Primary arthrodesis for treatment of special types of Lisfranc fracture dislocation

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Background
Lisfranc fracture dislocation is a devastating trauma affecting usually young active age group, with a high rate of missing or misdiagnosis, resulting in prolonged recovery and significant long-term morbidity.
Objective
This study describes the indications, contraindications, technique, and results of treating severe Lisfranc fracture dislocation by primary arthrodesis.
Patients and methods
A prospective study was conducted on 10 patients with closed Lisfranc fracture dislocation, who had been treated at Benha University Hospital and Benha Insurance Hospital between January 2010 and March 2013. Mechanism of injury was high-velocity injury in five patients, fall from a height in four patients, and a hyperplanterflexion foot trauma during descending stairs in one patient. Mean age at time of surgery was 27.7 years (range, 19–38 years). All patients were followed up with a follow-up period of 21.3 months (range, 6–36 months).
Results
According to the American Orthopedic Foot and Ankle Society scale, the clinical outcome was 81.7 (range, 79–84). Complications met in this study were as follows: three patients had a postoperative Sudeck's atrophy, one patient developed superficial wound problem, and two patients had forefoot stiffness and difficulties in shoe wearing.
Conclusion
Open reduction and internal fixation of severe Lisfranc fracture dislocation with screws and primary arthrodesis is the treatment of choice, as these fracture dislocations are known for their affinity for post-traumatic arthritis and subsequent need for a second operation. The level of evidence for this article was case series type IV.

Keywords:
fracture dislocation, Lisfranc, midfoot injuries, tarsometatarsal

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Introduction

Trauma to the tarsometatarsal joint was first identified during the Napoleonic Wars, by Lisfranc de St Martin, a war gynecologist surgeon, who was a pioneer to do amputation at this level. He observed soldiers falling off their horses, with a foot caught in the stirrup, forcing the foot into a slow hyperplantar flexion of the forefoot on the rear foot. This unfortunate soldier sustained a vascular injury as well and underwent partial amputation of the foot at the tarsometatarsal joint. Since then, many authors have sought to classify and outline the treatment for these injuries [1,2].

Lisfranc injuries are relatively uncommon, accounting for 0.2% of all fractures. They are typically the result of a high-energy trauma, such as motor vehicle accidents and falls from heights, and 58% of them are associated with polytrauma [3]. Almost 40% of Lisfranc fracture dislocations in patients who had polytrauma are not recognized, and 20% are misdiagnosed. This may contribute to the gross underestimation of the these injuries, which are the most common in the third decade of life, with males being affected two to four times more often than females [4].

To know how to treat Lisfranc fracture dislocation 'ideally,' it is imperative to know the anatomy of tarsometatarsal joints' anatomy. They are arthroidal synovial joint type, formed by bones of first, second, and third metatarsal bases with medial, intermediate and lateral cuneiforms, respectively, whereas the fourth and fifth metatarsal bases articulate with the cuboid bone [5]. Chiodo and Myerson [6] theorized the three-column theory, involving the following: medial column formed by articulation between the first metatarsal phalangeal joint

(MPJ) and medial cuneiform with the navicular bone; middle column, which was the most rigid, formed by the second and third MPJs with middle and lateral cuneiforms with the navicular bone; and lateral column, which is the most mobile formed by fourth and fifth MPJs with the cuboid bone. The rigidity of the medial and the middle columns was essential for the foot to function effectively as a lever arm during normal gait [6,7]. There are dorsal and stronger planter ligaments, which may account for the dorsal direction of dislocations. There is no interosseous ligament between the medial and the middle cuneiforms or between the first and second metatarsal bases. The important interosseous 'Lisfranc' ligament is located between the medial cuneiform and the base of the second metatarsal, measuring 1 cm in length and 0.5 cm in width [3,8].

Objective of the study

Lisfranc fracture dislocation is a devastating trauma affecting usually the young active age group, with a high rate of missing or misdiagnosis, resulting in prolonged recovery and significant long-term morbidity. The objective is to document the indications, contraindications, technique, and results of treating severe forms of Lisfranc fracture dislocation by open reduction and primary arthrodesis.

'The authors have obtained the patient's informed written consent for print and electronic publication of the case report.'

Patients and methods

A prospective study was conducted on 10 patients with closed Lisfranc fracture dislocation who had been treated at Benha University Hospital and Benha Insurance Hospital between January 2010 and March 2013. The study was approved by the institutional ethics committee in Department of Orthopedic, Benha University, Benha, Egypt. Mechanism of injury was high-velocity injury in five patients, fall from a height in four patients and a hyperplantar flexion foot trauma during descending stairs in one patient. All the patients were males. Right side was affected in eight cases, whereas two cases in the left side. Mean age at the time of surgery was 27.7 years (range, 19–38 years). There were no associated fractures. All patients were followed up with a follow-up period of 21.3 months (range, 6–36 months). Time elapsed between trauma and surgery varied from 7 to 14 days, with an average of 8 days.

There is no accepted universal classification. Various classification systems such as Hardcastle and Nunley and Vertullo had identified different fracture and dislocation patterns; however, they failed to encompass all injury patterns specially crush injuries and do not specifically correlate to treatment plans or establish the prognosis [9].

Figure 1

Flick sign.

Inclusion criteria

The following were the inclusion criteria:

(1) Severe comminuted intra-articular forms of Lisfranc fracture dislocation with a high suspicion of risk for post-traumatic arthritis [3].
(2) Delayed or missed diagnosis [3].
(3) Presence of 'fleck sign,' which is caused by avulsion of the Lisfranc ligament, usually off the second metatarsal base (i.e. ligamentous injury) [10] (Fig. 1).
(4) Fracture of the second metatarsal base [10].

Exclusion criteria

The following were the exclusion criteria:

(1) Severe soft tissue damage.
(2) Advanced post-traumatic swelling.

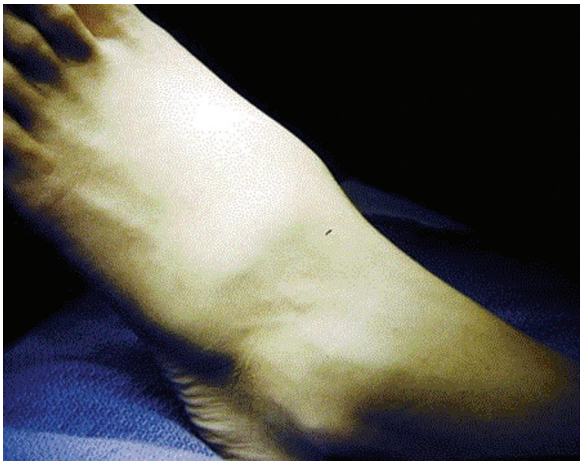
Diagnosis of a Lisfranc fracture dislocation

Diagnosis of Lisfranc fracture dislocation can be achieved by two ways:

(1) Clinically: patients may reveal tenderness, swelling, and deformity of the dorsum foot, especially over the tarsometatarsal joints. Weight

bearing is extremely painful. Planter ecchymosis may occur. Passive movement of the individual heads of the metatarsals produces pain at the tarsometatarsal joints (Fig. 2).

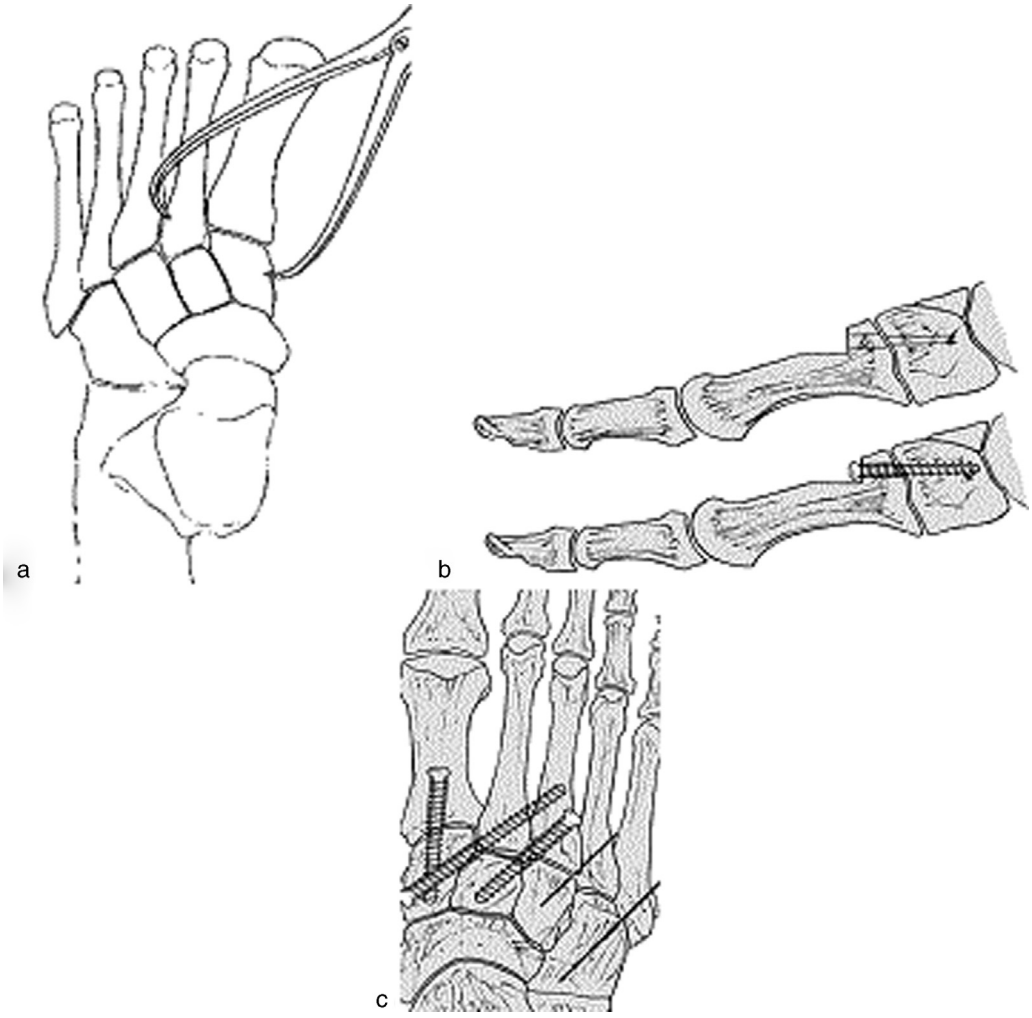
Figure 2



Clinical deformity.

(2) Radiologically, it can be obtained by doing the following:
   (a) Anteroposterior (AP) radiography foot: normally, the medial aspect of the base of the second metatarsal should be aligned with the medial aspect of the middle cuneiform.
   (b) Oblique 30° radiography foot: normally, the medial aspect of the fourth metatarsal base should be aligned with the medial aspect of the cuboid bone.
   (c) Lateral ankle radiography: normally, the dorsal surface of the first and second metatarsals should be level to the corresponding cuneiforms without dorsal displacement.
   (d) Comparative radiography of the other healthy side, especially if diastasis between the first and second metatarsal bases is more than 2 mm in the AP view [11].
   (e) Computed tomography.

Figure 3



(a–c) Reduction technique [9,12].

Surgical technique

The soft tissue envelope was respected, and surgical timing was delayed until the skin 'wrinkle test' became positive, indicating that the swelling had subsided [3].

The patients were taken to the operating room, where they were placed supine position. Anesthesia was either general or regional one according to the anesthetician's decision. A preoperative antibiotic was given at induction of anesthesia. The affected extremity was elevated by putting a sand bag below the patient's ipsilateral hip. After standard preparing and draping of the extremity, a thigh tourniquet was exsanguinated [12].

Intervening soft tissue flaps should be meticulously preserved to avoid wound slough or necrosis. An incision (incision A) was made in the interval between the first and the second metatarsal bases 5–6 cm in length, exposing the medial three rays, with dissection between the tendons of the extensor hallucis longus and brevis. The deep peroneal nerve and dorsalis pedis artery were protected throughout this exposure. The first metatarsal is reduced by direct manipulation until the proximal joint surface of the first metatarsal seats upon the distal joint surface of the medial cuneiform. A small pointed reduction clamp was used to compress the medial cuneiform to the base of the second metatarsal base (Fig. 3a). Intraoperative AP and oblique foot radiographs under fluoroscopy were used to check the reduction. Provisional fixation by K-wires was used [10,12,13].

A second incision (incision B) was made lateral to the base of the third metatarsal and lateral cuneiform with dissection between the third and fourth heads of the extensor digitorum brevis, thus allowing access to the lateral side of the third metatarsal and medial side of the fourth metatarsal. Moreover, temporary two K-wires for fixation were used and checked under fluoroscopy.

Finally, a third incision (incision C) between the fourth and fifth metatarsal bases with dissection between the extensor digitorum brevis and peroneus brevis or tertius was occasionally required to obtain a smooth reduction between the cuboid and the fourth and fifth metatarsals. Definitive two K-wires were used, and the reduction was checked under fluoroscopy. All wires that will stay in place were clipped under the skin [10].

Primary arthrodesis technique was used to fix the first, second, and third metatarsal bases to their corresponding cuneiform bones. Articular cartilage was debrided, and screws for fixation (3.5 mm cortical screws) were used.

A small notch or trough was made in the dorsal cortex of the first metatarsal at least 2 cm distal to the joint with a 3-mm bur. This notch served two purposes. The first was to prevent the screw head from striking the inclined surface of the metatarsal and splitting the proximal side of the dorsal cortex, and the second that it provides an indentation into which the head of the screw can be countersunk [14] (Fig. 3b).

Screw fixation technique is crucial. The first metatarsal base was fixed to the medial cuneiform

Table 1 American Orthopedic Foot and Ankle Society midfoot score system [15]

Items	Degree
Pain (40 points)	
None	40
Mild, occasional	30
Moderate, daily	20
Severe, almost always present	0
Function (45 points)	
Activity limitations, support	
No limitations, no support	10
No limitation of daily activities, limitation of recreational activities, no support	7
Limited daily and recreational activities, cane	4
Severe limitation of daily and recreational activities, walker, crutches, wheelchair	0
Footwear requirements	
Fashionable, conventional shoes with no insert	5
Comfort footwear, shoe insert	3
Modified shoe or brace	0
Maximal walking distance and blocks	
>6	10
4–6	7
1–3	4
<3	0
Walking surfaces	
No difficulty on any surface	10
Some difficulty on uneven terrain, stairs, inclines, ladders	5
Severe difficulty on uneven terrain, stairs, inclines, ladders	0
Gait abnormality	
None, slight	10
Obvious	5
Marked	0
Alignment (15 points)	
Good, plantigrade foot, midfoot aligned	15
Fair, plantigrade foot, some degree of midfoot misalignment observed, no symptoms	8
Poor, nonplantigrade foot, severe misalignment, symptoms	0

Figure 4

(a) Preoperative (anteroposterior foot view). (b) Preoperative (lateral foot view). (c) Postoperative (anteroposterior foot view). (d) Sound arthrodesis.

by one screw. The Lisfranc ligament was compensated by a screw along its normal direction. The second metatarsal base was fixed to the middle cuneiform by a third screw. Thus, the second metatarsal bone (corner stone bone) was fixed in its original anatomical site. Another screw was used for fixing the third metatarsal base with the lateral cuneiform. Finally, two K-wires were used for fixing the fourth and the fifth metatarsal bases to the cuboids bone (Fig. 3c).

It should be noted that screws for fixation provide greater stability and superior results compared with K-wires for fixation [12].

Postoperative protocol

The affected extremity was put in a below-knee slab with elevation for 7–14 days postoperatively till the time of sutures removal. After that, a nonwalking below-knee cast was applied for 6 weeks. After this period, the two K-wires placed in the fourth and fifth metatarsal bases were removed. Gradual weight bearing was commenced as pain could be tolerated.

Results

According to the American Orthopedic Foot and Ankle Society (AOFAS) scale (Table 1), the clinical outcome was 81.7 (range, 79–84). All

Table 2 Summary of cases

Age and sex	Mechanism of trauma	Time between trauma and operation (days)	Injury pattern and treatment	Complications	Follow-up (months)	Score
33 (M)	RTA	7	Diastasis >2 mm between 1st and 2nd metatarsal bases. ttt by primary arthrodesis of the second metatarsal base	Sudeck's atrophy	36	80
28 (M)	Fall from a height	7	Comminuted Lisfranc fracture dislocation. ttt by ORIF and primary arthrodesis of the medial three TMT joints by screws and ORIF and 2 K-wires for fixation of 4th and 5th TMT joints	None	32	82
19 (M)	Hyperplantar flexion foot trauma during descending stairs	7	Comminuted fracture dislocation of second metatarsal base. ttt by ORIF and primary arthrodesis of the 2nd TMT joint. Fixation by 2 screws, one between the 2nd metatarsal base and medial cuneiform and the other between the 2nd metatarsal base and middle cuneiform	Forefoot stiffness	28	81
30 (M)	Fall from a height	8	Fleck sign, ttt. by ORIF and primary arthrodesis of the 2nd metatarsal base by 2 screws, one between the 2nd metatarsal base and medial cuneiform and the other between the second metatarsal base and middle cuneiform	None	25	84
28 (M)	RTA	14	Comminuted Lisfranc fracture dislocation ttt. by ORIF and primary arthrodesis of the medial 3 TMT joints by screws and 2 K-wires for fixation of 4th and 5th TMT joints	Sudeck's atrophy	23	81
21 (M)	RTA	8	Comminuted Lisfranc fracture dislocation. ttt. by ORIF and primary arthrodesis of medial 3 TMT joints by screws and 2 K-wires for fixation of 4th and 5th TMT joints	Superficial wound infection	20	79
34 (M)	Fall from a height	7	Diastasis >2 mm between 1st and 2nd metatarsal bases. ttt. by ORIF and primary arthrodesis of the 2nd metatarsal base by 2 screws: one between the 2nd metatarsal base and medial cuneiform and the other between the 2nd metatarsal base and middle cuneiform	None	18	81
22 (M)	RTA	8	Comminuted Lisfranc fracture dislocation. ttt. by ORIF and primary arthrodesis of the medial 3 TMT joints by screws and 2 K-wires for fixation of 4th and 5th TMT joints	Sudeck's atrophy	15	82
38 (M)	Fall from a height	7	Comminuted fracture dislocation of 2nd metatarsal base ttt. by ORIF and primary arthrodesis of the 2nd TMT joint by 2 screws, one between the 2nd metatarsal base and medial cuneiform and the other between the 2nd metatarsal base and middle cuneiform	Forefoot stiffness	10	84
24 (M)	RTA	7	Comminuted Lisfranc fracture dislocation. ttt. by ORIF and primary arthrodesis of medial 3 TMT joints by screws and 2 K-wires for fixation of 4th and 5th TMT joints	None	6	83

M, male; ORIF, open reduction and internal fixation; RTA, road traffic accident; TMT, tarsometatarsal.

patients were followed up. A total of eight patients had an anatomical reduction, that is, less than 2-mm displacement at tarsometatarsal joints or diastasis between the first and second metatarsal bases. Moreover, two patients had a near anatomical reduction owing to severe comminution of the metatarsal bases.

All patients at follow-up showed solid union, which was confirmed clinically and radiographically (Fig. 4). Complications recorded were as follows: three patients had a postoperative Sudeck's atrophy and were completely cured after 2 months. They were treated by encouragement of weight bearing, NSAIDs, hot fomentations, and physiotherapy. One patient who developed superficial wound problem was treated by wound dressing and antibiotic till the wound was completely cured. There were two patients who had forefoot stiffness and difficulties in shoe wearing (Table 2).

Discussion

Although tarsometatarsal injuries (Lisfranc fracture dislocation) are rare, they carry considerable potential for long-term disability. In polytrauma patients, significant disability is often produced by neglected foot fracture dislocation after the major fractures are healed [16].

Despite anatomic reduction, a high percentage of patients developed post-traumatic arthritis of the tarsometatarsal joints [17]. In a study by Mulier *et al*. [16], there were 16 patients from 31 patients who had a fracture dislocation of the tarsometatarsal joint complex and were treated surgically with an excellent anatomical reduction. They developed symptomatic degenerative arthritis, indicating that the injury itself may produce traumatic chondrolysis.

Here in this study, which was done on 10 patients, the clinical outcome using the AOFAS midfoot sore system was 81.7 (range, 79–84). All patients were followed up with a follow-up period of 21.3 months (range, 6–36 months). Complications met in this study were as follows: three patients had a postoperative Sudeck's atrophy, one patient developed superficial wound problem, and two patients had forefoot stiffness and difficulties in shoe wearing. Comparing this result with the study by Ly and Coetzee [18], which used the same surgical technique as in this study and was performed on 21 patients achieved anatomical reduction in 20 patient using the AOFAS score with a follow-up period of 2 years and an average clinical score of 88. The complications reported were hardware removal in four patients, nonunion treated by bone graft in one patient, and a flexor tendon release after compartmental syndrome in one patient.

Open reduction and primary arthrodesis of severe 'bony or ligamentous' Lisfranc fracture dislocation seems to be a logical operation for those fractures which were famous for their high affinity for post-traumatic arthritis and subsequent need for a second operation. This result is compatible with the results of Henning *et al*., 2009 [19], and Ly and Coetzee, 2006 [18].

Conclusion

Lisfranc injuries can be a life-changing experience for anyone. They are often misdiagnosed and difficult to treat. These injuries result in high predictable osteoarthritis and take complaint nonweight-bearing to heal. However, if handled properly, various treatment options can allow patients to return to a preoperative activity level. It is important for podiatric physicians to be well versed in Lisfranc injuries, who represent the frontline for both diagnosis and treatment. Primary arthrodesis looks a logical operation for those having severe comminuted Lisfranc fracture dislocation who will definitely need a further operation to treat a complicating severe tarsometatarsal joint osteoarthritis.

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Conflicts of interest

The authors declare no conflicts of interest.

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