The Treatment of Lisfranc Injuries: Review of Current Literature

Thomas Mulier[1], Julien de Haan[1], Pieter Vriesendorp[1], Peter Reynders[2]

Abstract

Tarsometatarsal or Lisfranc fracture dislocations (LFD) are rare, easily overlooked, and lead to long-term disability. Recognition of such injuries is important so that adequate treatment can be provided. As many as 20% of LFD are either misdiagnosed or overlooked, and these can be a permanent source of pain in polytraumatic patients after the major fractures have healed. It is important to distinguish pure Lisfranc joint dislocations (LD) from LFD and Chopart–Lisfranc dislocations (CLFD). Here, we discuss the protocols for treating these different types of injury.

Key Words

Lisfranc dislocation · Lisfranc fracture dislocations · Tarsometatarsal fracture dislocation

Eur J Trauma Emerg Surg 2010;36:206–16

DOI 10.1007/s00068-010-1034-5

Introduction

Lisfranc fracture dislocations (LFD) or fracture dislocations of the tarsometatarsal joint are rare, easily overlooked, and can lead to long-term disability. It is important to recognize such injuries so that adequate treatment can be provided. This recognition is important given the fact that as many as 20% of such injuries are either misdiagnosed or overlooked, possibly becoming a permanent source of pain, such as in patients suffering from polytraumatic injuries, after the major fractures have healed [1–7].

LFD occur at the rate of one person per 55,000 population per year and result from direct and indirect forces acting on or through the Lisfranc joint. If overlooked, or not treated correctly, Lisfranc injuries can and frequently will result in the loss of function and painful malunion [8–10]. The deformities depend on the type of primary injury and can vary widely, but planus or planovalgus deformities associated with forefoot abduction are the most common, although cavus deformities with forefoot adduction may also be present [8–10].

The treatment options reported in the literature vary from closed reduction or closed reduction and percutaneous pinning in simple dislocations to open reduction and temporary screw fixation, screw fixation combined with external fixation, and primary arthrodesis in severe fracture dislocations [11–26]. To determine the optimal type of treatment, the health care provider must be able to distinguish between LFD and primarily ligamentous Lisfranc joint dislocations (LD) [16, 17] as the treatment protocols are different for these two types of injury. Closed reduction is not sufficient to achieve anatomical reduction in the majority of LFD because of interposed soft tissue and small bony fragments from fractures of the base of the metatarsals. However, a correct anatomical reduction can be considered to be critical for optimal outcomes, and this can best be achieved with open reduction and internal fixation. Primary arthrodesis may be considered in patients with purely ligamentous LD [16, 17]. The outcome will be significantly poorer if operative treatment is delayed for more than 6 months [21]. However, even with accurate diagnosis and early treatment, these injuries can result in chronic disability. Rammelt et al. noted that even with appropriate treatment, some patients will develop painful osteoarthrosis, necessitating conversion to an arthrodesis of the tarsometatarsal joints to relieve the pain [21].

Anatomy of the Lisfranc Joint

Anatomy plays an important role in the injury patterns [5, 6, 9, 27–29]. The second metatarsal is firmly keyed into a tight articulation with the five adjacent bones.

[1] Department Orthopedic Surgery, H. Hartziekenhuis, Leuven, Belgium,
[2] Department of Traumatology, University Hospitals Leuven, Leuven, Belgium.

Received: February 12, 2010; revision accepted: May 7, 2010; Published Online: June 1, 2010

This mortise effect is considered to be the primary stabilizer of this area. Several factors contribute to the stability of the Lisfranc joint. The arch configuration of the joint in the coronal plane is created by the trapezoidal shape of the cuneiforms and metatarsals; this configuration resists dorsal displacement.

The bony architecture contributes to stability because of the keystone effect of the base of the second metatarsal, which is recessed between the medial and lateral cuneiforms [5, 6, 9].

This stability is further enhanced by dorsal and plantar transverse ligaments and by the intermetatarsal ligaments. However, there is no intermetatarsal ligament between the bases of the first and second metatarsals. The first metatarsal is secured only to the medial cuneiform, while the second metatarsal is secured to the medial cuneiform by the strong oblique Lisfranc ligament. Because of the bony architecture and strong plantar ligaments, the bases of the metatarsals are much more likely to displace in a dorsal rather than plantar direction. In addition to the weak dorsal and strong plantar ligaments, interosseus ligaments also contribute to Lisfranc joint stability [5, 6, 9].

Mechanism of Injury

Most Lisfranc injuries are the result of an indirect mechanism of injury: 80% of patients suffer indirect injuries and 70% of those with LFD sustain multiple injuries or qualify as polytraumatic [9, 19, 29]. When the foot is forced into maximum plantar flexion, the weaker dorsal ligaments will tear and allow dorsal dislocation and fracture of the plantar aspect of the metatarsal bases. Additional forces will shift the metatarsals on the tarsus, producing abduction and lateral displacement, with compression fractures of the tarsal bones, Chopart's joint, and the subtalar joint (Lisfranc joint complex fractures) [8, 24]. Direct crushing injuries (e.g., by a car tire or a heavy object falling on the foot) account for a smaller proportion of midfoot trauma. These lead more frequently to plantar dislocation (60%) or dorsal dislocation (40%).

The pattern of injury varies with the point of application and the direction of the deforming force [19]. Twenty percent of patients with Lisfranc injuries have isolated ruptures of the Lisfranc ligament [30–32]. These injuries are caused by a combination of external rotation and full pronation of the forefoot and primarily occur as sports injuries in athletes [30]. About 30% have associated foot lesions in Chopart's joint and (less frequently) in the subtalar or tibiotalar joint [8, 24]. Most of LFD occur in males (60–70%) with a mean age of 31 years [19, 29].

Classifications

Quenu and Kuss [33] divided the LFD into three groups based on radiographic findings: homolateral, isolated, and divergent (Figure 1). Hardcastle et al. [34] popularized this classification, which was further modified by Myerson et al. [19]:

- Type A: Total incongruity in any plane or direction.
- Type B: Partial incongruity/homolateral incomplete. This was divided into type B1, which affects the medial articulation alone, and type B2, which affects the lateral articulation alone.
- Type C: Divergent/total or partial displacement when the medial and lateral metatarsals are displaced in opposite directions and opposite planes. This was further divided into whether all four (type C2) or fewer metatarsals are displaced (type C1).

However, this classification is not very useful in the more subtle Lisfranc injuries. Therefore, Nunley et al. described a new classification involving stages I–III [30], which is mainly used in athletes or partial LI (Figure 2a to 2c). This classification is mainly based on clinical examination, X-rays, bone scan, computed

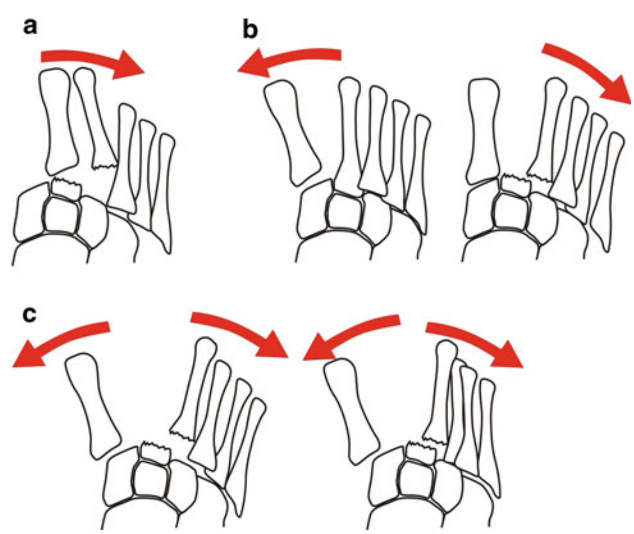

Figure 1. Classification of Lisfranc fracture dislocations according to Hardcastle and Qeunu [33, 34]. Type A: total incongruity in any plane or direction. Type B: partial incongruity. Left (type B1): Affects the medial articulation alone; right (type B2): affects the lateral articulation alone. Type C: Divergent/total or partial displacement when medial and lateral metatarsals are displaced in opposite directions.

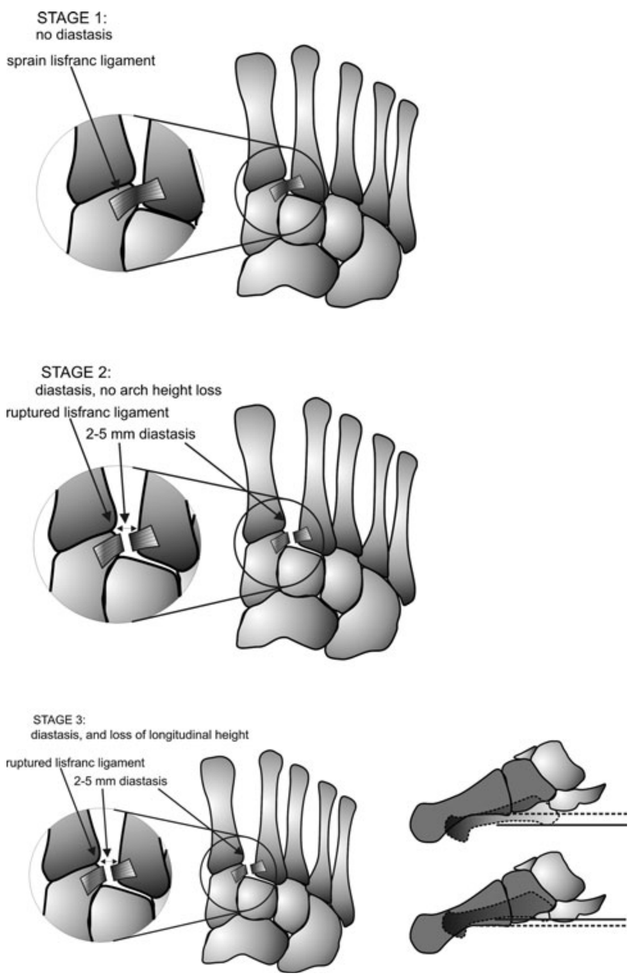

Figure 2a to 2c. Nunley et al. [30] described a new classification based on three stages (I–III), which is mainly used in athletes or partial Lisfranc injuries. It is mainly based on clinical examination X-rays, bone scan, computed tomography scan, and magnetic resonance imaging investigations. a) Stage I is a sprain to the Lisfranc ligament with no diastasis or arch height loss seen on radiographs, but increased uptake on bone scintigrams. b) Stage II sprains have a first to second intermetatarsal diastasis of 1–5 mm because of failure of the Lisfranc ligament, but no arch height loss. c) Stage III sprains display first to second intermetatarsal diastasis and loss of arch height, as represented by a decrease or inversion of the distance between the plantar aspect of the fifth metatarsal bone and the plantar aspect of the medial cuneiform bone on an erect lateral radiograph.

tomography (CT) scan, and magnetic resonance imaging (MRI) investigations. Stage I is a sprain to the Lisfranc ligament with no diastasis or arch height loss seen on radiographs, but increased uptake on bone scintigrams. Stage II sprains have a first to second intermetatarsal diastasis of 1–5 mm because of failure of the Lisfranc ligament, but no arch height loss. Stage III sprains display first to second intermetatarsal diastasis and a loss of arch height, as represented by a decrease or inversion of the distance between the plantar aspect of the fifth metatarsal bone and the plantar aspect of the medial cuneiform bone on an erect lateral radiograph [30].

Diagnosis

Fractures and dislocations of the tarsometatarsal (Lisfranc) joint are frequently overlooked or misdiagnosed [1–10], primarily due to the low incidence of these injuries and the wide variations in the pattern of injury and clinical presentation. There is currently a lack of knowledge of the specific clinical signs and radiological projections of such injuries. Furthermore, tarsometatarsal injuries are often seen in patients with multiple injuries [9, 19, 21]. The importance of careful physical and radiological examination of these patients cannot be overestimated because as many as 20% of such injuries are missed at initial presentation [6, 7, 9, 10]. Strong pain and swelling compared to ''normal'' radiographs should alert the treating physician of a potential LI. A toe dislocation may be an indirect consequence and pathognomonic sign of a Lisfranc injury [3, 9].

Physical examination reveals swelling and tenderness of the forefoot and a typical ecchymosis on the plantar aspect of the midfoot [9].

Radiographic Assessment

Diagnosis is made with standard radiographs: anteroposterior, lateral, and oblique radiographs (Figure 3).

Alignment is assessed on the basis of whether the medial border of the second metatarsal lines up with the medial border of the middle cuneiform on the anteroposterior radiograph, whether the medial border of the fourth metatarsal lines up with the medial border of the cuboid on the oblique radiograph, and whether there is any dorsal displacement of the metatarsals relative to the tarsal bones on the lateral radiograph.

A number of radiographic findings are characteristic of Lisfranc injuries [5, 9, 12, 19, 21, 28, 29, 31, 32]:

(1) Tthe Lisfranc fracture or fleck sign, in which an avulsion is seen at the base of the second metatarsal or from the medial cuneiform
(2) Widening (>2.5 mm) between the first and second metatarsals or between the bases of the respective metatarsals
(3) Impaction fractures of the cuboid, medial cuneiform, and navicular bone

Figure 3. Typical radiological signs in Lisfranc injuries: (1) Lisfranc fracture or fleck sign, in which an avulsion is seen at the base of the second metatarsal or from the medial cuneiform, and (2) the widening (>2.5 mm) between the first and second metatarsals or between the bases of the respective metatarsals.

(4) The medial cuneiform needs to be dorsal to the base of the fifth metatarsal on a normal lateral weight-bearing film. Flattening of the longitudinal arch is more indicative of a poor prognosis and considered to be an indication for open reduction
(5) In subtle injuries: weight-bearing radiography films of the injured and uninjured foot to assess the diastasis between first and second metatarsals (<2.6 mm)
(6) Dynamic examinations under fluoroscopic guidance can demonstrate ligamentous injuries that are difficult to diagnose on standard or weight-bearing radiographs.If non-weight-bearing radiographs in the exact projections are inconclusive and a subtle injury is suspected, abduction/adduction stress views may be carried out under sedation or local anaesthesia
(7) Linked toe dislocation sign [9]

Computed tomography Scan, Magnetic Resonance Imaging, Bone Scan

The CT scan is highly recommended for the evaluation and surgical planning of all complex injuries (scan direction: cranio-caudal, slice thickness 1 mm) [5, 9] (Figure 3). The excellent three-dimensional imaging capabilities of the present CT apparatuses have improved understanding of complex fracture dislocation patterns of the tarsometatarsal joints and allow presurgical planning. MRI has been reported to enable visualization of the Lisfranc ligament disruption, especially in patients with subtle injuries. Bone scintigraphy is a sensitive method for evaluating bone injury because it can show minor metabolic and blood flow changes when the findings of other imaging modalities are normal. It is mainly used to diagnose subtle injuries of the Lisfranc ligament complex and is 100% sensitive in Nunley stage I injuries [30].

Treatment

Closed Reduction and Cast Application

Closed reduction and cast application methods have been commonly used in the past. Longitudinal traction and counter traction are applied, while a general or spinal anesthetic is administered. Manipulation of the forefoot is required in addition to traction. The inherent instability of the injury and intervening soft tissues often makes it difficult to obtain a good reduction in all planes of displacement. A non-weight-bearing cast is applied for 4–6 weeks, with the patients subsequently advanced to a full weight-bearing in a walking boot for a period of 4–6 weeks.

This type of treatment is mainly used in patients with contraindications for more aggressive treatment.

Closed Reduction and Internal Fixation

Closed reduction and internal fixation involves the same approach as that described above, but, in addition, small amounts of residual diastasis between the first and second metatarsals can be reduced with percutaneous reduction clamps.Closed reduction and percutaneous fixation can be recommended for isolated injuries to the first and second tarsometatrsal joint. Lag screw fixation can be used with a 3.5-mm cannulated screw directed from the medial cuneiform into the metaphysics of the second metatarsal. Radiographs need to be obtained to assess the accuracy of reduction.

Open Reduction and Internal Fixation

The first and second tarsometatarsal joints are addressed through a single dorsal incision over the first intermetatarsal space. The branches of the superficial and deep peroneal nerves and the dorsalis pedis artery are preserved, and the first and second metatarsocu-

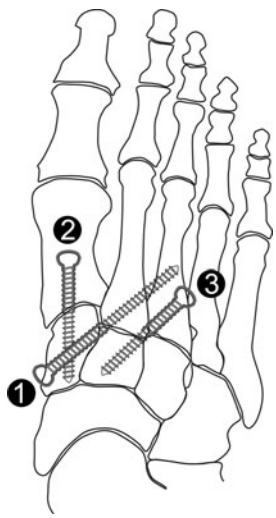

Figure 4. Open reduction and temporary compression screw fixation of the tarsometatarsal joints. The first compression screw is standardly placed from the medial cuneiform to the base of the second metatarsal, while the second screw is placed from the base of the first metatarsal to the medial cuneiform. The third screw is placed from the base of the third metatarsal in an oblique direction to the second cuneiform. The lateral tarsometatarsal joints should be left free or only be stabilized with K-wires.

neiform joints are opened and irrigated. Comminuted fragments are reduced when possible; smaller, irreducible fragments are removed. The first tarsometatarsal joint is aligned by reducing the medial border of the medial cuneiform to the medial border of the first metatarsal. The plantar-medial aspect of the joint is directly visualized to ensure that there is no plantar gap. Figure 4 is a schematic representation of the open reduction and internal fixation

The joint is reduced with a provisional Kirschner wire, and then one 3.5-mm transarticular countersunk cortical set screw is inserted from the metatarsal base proximally into the medial cuneiform, with care being taken to avoid violating the adjacent naviculocuneiform joint. If instability persists, an additional 3.5-mm screw can be placed from proximal to the distal and lateral to the first screw to add rotational stability. The second metatarsal is then reduced to the medial border of the middle cuneiform and is held provisionally with a Kirschner wire. A 3.5-mm countersunk cortical screw is placed from distal to proximal across the joint. An additional 3.5-mm countersunk cortical set screw (the Lisfranc screw) is inserted under biplanar fluoroscopy from the medial cuneiform into the base of the second metatarsal to increase the stability of the fixation. This Lisfranc screw is best placed in the line of the interosseous Lisfranc ligament [4–6, 17, 20, 22, 23, 27].

When the third metatarsal base is dislocated, a second dorsal incision is made between the third and fourth metatarsals to expose the third metatarsocuneiform joint. This joint is reduced and stabilized with a countersunk 3.5-mm screw from a distal to a proximal direction.

The fourth and fifth tarsometatarsal joints usually reduce once the above three reductions are achieved and are held with one or two transarticular percutaneous smooth (non-treaded) Kirschner wires from the base of the fifth metatarsal into the cuboid. Open reduction of these lateral two joints is seldom required.

In case of excessive comminution or persistent instability, supplementary smooth (non-treaded) Kirschner wire fixation, supplementary 2.7-mm cortical screws, or a joint-spanning one-quarter tubular plate (usually because of comminution of the second metatarsal base) can be used.

Associated cuneiform or cuboid fracture may require reduction and fixation with Kirschner wires, screws, a plate and screws, or a combination of these implants.

The alignment of the fractures and tarsometatarsal joints and the position of the implants are checked with fluoroscopy and intra-operative radiographs. Each foot is also examined clinically after fixation to assess the stability of the medial and lateral columns. Plantar alignment of the metatarsal heads is also checked. A short leg splint is applied at the end of the procedure, with the ankle in the plantigrade position. It is worn for 2 weeks, and then a short leg non-weight-bearing cast is worn for an additional 4 weeks. At 6 weeks post-surgery, the percutaneous lateral Kirschner wires are removed. The patients are then advanced to full weight-bearing in a walking boot for a period of 4–6 weeks. The internal fixation is removed only if it is painful. Insoles are used during the first two postoperative years.

Primary or Secondary Arthrodesis

The same approach and incision are used in primary arthrodesis [15] (Figure 5). First, the articular cartilage is removed from the opposing surfaces of the joints with curettes and rongeurs. A saw must be avoided because of the detrimental thermal effect on the bone.

The first tarsometatarsal joint is at a depth of 28–34 mm and must be exposed completely to avoid the tendency to fuse it in dorsiflexion [17]. The surfaces are prepared after removing the cartilage but leaving as much of the subchondral bones as possible.

After reduction is obtained, stabilization is achieved using 4.5-mm cancellous or countersunk cortical screws placed from distal to proximal in the first, second, and third tarsometatarsal joints. If the fourth and fifth tarsometatarsal joints are unstable, reduction is performed under fluoroscopy and stabilized with 2-mm K-wires [15, 17, 18, 20, 23, 25, 26]. Postoperatively, a splint is given for 2 weeks, followed by 4 weeks of non-weight-bearing cast. Partial weight bearing is started on a bunion shoe after 6 weeks, often

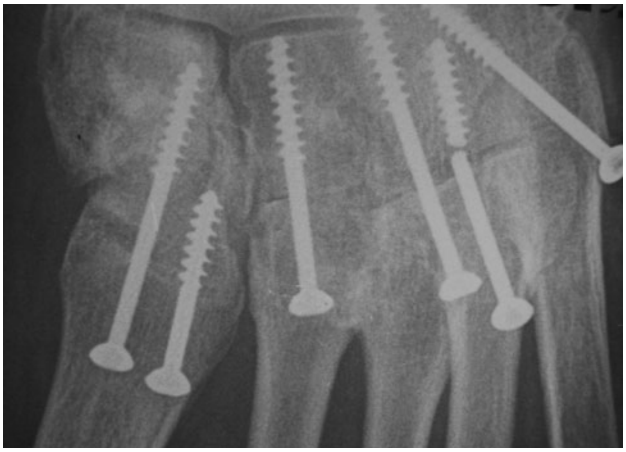

Figure 5. Primary arthrodesis. Primary arthrodesis is performed in (1) severely comminuted fractures (Lisfranc fracture dislocations) where reconstruction of the tarsometatarsal joint is not possible and (2) pure Lisfranc dislocations (LD) where open reduction and internal fixation results in high percentages of post-traumatic arthritis. Note: the breakage of the lateral screw; the lateral tarsometatarsal joints should be left free or only be stabilized with K-wires.

depending upon the associated lower limb injuries. Full weight-bearing is allowed after 10 weeks. K-wires are removed at 6 weeks, before weight-bearing is started.

Discussion

Diagnosis and treatment of Lisfranc joint dislocations, and especially Lisfranc joint fracture dislocations, are still problems in trauma care and influence the functional outcome of the entire foot in the mid- and long-term follow-up [1–10]. In particular, the Chopart–LFD results in a high degree of residual impairment [8]. However, even in this type of injury, an early anatomic open reduction and optimal internal stabilization have been found to improve the final outcome [8].

Published results indicate 34–80% of LFD cases have good treatment outcomes [19, 29].

We performed two review studies in 1997 and 2002 on LFD [20, 29]. The 1997 study was a retrospective study in which we compared the outcomes of four different treatment methods (closed reduction, closed reduction and percutaneous pinning, open reduction and temporary screw fixation, and primary arthrodesis) in 52 patients with LFD [29]. The 2002 study was a surgeon-randomized study [20] in which we compared the results after open reduction and internal fixation (16 patients) with those using primary arthrodesis (12 patients) in cases of severe LFD. These two studies led to the following conclusions:

- Patients with direct injuries (crush) and patients with additional midfoot injuries seem to fare less well than those with indirect or isolated tarsometatarsal injuries.
- The best results were obtained in patients treated with open reduction and temporary screw fixation and in patients with percutaneous K-wire fixation, if applicable.
- Internal fixation is often necessary because of the high incidence of redislocation or treatment failure after percutaneous K-wire fixation.
- Degenerative changes after open reduction and internal fixation were more frequent after screw fixation than after K-wire fixation. This may be partially explained by the more severe initial injury pattern in these patients. These degenerative changes did not seem to influence the functional results, as long as the lateral tarsometatarsal joints were not involved. The degenerative arthritis did not progress in time (mean follow-up 3–4 years), but a longer follow-up may be necessary to assess temporary screw fixation as the treatment of choice in Lisfranc injuries.
- The type of lesion did seem to influence the final results. Hardcastle type A, B2, and C1 lesions scored better than type B1 and type C2 [29].
- The quality of the reduction was more important in our series than the type of treatment per se. Within each of the four different treatment groups, all patients with excellent or good reductions attained acceptable clinical results.
- The major goal was to obtain a stable anatomical reduction by whatever means possible. Of our patients with good long-term results following open reduction and screw fixation, 86% had a reduction which was considered excellent or good, while none of the poor results had a good or excellent reduction [29].
- Trauma of the joint per se was also important. Despite anatomic reduction, a portion of these patients developed posttraumatic arthritis of the midfoot [19–21]. Of our patients with an excellent reduction, 16% developed symptomatic degenerative arthritis and poor clinical results, indicating that the injury itself may produce traumatic chondrolysis.
- In general, the reported rate of posttraumatic arthritis was variable, ranging from 25 to 50% [4, 21, 29]. In all our patients, posttraumatic arthritis was present to some degree.
- Arthritis has been attributed to articular damage at the time of injury and has been related to the degree of articular surface communition identified at surgery. The radiological presence or absence of

Table 1. Studies comparing primary arthrodesis and ORIF in Lisfranc fracture dislocations. ORIF: Open reduction internal fixation; PA: primary arthrodesis; SD: secondary arthrodesis; NA: not available.

Author	Group (ORIF, PA, SD)	Number of patients	Mean follow-up (months)	Average midfoot AOFAS score[a]	Percentage of posttraumatic arthritis
Richter et al. [7]	ORIF	85	108	72	38
	PA	10			-
	SA				-
Kuo et al. [16]	ORIF	42	52	80.2	15
	SA	6	52	58	100
Mulier et al. [20]	ORIF	16	30	78	94
	PA	12	30.5	65	-
Ly and Coetzee [17]	ORIF	21	42.5	68.6	NA
	PA	21	42.5	88	-
Rammelt et al. [21]	ORIF	22	37	81	NA
	SA	22	35	71	-

[a]The AOFAS (American Orthopaedic Foot and Ankle Society score is based on a scale of 0–100 points, with 100 points indicating an excellent or maximum outcome [36]

arthritis often shows little correlation with functional outcome or subjective rating [6, 19].

Based on our literature review of LFD treatment options, we recommend that the points in the following sections be taken into consideration.

Open Reduction and Internal Fixation

Anatomical reduction and stable internal fixation has become a standard principle governing treatment of tarsometatarsal fracture-dislocations. Most authors are in agreement that stable anatomical reduction leads to optimal results [5, 15–17, 19] (Table 1). Kuo et al. [16] support this concept as patients in their study with anatomical reduction had a significantly better average American Orthopaedic Foot and Ankle Society (AOFAS) score ($p = 0.05$) and a significantly lower prevalence of secondary osteoarthritis ($p = 0.004$). The advantage of open reduction is that it allows direct visualization of the fracture-dislocation for the debridement of comminuted fracture fragments, soft tissue, and osteochondral debris. This facilitates precise reduction of the injury.

The choice of whether to use K-wires or screws for internal fixation after the open reduction of tarsometatarsal fracture-dislocations is controversial [21], with some authors preferring K-wire fixation, while others opt for screw fixation. Although a few reports show a slightly higher failure rate after K-wire fixation, there is no clear evidence indicating the superiority of one method of treatment over the other. On the other hand, Rammelt et al. have shown no difference in outcome between patients treated with K-wires and screws, and no loss of correction after K-wire fixation. These authors preferred K-wires in patients with multiple injuries, in cases in which the condition of the soft tissues is critical, and when comminuted fractures of the metatarsal bases do not allow adequate purchase for a screw [21].

There is as yet no clear evidence on how long to maintain fixation after primary open reduction. K-wires are usually removed after 8 weeks, but screws are left in place for 3–36 months, and some authors even advocate their removal only in symptomatic patients. Rammelt et al. [21] propose that 8 weeks of fixation is sufficient to maintain reduction.

Primary Arthrodesis

Open reduction and internal fixation is the most recommended treatment option for Lisfranc joint injuries (Table 1). However, because persistent pain and posttraumatic degenerative changes occur despite anatomic reduction, Ly and Coetzee [17] speculated that there may be a subset of Lisfranc injuries that are better treated with primary arthrodesis of the involved tarsometatarsal joints. These authors postulate that, if the injuries are primarily ligamentous, healing of the ligaments and capsules provide insufficient strength to maintain the initial reduction. In their study, this hypothesis was supported by the fact that, despite initial anatomic reduction in 18 of the 20 patients, some loss of correction, further collapse, and degenerative changes of the Lisfranc joint developed after screw removal in 15 patients.

In one of our studies, we compared open reduction and internal fixation (16 patients) with complete arthrodesis (6 patients) and partial arthrodesis (6 patients) [20]. Based on our results, we concluded that a complete fusion (of all 5 tarsometatarsal joints) yields poor results and that open reduction and internal fixation provides a better functional outcome. We reported that, at the time of final follow-up (at 30 months), 94% of the open-reduction group already had radiographic signs of degenerative changes of the tarsometatarsal joints. At that juncture, the open-reduction group had the same functional score as the group treated with partial fusion, but it can be assumed that the score in the open-reduction group would decrease with time because of the high rate of identified degenerative changes [20].

In summary, because of the poor healing potential of the ligament–osseous interface and the trend toward a higher rate of loss of correction, increasing deformity, and degenerative arthritic changes, primarily ligamentous injuries are a subset of Lisfranc joint injuries that are not as amenable to internal fixation [16, 17, 21]. Stable arthrodesis may be a better primary treatment for these injuries, with superior short and medium-term outcomes than those following open reduction and internal fixation.

Secondary Corrective Arthrodesis

Rammelt et al. [21] reviewed a group of 20 patients with Lisfranc dislocations where secondary arthrodesis was performed because of persistent pain (Table 1). Secondary corrective arthrodesis resulted in a significant reduction of pain and an improvement in function after initially overlooked or misdiagnosed tarsometatarsal fracture dislocations, which is in accordance with earlier studies [16, 18, 26]. Fusion of the tarsometatarsal joint resulted in increased stiffness of the midfoot, whereas K-wires and screws were removed after 8 weeks in the primary treatment group. However, the latter procedure may lead to more residual pain and functional impairment in the arthrodesis group, such as difficulty in walking over uneven ground and alterations in footwear.

The high satisfaction rate in 18 of the 20 patients in the secondary arthrodesis group despite inferior functional results may be attributed to the relief of pain and significant functional improvement compared to the pre-operative state.

The experience of a painful disability and the resulting socioeconomic costs should not be underestimated in these patients. Therefore, a wait-and-see attitude should not be adopted when dealing with these injuries.

Lisfranc Injuries in the Athlete

Athletic injuries are currently classified in the classification system developed by Nunley et al. [30] that is based on clinical findings, weight-bearing radiographs, and bone scintigram results (Figure 2a–2c). This system categories such injuries into three stages. Midfoot sprains in athletes represent a lower velocity injury, with no displacement or subtle diastasis. The most common mechanisms of Lisfranc complex injury in athletes typically occur when an axial load is sustained by the foot when it is plantar flexed and slightly rotated. Complete disruption of the Lisfranc ligament and associated capsuloligamentous structures leads to varying degrees of tarsometatarsal separation. The most common type of injury in athletes is the partially incongruent injury with either medial or lateral dislocation. Partial Lisfranc complex injuries cause significant pain and disability and, if not appropriately treated, lead to significant loss of an athlete's function. Weight-bearing radiographs and bone scintigrams are sensitive, reproducible, and relatively inexpensive methods for investigating these injuries. Rapid and accurate diagnosis is essential if the athlete is to return to successful play [30, 31].

Nunley et al. recommend non-operative management for stage I injuries (undisplaced) and anatomic reduction and fixation for stage II (diastasis with no arch height loss) and stage III (diastasis with arch height loss) injuries. Restoration and maintenance of the anatomic alignment of the Lisfranc joint is the key to appropriate treatment of injury to the midfoot [30].

Neuropathic Lisfranc Fracture Dislocations and Acute Lisfranc Fracture in Diabetic Patients

It is important to differentiate an acute neuropathic fracture from an acute fracture in a patient that has a diabetic peripheral neuropathy [9].

Acute fractures of the midfoot in a diabetic may be treated with the same indications and techniques for open reduction and internal fixation as in a non-diabetic patient, assuming that the patient is medically fit, vascular status is adequate, and the skin is in a good condition. Stable rigid internal fixation is the treatment of choice.

Patients with acute neuropathic fracture with early demineralization and soft tissue inflammation are poorer candidates for surgical treatment.

It is important to extend the length of immobilization to double or triple the normal length that the patient would otherwise be non-weight bearing. Therefore, the typical diabetic Lisfranc fracture would be kept non-weight bearing for approximately 3 months (as opposed to 6 weeks), and casting would continue until approximately 4–5 months following the injury. Bracing of the foot is therefore used for 1 year following the injury to prevent the late development of a neuropathic joint [9].

Compensation Costs

Calder et al. [35] reviewed a series of 32 patients with LFD. Based on their study, they state that it is important to note that those patients who pursue compensation claims following surgery for displaced Lisfranc injuries have a poor prognosis, independent of any other factors, such as age, type of injury, and gender. This should be borne in mind when predicting the outcome following surgery for Lisfranc fracture/dislocations in medico-legal reporting.

This finding also has important implications for healthcare work coverage and/or companies responsible for schemes aimed at returning such patients to full employment, as the average Workcover payment was more than $50,000 (approximately €37,000) [35].

Conclusion

(1) The diagnosis and treatment of Lisfranc joint dislocations (LD), and especially Lisfranc joint fracture dislocations (LFD) are problematic in trauma care and influence the functional outcome in the mid- and long-term follow-up.
(2) It is important to distinguish subtle Lisfranc injuries in athletes (LI) from pure LD, LFD, and Chopart–Lisfranc dislocations (CLFD). Treatment protocols are different in these different types on injury.
(3) Conservative treatment is unacceptable in severe fracture-dislocations. Open reduction and temporary screw or K-wire fixation is the treatment of choice in severe fracture-dislocations (LFD and CFLD). The quality of the initial reduction is the major determinant for obtaining an excellent end result.
(4) Stable arthrodesis appears to be a better primary treatment option for primarily ligamentous Lisfranc injuries (LD)
(5) Rapid, accurate diagnosis and treatment of LI is essential if the athlete is to return to play.
(6) Delaying the treatment of LFD will lead to significantly inferior results, resulting in a painful disability and high socioeconomic costs.

Conflict of interest statement

The authors declare that there is no actual or potential conflict of interest in relation to this article.

References

1. Goosens M, De Stoop N. Lisfranc fracture-dislocations: aetiology, radiology and results of treatment. Clin Orthop Rel Res 1986;176:154–62.
2. Resch S, Stenström A. The treatment of tarsometatarsal injuries. Foot Ankle 1990;11:117–23.
3. Arntz CT, Hansen ST. Dislocations and fracture-dislocations of the tarsometatarsal joints. Orthop Clin North Am 1987;18:105–14.
4. Arntz CT, Veith RG, Hansen ST. Fractures and fracture-dislocations of the tarsometatarsal joint. J Bone Joint Surg 1988;70A:173–81.
5. Hansen ST. Tarsometatarsal (Lisfranc), tarsal and intertarsal fracture-dislocations. In: Browner BD, Jupiter JB, Levine AM, Trafton PG Skeletal Trauma. Philadelphia: W.B. Saunders, 1992:1977–1981.
6. Myerson MS. The diagnosis and treatment of injuries to the Lisfranc joint complex. Orthopedic Clin North Am 1989;20:655–64.
7. Richter M, Thermann H, Hüfner T, Schmidt U, Krettek C. Aetiology, treatment and outcome in Lisfranc joint dislocations and fracture dislocations. Foot Ankle Surg 2002;8:21–32.
8. Randt T, Dahlen C, Schikore H, Zwipp H. Dislocation fractures in the area of the middle foot: injuries of the Chopart and Lisfranc joint. Zentralbl Chir 1998;123:1257–66.
9. Rutledge E, Templeman D, de Souza L. Evaluation and treatment of Lisfranc fracture dislocations. Foot Ankle Clin 1999;4:603–15.
10. Vuori JP, Aro HT. Lisfranc joint injuries: trauma mechanisms and associated injuries. J Trauma 1993;35:40–5.
11. Besse JL, Kasmaoui EH, Lerat J-L, Moyen B. Tarso-metatarsal fracture-dislocation: treatment by percutaneous pinning or open reduction (a report on 17 cases). Foot Ankle Surg 2005;11:17–23.
12. Chiodo CP, Myerson MS. Developments and advances in the diagnosis and treatment of injuries to the tarsometatarsal joint. Orthop Clin North Am 2001;32:11–20.
13. Hesp WL, van der Werken C, Goris RJ. Lisfranc dislocations: fractures and/or dislocations through the tarso-metatarsal joints. Injury 1984;15:261–6.
14. Kenzora JE, Edwards CC, Browner BD, Gamble JG, Desilva JB. Acute management of major trauma involving the foot and ankle with Hoffman external fixation. Foot Ankle 1981;1:348–61.
15. Komenda GA, Myerson MS, Biddinger KR. Results of arthrodesis of the tarsometatarsal joints after traumatic injury. J Bone Joint Surg Am 1996;78:1665–76.
16. Kuo RS, Tejwani NC, Hansen ST Jr, Sangeorzan BJ. Outcome after open reduction and internal fixation of Lisfranc joint injuries. J Bone Joint Surg Am 2000;82:1609–18.
17. Ly TV, Coetzee JC. Treatment of primarily ligamentous Lisfranc joint injuries: primary arthrodesis compared with open reduction and internal fixation: a prospective, randomized study. J Bone Joint Surg Am 2006;88-A:514–20.
18. Mann RA, Prieskorn D, Sobel M. Mid-tarsal and tarsometatarsal arthrodesis for primary degenerative osteoarthrosis or osteoarthrosis after trauma. J Bone Joint Surg Am 1996;78:1376–85.
19. 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.
20. Mulier T, Reynders P, Dereymaeker G, Broos P. Severe Lisfranc injuries: primary arthrodesis or ORIF? Foot Ankle Int 2002;23:902–5.
21. Rammelt S, Schneiders W, Schikore H, Holch M, Heineck J, Zwipp H. Primary open reduction and fixation compared with delayed corrective arthrodesis in the treatment of tarsometatarsal (Lisfranc) fracture dislocation. J Bone Joint Surg Br 2008;90-B:1499–506.

22. Sangeorzan BJ, Hansen ST. Early and late posttraumatic foot reconstruction. Clin Orthop 1989;243:76–91.
23. Sangeorzan BJ, Veith RG, Hansen ST. Salvage of Lisfranc tarsometatarsal joint by arthrodesis. Foot Ankle 1990;10:193–200.
24. Suren EG, Zwipp H. Acute ligamentous injuries of the Chopart and Lisfranc joint line. Orthopäde 1986;15:479–86.
25. Treadwell JR, Kahn MD. Lisfranc arthrodesis for chronic pain: a cannulated screw technique. J Foot Ankle Surg 1998;37:28–36.
26. Zwipp H, Rammelt S, Holch M, Dahlen C. Lisfranc arthrodesis after malunited fracture healing. Unfallchirurg 1999;102:918–23.
27. Trevino SG, Koudros S. Controversies in tarsometatarsal injuries. Orthopedic Clin North Am 1995;22:229–38.
28. Wiley J. The mechanism of tarsometatarsal joint injuries. J Bone Joint Surg 1971;53:474–82.
29. Mulier T, Reynders P, Sioen W. The treatment of Lisfranc injuries. Acta Orthop Belg 1997;63:82–90.
30. Nunley J, Vertullo C. Lisfranc injuries in the athlete. Am J Sports Med 2002;30:871–878.
31. Curtis MJ, Myerson M, Szura B. Tarsometatarsal joint injuries in the athlete. Am J Sports Med 1993;21:497–502.
32. Fasciszewski T, Burks RT, Manaster BJ. Subtle injuries of the Lisfranc joint. J Bone Joint Surg 1990;72A:1519–22.
33. Quenu E, Kuss G. Etude sur les luxations du metatarse. Rev Chir 1909;39:281–336.
34. Hardcastle PH, Reschauer R, Sschoffmann W. Injuries to the tarsometatarsal joint. J Bone Joint Surg 1982;64B:349–56.
35. Calder JD, Whitehouse SL, Saxby TS. Results of isolated Lisfranc injuries and the effect of compensation claims. J Bone Joint Surg Br 2004;86-B:527–30.
36. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux and lesser toes. Foot Ankle Int 1994;15:349–53.

Address for Correspondence
Thomas Mulier, MD
Department Orthopedic Surgery
H. Hartziekenhuis, Naamsestraat 105
3000, Leuven
Belgium
Phone (+32/16) 209 207, Fax -356
e-mail: tom.mulier@hhleuven.be

Appendix (Next page): Treatment Algorithm of Lisfranc Lesions

Appendix: Treatment Algorithm of Lisfranc Lesions