on the antero-posterior view; and 3) continuous line from the medial side of the fourth metatarsal and the cuboid on the oblique view of the first post-operative radiographic images or computed tomography (CT-scan) if available. Reduction was considered acceptable if these radiographic parameters were within the 2 mm range, or malreduced if they were off by greater than 2 mm. [24 6]

Secondary displacement was defined as a change of 2 mm or more in the above named radiographic parameters of the post-operative reduction, between the first post-operative image and sequential imaging within the first six months.

Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS, Chicago, IL). Normality of data was assessed using the Kolmogorov-Smirnov test and by inspecting frequency histograms. The Levene's test was applied in order to assess homogeneity of variance between data. Numeric data were found to be not normally distributed and are expressed as median with first and third quartile; categorical data are shown as numbers with percentages. A Mann-Whitney U-test (numeric data) or Chi2 analysis (categorical data) was performed in order to assess statistical significance between groups with closed versus open approach and groups with flexible (K-wires only) fixation versus rigid fixation. A p-value <0.05 was taken as threshold of statistical significance.

Results

A total of 28 patients were identified from the electronic hospital database. The different patient, fracture, and surgical characteristics are summarised in Table 1. The median age was 40 years (P_{25}-P_{75} 26-54), and 19 patients were male. Twelve injuries were classified as type-A, one as type-B1, 12 as type-B2, two as type-C1, and one as type-C2. More than half of the injuries were due to a high-energy trauma. Twentyseven injuries were closed injuries.

Six patients were treated with closed reduction and percutaneous fixation and 22 with open reduction internal fixation. Sixteen patients were treated with Kirschner wires only (6 closed, 10 open), seven with screws with/without Kirschner wires, and five with medial plating with/without Kirschner wires.

When comparing the closed reduction and the open reduction group, no differences were noted in the patient and fracture characteristics. There was however a significant difference in the rate of anatomical reductions post-operatively; in the closed group two out of six (33.3%) reductions were considered anatomical versus 19 out of 22 (86.4%) in the open group (p=0.021). Overall, six secondary displacements occurred, of which five after open reduction. Two patients underwent secondary surgical intervention after a failed open procedure. Major infectious complications occurred in two patients (No 9 and 13) treated with open reduction and K-wire fixation for an open and one closed fracture-dislocation (p = 1.00).

When assessing differences between the more flexible and the rigid fixation, both groups were found comparable with respect to patient and fracture characteristics. Differences, however, were noted for reduction and stability. All six secondary displacements occurred in the flexible fixation group (37.5%; versus none in the rigid fixation group (p=0.024). Also, both re-operations had been performed in patients treated with open reduction Kirschner wire fixation. The current study lacked statistical power to reach statistical significance for the re-operation rate.

Discussion

The influence of the approach and type of fixation on the accuracy and the stability of the reduction in acute tarsometatarsal fracture-dislocations were assessed in the current study. Despite the relatively small number of patients the results clearly show a higher rate of anatomical reduction following an open approach. Secondly, screw fixation resulted in a superior stability, as measured by a reduced number of secondary displacements both in low and high energy Lisfranc injuries.

In the current study four out of six Lisfranc injuries treated with closed reductions were not anatomically reduced. A less than anatomical reduction may have significant influence on increasing the chance of arthrosis. [18,19,30] The number of patients suffering from arthrosis following a tarsometatarsal injury is estimated between 20 and 50 percent. [18,19,22,23] In several studies the direct influence of the accuracy of the reduction on the functional outcome has been identified, suggesting potential benefit of an anatomical reduction and maintaining this reduction. [4,10,15,19,24,34,35,42]

Kirschner wires and tarsometatarsal fracture-dislocations have a rich history. [14-16] They are still frequently used for the closed or open stabilisation after reduction of Lisfranc injuries. [5,11,18,28,29,33,36] Different techniques for Kirschner wire fixation were used, making the comparison of these recent studies difficult. Secondary displacement or non-anatomical reductions occurred in 13% to 25 percent [11,18,36], These studies however frequently used five mm diastasis as the threshold for non-anatomical reduction or secondary displacement [11,36], as in the current study a maximum of two mm diastasis between the first and second metatarsal was considered normal. This largely explains the higher number of non-anatomical reductions (32%) and secondary displacement (21%).

With respect to functional outcome when using Kirschner wires, the average American Orthopaedic Foot Ankle Society midfoot score ranges in the literature between 72 and 81 points (out of a maximum of 100 points). [5,18,33,36] These scores are very similar when compared with the rigid joint immobilisation with screws [19,21,31,33,41], which might imply that, despite a positive effect on obtaining and maintaining an anatomical reduction, the type of fixation does not substantially affect (long-term) outcome, thus outcome appears more related to the initial trauma. Even though there is evidence that the type of implant does not affect the functional outcome, we did not address outcome in this group of patients; therefore, the effect on outcome of secondary displacement should be investigated in future studies.

The benefit of using Kirschner wires is the ease of insertion and removal in both open and closed approaches. More extensive secondary surgery is required to remove implants. There are however concerns on the stability of the fixation when comparing Kirschner wires and screw fixation. [19,20,33] Transarticular screw fixation apparently gives a more rigid stabilisation, but articular damage is substantial and lies between 2 and 7.6% per joint-surface. [3,13] An alternative to the transarticular screw is extra-articular plating, which gives a similar stability.[3] The need for implant removal is still subject of debate. Screws are frequently removed in order to prevent breakage. [17] The stabilisation should be at least three to four months. This might prove too long for smooth pins, which may show loosening over time [8]. In addition, secondary surgery is associated with extra costs. Weighing the pros and cons of Kirschner wires, Chiodo *et al.* recommended to use Kirschner wires only in lateral column stabilisation and in case of severe comminution. [8]

There is currently substantial heterogeneity in treatment, both in the literature as well as in the current study, and correlation with outcome is poor. The currently available classifications do not always guide treatment well, have moderate interobserver agreement, and do not

predict outcome. [15,27,40] More currently the principal author prefers to use extra-articular stabilisation using plating of the medial column, as it is frequently the per-operative observation using stress testing that even in partial incongruity (Myerson type B2) Lisfranc injuries, as judged from the pre-operative imaging) the medial column is involved making it a complete incongruity injury type. Therefore, classifying the injuries preoperatively according to the involvement and the type of injury of the different columns of the foot may aid in identifying the columns that need to be addressed, and may also support the type of fixation (e.g. fusion in pure ligamentary, plate or screws in partial fractures, plating in comminuted fractures). Whether or not these findings hold true in a larger sample, should be validated in a prospective study.

In conclusion, the open approach and fixation with screws (and plates) of acute tarsometatarsal injuries provide a more accurate reduction and a superior stability with less secondary displacement.

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Figures

Figure 1. Lisfranc injury treated with open reduction and internal Kirschner wire fixation

a. Myerson type B2 injury b. treated with two Kirschner wires, c. secondary displacement most apparent following implant removal at 12 weeks

Figure 2. Lisfranc injury treated with open reduction and internal fixation with extra-articular plating

a. Myerson B2 injury with peroperatively diagnosed instability of the medial column, b. treatment with plating of the medial and central column and Kirschner wires for the lateral column, c. no secondary displacement post-operatively (implant removal at 16 weeks)

Table 1. Patient, injury and treatment characteristics for all individual patient

Patient	Gender	Age	Trauma	HET/LET	Myerson	Column*			Approach	Stabilization	Reduction accurate	Secundary displacement	Secundary surgery
						Medial	Central	Lateral					
1	M	57	Fall	L	a	1	1	2	orif	Screws + K-wire	Y	N	N
2	F	18	Fall	H	a	1	2	1	perc	K-wires	N	N	N
3	M	20	MVA	H	b2	0	2	0	orif	Screws	Y	N	N
4	M	42	Crush	H	a	1	1	3	perc	K-wires	N	N	N
5	M	28	Inversion	L	b2	0	1	0	orif	Screws + K-wire	Y	N	N
6	M	62	Fall	H	b2	1	2	2	orif	Screws	Y	N	N
7	F	26	Crush	H	a	1	1	1	perc	K-wires	N	N	N
8	F	62	Inversion	L	a	1	2	2	perc	K-wires	N	Y	N
9	M	22	Crush	H	a	0	2	2	orif	K-wires	N	N	N
10	M	54	Crush	H	c1	1	1	0	orif	Screws + K-wire	Y	N	N
11	M	44	MVA	H	b2	0	2	1	perc	K-wires	Y	N	N
12	M	68	MVA	L	c1	0	1	0	perc	K-wires	Y	N	N
13	M	53	MVA	H	a	1	2	1	orif	K-wires	N	N	N
14	F	28	Fall	L	b2	0	2	1	orif	K-wires	Y	N	N
15	M	31	Fall	L	b2	0	1	2	orif	K-wires	Y	Y	Y
16	F	18	MVA	H	b1	1	1	0	orif	Screws	Y	N	N
17	M	47	Fall	L	b2	0	1	1	orif	K-wires	Y	Y	N
18	M	27	Fall	L	a	1	1	1	orif	K-wires	Y	Y	Y
19	F	67	Fall	L	a	1	2	1	orif	K-wires	N	Y	N
20	M	25	Fall	L	b2	0	2	1	orif	K-wires	Y	N	N
21	M	45	MVA	L	b2	0	2	3	orif	K-wires	Y	Y	N
22	M	26	Fall	H	b2	0	3	2	orif	K-wires	Y	N	N
23	F	18	MVA	H	a	1	1	1	orif	Plate + K-wires	Y	N	N
24	F	45	Fall	L	a	3	1	1	orif	Plate + K-wires	Y	N	N
25	M	38	MVA	H	c2	1	1	0	orif	Plate	Y	N	N
26	M	59	Crush	H	b2	1	2	1	orif	Screws + K-wire	Y	N	N
27	M	20	Inversion	L	b2	1	2	1	orif	Plate	Y	N	N
28	F	43	Fall	L	a	1	2	1	orif	Plate	Y	N	N

F, Female; M, Male; MVA, motor vehicle accident; LET, Low Energy Trauma; HET, High Energy Trauma; PERC, percutaneous treatment; ORIF, Open Reduction and Internal Fixation; K-wires, Kirschner wires; Y, yes; N, No; * Column involvement 0, not involved; 1, pure ligamentary; 2, simple fracture; 3, comminuted fracture of the joint