Lisfranc injuries: assessment, diagnosis and management

Lisfranc injuries are a specific group of injuries which lead to the instability of the Lisfranc joint. Instability results either through fracture–dislocations involving the base of the second tarsometatarsal, or through disruption of the Lisfranc ligament. The actual mechanism that leads to Lisfranc injuries can be either direct or indirect. Injuries can significantly impact the stability of the foot and, if missed, the consequences can be severe with resultant deformity that can cause long-term disability.

Lisfranc injuries are uncommon and account for 0.2% (frequency can vary from 0.1–0.9%) of all orthopaedic injuries (Aitken and Poulsen, 1963; English, 1964). Injuries vary widely in their presentation, and the bony architecture of the midfoot is difficult to interpret on plain radiographs thus making Lisfranc injuries challenging to diagnose and manage. This article illustrates the relevant biomechanics of the foot, the mechanism of the injury, and the treatment options to restore the anatomy and biomechanical function of the foot following injury.

Anatomy and biomechanics

The bony anatomy of the midfoot joints form a structure like a Roman arch (*Figure 1*). The concavity on the plantar aspect of the foot formed by this rigid bony configuration creates a protected space for neurovascular structures, preventing them from being compressed during weight-bearing activities. The articulation of the middle cuneiform with the second metatarsal is often described as the 'keystone'. A Lisfranc injury is the disruption to this keystone. Disruption can be a soft tissue injury, for example injury to the 'Y'-shaped ligament (named the Lisfranc ligament), or a bony injury to the base of the second metatarsal that can lead to a fracture–dislocation (Peicha et al, 2002).

It should be noted that there is no intermetatarsal ligament between the first and second metatarsal bones. The stability between these two metatarsi is provided by both the Lisfranc ligament, and the articulation of the proximal end of the second metatarsal with the middle cuneiform which is also recessed into a mortise by the medial and lateral cuneiforms (Peicha et al, 2002). The Lisfranc ligament is a strong ligament that connects the medial cuneiform and base of the second metatarsus on the plantar aspect of the foot; it provides stability between the medial and middle cuneiforms in addition to stability from the second metatarsal base to the medial cuneiform (*Figure 2*). The Lisfranc ligament maintains alignment between the metatarsal and tarsal bones. Disruption of this ligament causes instability at the keystone of the arch and therefore destabilizes the bony arch as a whole leading to its collapse. It is also important to consider that while the Lisfranc joint is an inherently stiff construction, there are micro-movements at the level of each joint, and the amount of mobility at the tarsometatarsal level increases from medial to lateral. This serves two main objectives:

1. It provides the stiffness needed for load transfer from the ankle to the toes
2. It allows an even load to be distributed between the metatarsal heads during the stance phase of gait (Ouzounian and Shereff, 1989).

Figure 1. The Roman arch concept: the importance of the keystone in the mid foot represented by the articulation of the second metatarsal base with the middle cuneiform (C2).

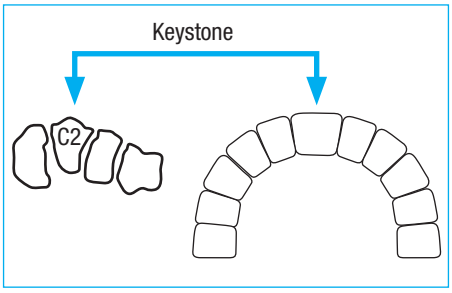
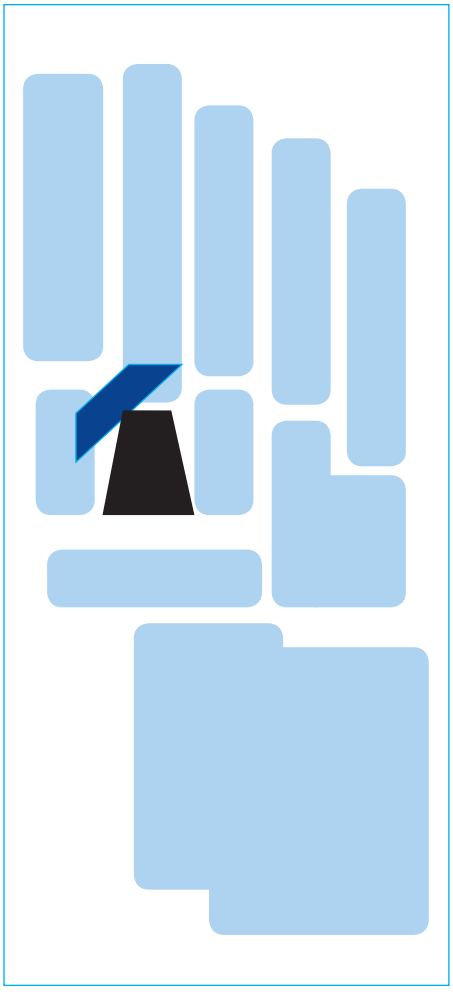


Figure 2. The Lisfranc ligament joining the base of the second metatarsal with the medial cuneiform on the plantar aspect of the foot.



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Aetiology

Lisfranc injuries are more common among men, and have a peak incidence at around 30 years of age. The actual mechanism can be either direct or indirect. Direct injuries, for example crush injuries, can cause significant variation in patterns of injury; these injuries are more likely to be associated with compartment syndromes. Indirect injuries result typically from an axial load applied to the longitudinal axis of the foot with an associated rotational and compressive force that act through a hyper-plantarflexed forefoot. This compression and valgus force leads to the metatarsal bases typically being displaced in a dorsal or lateral direction. Indirect injuries often result from sporting accidents, road traffic accidents or falls from height.

Clinical assessment

Patients with a Lisfranc injury will often present complaining of severe pain and inability to weight-bear. They often have swelling throughout the midfoot, and medial plantar bruising which is pathognomonic for Lisfranc injuries. Palpation may elicit tenderness over the tarsometatarsal joint. Crush injuries often present with a swollen foot, and these injuries can be associated with compartment syndrome. In these patients, the pain will be out of proportion to the clinical findings and there will be significant pain on passive flexion and extension. Occasionally, Lisfranc injuries may be subtle and have less severe symptoms on presentation.

Imaging and classification

Plain radiographs are the initial imaging of choice. There are five radiographic signs (*Figure 3*) associated with Lisfranc injuries and midfoot instability found on the anteroposterior, true lateral and oblique images:

1. Widening of the space between the first and second metatarsi (anteroposterior view)
2. Evidence of bony fragment in the first intermetatarsal interval (fleck sign; *Figure 3a*) (anteroposterior view) (Arntz et al, 1988)
3. Discontinuity of a line drawn from the medial base of the second metatarsal to the medial side of the middle cuneiform (anteroposterior view)
4. Dorsal displacement of the proximal base of the first or second metatarsal (lateral view; *Figure 3b*)
5. Failure of the medial side of the third and fourth metatarsi (*Figure 3c*) to line up with the lateral cuneiform and cuboid bones respectively (oblique view).

Weight-bearing views are recommended where possible. Standard plain radiographs provide a static image, but weight-bearing films provide an opportunity to assess dynamic instability. This is a valid test to assess for any diastasis between the first and second metatarsi bases (*Figure 4*). Further imaging such as computed tomography scans (*Figure 5*) is particularly helpful for operative planning as well as determining associated injuries that need to be addressed. Magnetic resonance imaging scans may be used to assess purely ligamentous injuries.

Figure 3. a. Anteroposterior X-ray of the foot showing the fleck sign. **b.** Lateral X-ray of the foot showing subtle dorsal displacement of the second metatarsal base. **c.** Oblique X-ray of the foot showing a lack of continuity at the third and fourth metatarsal bases.

Figure 4. a. Non-weight-bearing anteroposterior X-ray. **b.** Weight-bearing image of same patient demonstrating dynamic instability.

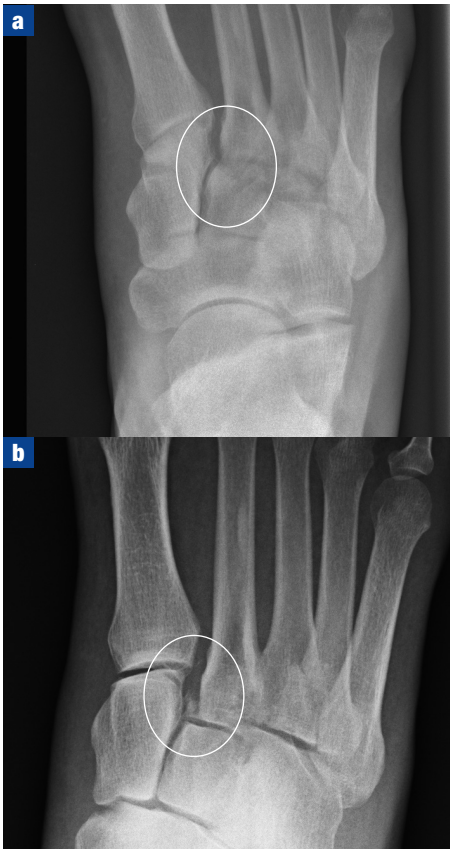


Figure 5. a. Computed tomography sagittal view showing dislocation at the tarsometatarsal joint which may have been missed on the lateral X-ray (*Figure 3b*). **b.** Axial computed tomography showing lateral displacement of metatarsi.

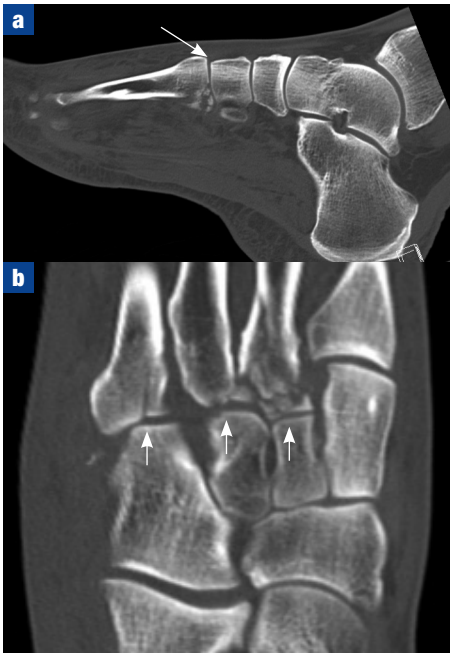


Figure 6. Quenu and Kuss classification.

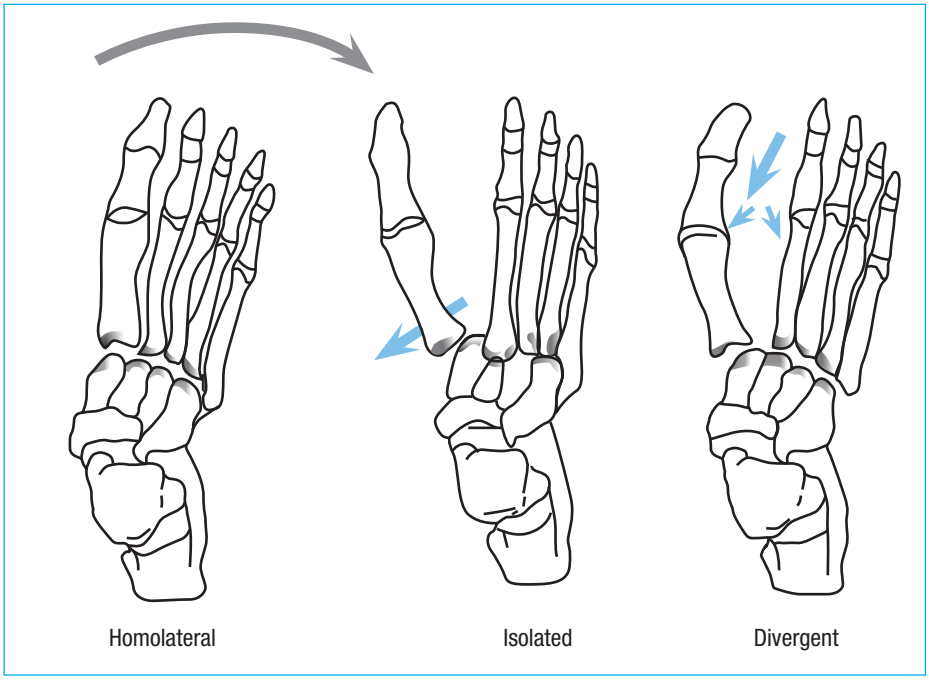
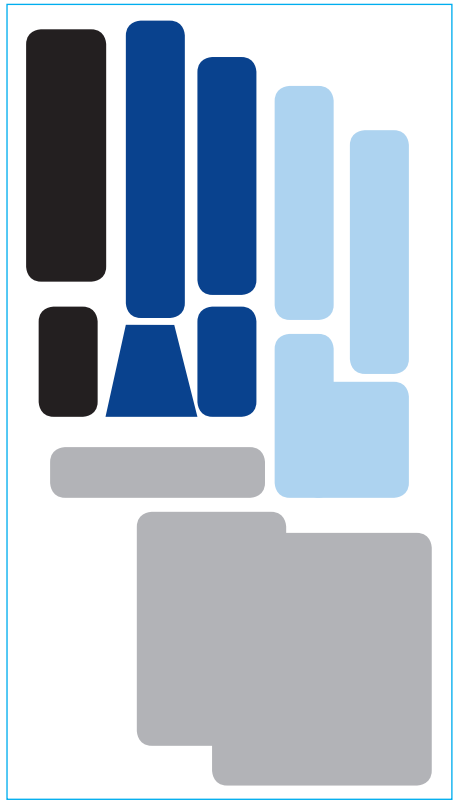


Figure 7. The three-column theory describes the three functional units of the tarsometatarsal articulation. Black: medial column (first metatarsal and medial cuneiform); dark blue: the middle column (articulations between the second and third tarsometatarsal joints); light blue: lateral column (articulations between the cuboid and the fourth and fifth metatarsi).



There are a number of classifications for Lisfranc injuries. In 1909 Quenu and Kuss described three patterns of injury at the tarsometatarsal joint which are homolateral, isolated or divergent (*Figure 6*). Modifications of this classification were first introduced by Hardcastle (1979) based on the three-column concept, which included type A (total incongruity), type B (partial incongruity) or type C (as divergent) (Hardcastle et al, 1982). Myerson later went on to subdivide the Hardcastle classification further into B1/B2 and C1/C2 (Myerson et al, 1986). Of these systems, the Quenu and Kuss classification is often used for its simplicity and ease of reproducibility.

Management

In principle the overall aim of the management of Lisfranc injuries is to restore the stability of the mid-foot which is essential for weight-bearing activity. In 2001, Chiodo and Myerson presented a classification to assess the stability of the foot based on the three anatomical columns. The three-column theory describes the three functional units of the tarsometatarsal articulation (*Figure 7*). The first metatarsal and medial cuneiform joint make up the medial column. The middle column includes the articulations between the second and third tarsometatarsal joints. The lateral column consists of articulations between the cuboid and the fourth and fifth metatarsals (Chiodo and Myerson, 2001). There is a significant difference in the degree of movement between the different columns which has important implications in the treatment of these injuries with respect to the type of fixation. Komenda et al (1996) reported that post-traumatic arthritis is more common at the base of the second metatarsal, suggesting that incongruity is better tolerated at the medial and lateral columns. The lateral column, which has the greatest amount of sagittal plane motion, is the least likely to be involved in post-traumatic arthritis. Chiodo and Myerson (2001) and Komenda et al (1996) provide a sensible framework for deciding how to fix Lisfranc injuries.

Non-surgical treatment is only recommended when there is no dislocation or subluxation at the Lisfranc joint, and the anatomical relations between the mid-tarsal bones have been maintained. A historic value of 2 mm is often quoted as the upper limit of what the widening between the first and second metatarsi should be, but this is still excessive and further investigations such as weight-bearing views of the contralateral foot, computed tomography or magnetic resonance imaging should be considered to rule out a Lisfranc injury. Non-surgical treatment typically consists of 6–12 weeks of non-weight-bearing in a below-knee cast, followed by a rehabilitation programme (Lattermann et al, 2007).

Surgical treatment is indicated for displaced fractures, mid-foot subluxation or dislocation, and intermetatarsal widening between the first and second metatarsi. There are a number of operative options including open reduction and internal fixation, and primary fusion. In high energy injuries with extensive soft tissue damage, application of an external fixator can be used as part of a staged approach to the management of Lisfranc injuries (Kadow et al, 2014).

Closed reduction and K-wire fixation is rarely used as it is difficult to gauge the success of reduction using this technique because of the limitations of a percutaneous technique. This technique also has a number of associated risks that include pin-site complications, pin migration, and failure of treatment after the removal of K-wires.

Open reduction and internal fixation is the preferred operative treatment. It allows more accurate reduction, and typically involves application of intermetatarsal

Figure 8. Postoperative X-ray of an open reduction internal fixation for a Lisfranc injury.

screws, dorsal plates or a combination of both (*Figure 8*). Recently introduced low profile locking plates provide increased rigidity of the construct and can cause less soft tissue irritation. Primary arthrodesis has been recommended in primarily ligamentous injury and fracture–dislocations with severe articular surface damage. However, randomized studies have shown comparable outcome results between primary arthrodesis and open reduction and internal fixation (Ly and Coetzee, 2006; Coetzee and Ly, 2007; Henning et al, 2009).

More recently, novel surgical techniques for the management of chronic subtle injuries of the Lisfranc joint have been described. One such example is ligament reconstruction with single bone tunnel technique for chronic symptomatic subtle injury of the Lisfranc joint in athletes using autologous grafts where all athletes returned to high level activities (Miyamoto et al, 2015). The use of dual tightropes has also been described using adjustable suture buttons to connect the medial cuneiform to the second metatarsal base, and connect the medial cuneiform to the middle cuneiform (Crates and Barber, 2012).

Poor management of Lisfranc injuries may lead to a number of complications that will have notable consequences for the patient. These can include stiffness in the foot affecting normal gait, arthritis, complex regional pain syndrome, and loss of tarsometatarsal arch which can manifest as a widened foot or as a permanent pes planus.

Conclusions

A Lisfranc injury is the disruption to the keystone of the midfoot. This can be either a soft tissue injury or a bony injury to the base of the second metatarsal that leads to instability. These injuries are uncommon and account for approximately 0.2% of all orthopaedic injuries with the main demographic being men of around 30 years of age. Patients often present complaining of severe pain and an inability to weight-bear. On examination, they will have swelling throughout the midfoot and medial plantar bruising.

If missed, Lisfranc injuries can have devastating long-term consequences. In order to avoid these injuries, appropriate static and dynamic images are necessary, along with further images such as computed tomography or magnetic resonance imaging scans for operative planning. In general, open reduction and internal fixation is the mainstay of management for these injuries. It is essential to have a thorough understanding of the biomechanics and the anatomy of the foot to allow the clinician to identify the problem, and to apply appropriate management in order to give the patient the best possible clinical outcome. **BJHM**

Conflict of interest: none.

KEY POINTS

- Lisfranc injuries lead to the instability of the Lisfranc joint.
- Lisfranc injuries are uncommon. They can be a result or direct or indirect injuries. They typically result from an axial load applied to the longitudinal axis of the foot that is in a hyper-plantarflexed position.
- Both plain and weight-bearing X-rays are useful in providing both static and dynamic images.
- Open reduction and internal fixation is the mainstay of management for Lisfranc injuries.

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