Lisfranc fracture dislocation: a review of a commonly missed injury of the midfoot

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ABSTRACT

Musculoskeletal trauma to the foot is a common presentation to EDs. A Lisfranc fracture dislocation involves injury to the bony and soft tissue structures of the tarsometatarsal joint. While it is most commonly seen post high velocity trauma, it can also present post minor trauma. It is also misdiagnosed in approximately 20% of cases. These Lisfranc injuries typically present to EDs with pain particularly with weight bearing, swelling and post a characteristic mechanism of injury. Diagnosis is via clinical examination and radiological investigation —typically plain radiographs and CTs. Once diagnosed, Lisfranc injuries can be classified as stable or unstable. Stable injuries can be immobilised in EDs and discharged home. Unstable injuries require an orthopaedic referral for consideration of surgical fixation.

INTRODUCTION

Jacques Lisfranc was a Napoleonic surgeon who is most famous for his development of a midfoot amputation at the tarsometatarsal level as a way of treating gangrenous and frostbitten feet during the Napoleonic wars. His name has also since become synonymous with a variety of injury patterns involving the tarsometatarsal joint (TMTJ) of the foot.[1] In modern day medicine, a Lisfranc injury has come to represent fracture/dislocation of any of the articular structures of the tarsometatarsal complex—the metatarsals, the TMTJ, cuneiforms, cuboid and navicular.[2] Overall, Lisfranc injuries are uncommon but can leave patients with significant functional deficits.

EPIDEMIOLOGY

The incidence of Lisfranc fracture dislocation has been reported at 1 per 55 000/year.[3 4] Men are between twofold and fourfold more likely to sustain these injuries than women; most commonly in their third decade.[5] One of the largest reported studies of 76 Lisfranc injuries by Myerson *et al* found that 58% were associated with polytrauma and of these, motor vehicle accidents contributed nearly two-thirds of all injuries.[6] Concerningly, Lisfranc fracture dislocations can be misdiagnosed in up to 20% of cases[6 7]—with resultant long-term malalignment and functional weight bearing difficulties.

ANATOMY AND BIOMECHANICS

Anatomically, the Lisfranc joint is composed of the tarsometatarsal, intermetatarsal and anterior intertarsal joints. Each of the medial three metatarsals articulates with a cuneiform bone, while the lateral two metatarsals articulate with separate facets on the cuboid. Stability at the Lisfranc joint is provided by its osseous configuration. The middle cuneiform is recessed in comparison to the medial and lateral cuneiforms, and this recess accommodates the base of the second metatarsal, creating a mortice of sorts. Coronally, the cuneiforms are formed in a trapezoidal shape and create a 'Roman Arch'. The 'keystone' to this is the recessed second metatarsal base. This keystone confers stability in the coronal plane to the midfoot and in cases of Lisfranc fractures dislocation, the loss of the stability and rigidity of arch at the midfoot can result in a pes planus or flatfoot deformity.

Further stability is provided by a number of ligaments. The most significant of these is the Lisfranc ligament, which connects the base of the second metatarsal to the lateral aspect of the medial cuneiform (figure 1). Dorsal and plantar tarsometatarsal ligaments and intermetatarsal ligaments further bind the TMTJ, with the plantar ligaments being the strongest of them. There is no ligamentous connection between the first and second metatarsal bases, placing these structures at risk of divergent displacement during injury.[8] This is the anatomical basis upon which many existing classification systems have been developed.

Biomechanically, the Lisfranc joint represents the transition from midfoot to forefoot, and is therefore crucial for a normal gait pattern. Key to this transition is the passage of force or weight from the midfoot such that there is an equal weight distribution across the six weight bearing structures of the forefoot—namely the four metatarsal heads and the two sesamoids underlying the first metatarsal head.[9] Mobility within the joints of the TMTJ is therefore very important—particularly during weight bearing over uneven ground. Motion studies have found the lateral column to be significantly more mobile than the medial two columns with 10°–20° of motion, compared with 5°–10° medially and minimal movement at all in the intermediate column[10] (figure 2). The relative stiffness medially is possible because the centre of mobility on the medial side of the foot is at the talonavicular articulation. Biomechanically, the stiff intermediate column acts as a rigid lever arm during weight bearing, with the medial and lateral columns providing appropriate adjustment as weight bearing forces pass through the midfoot.

MECHANISMS OF INJURY

The mechanisms of injury of the TMTJ can range from low energy twisting injuries to high velocity trauma. The most common is direct injury—usually to the dorsum of the foot—such as in high velocity blunt trauma. Crush mechanisms are also common

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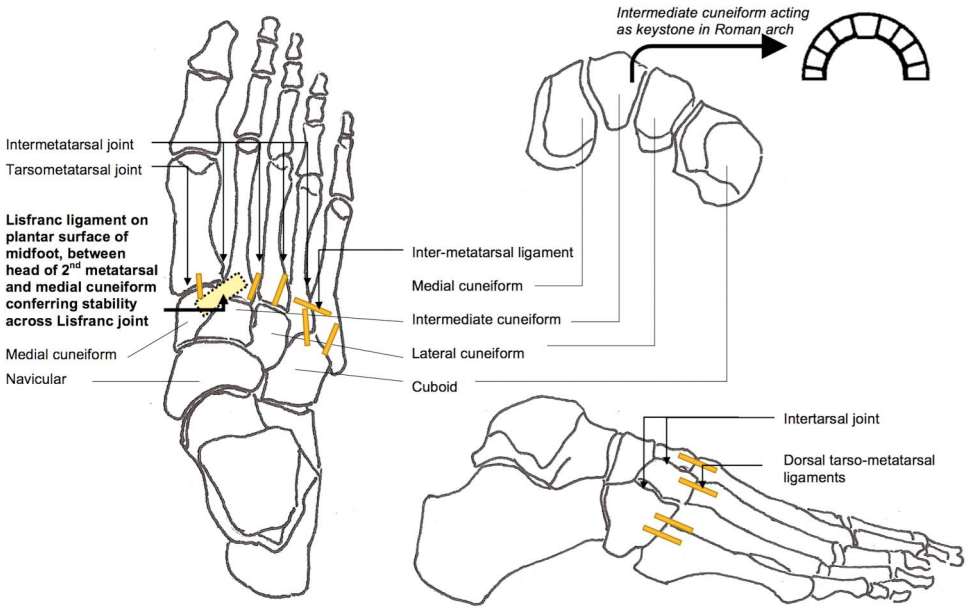

Figure 1 Anatomy of the midfoot and associated ligaments which confer stability across the Lisfranc joint.

and can result in open injuries with significant soft tissue damage to the dorsum of the foot or even compartment syndromes. By contrast, indirect injuries can also occur in a hyperplantar flexed foot which is subjected to axial loading—often sustained during sporting activities such as in football injuries when another player falls onto a heel from above during midstride. First, the dorsal ligaments are disrupted, then the stronger plantar or Lisfranc ligaments and finally bony injury to varying degrees. There is no known correlation between mechanism and type of fracture pattern,[10] but due to the high energy and potential soft tissue involvement, direct Lisfranc injuries are shown to have worse clinical outcomes.[6 11]

CLASSIFICATION

A number of classification systems have been proposed for Lisfranc fracture dislocation based upon mechanism by which the injury was sustained. The most recent and accepted is one devised by Myerson *et al*, which helps to define Lisfranc injuries in a way to aid in clinical decision-making. Fractures are described based on divergence at the first and second metatarsal interval—either a medial or lateral direction. Type A fractures demonstrate total incongruity at the TMTJ; type B fractures demonstrate partial incongruity of either the first ray in isolation (partial medial incongruity) or the remaining lateral four rays (partial lateral incongruity) and type C fractures develop divergence at the first and second rays with either partial (C1) or total (C2) displacement[6] (figure 3).

Despite the biomechanical and anatomical logic behind this approach to classifying Lisfranc injuries, no proposed classification system has been able to associate fracture pattern with treatment method or prognosis,[9 12] a weakness in the utility of these systems.

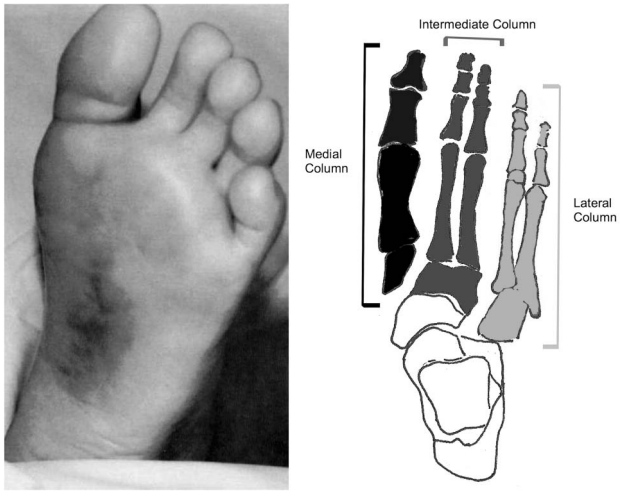

Figure 2 Right image: medial, intermediate and lateral columns associated with midfoot biomechanics. Left image: plantar ecchymosis.

DIAGNOSIS

Lower limb injuries are common presentations to EDs and 15% of these will involve foot pain and potentially suspicious mechanisms of injury.[13] The goal of the emergency physician should be to distinguish between non-urgent or non-serious musculoskeletal foot pain and which of these might constitute a Lisfranc fracture that requires onward orthopaedic referral.

History

The diagnosis of a Lisfranc injury is not always straightforward and requires a detailed history, thorough examination and appropriate imaging. On history, one of the key distinguishing features of more serious injury is the inability to weight bear. If compelled, weight bearing is often painful, and there is an unwillingness or inability to stand on tiptoes. A patient without weight bearing pain is unlikely to have suffered a Lisfranc facture dislocation.

Examination

Examination findings in Lisfranc injury can be varied—posing a challenge to early assessment and diagnosis. Plantar arch ecchymosis is considered pathognomonic for Lisfranc injury but may be absent in instances of ligamentous strain or minor fracturing[14] (figure 2[14]). However, there have been no studies assessing the positive predictive value of this sign, and the evidence for its significance appears anecdotal for now.[14] If any suspicion

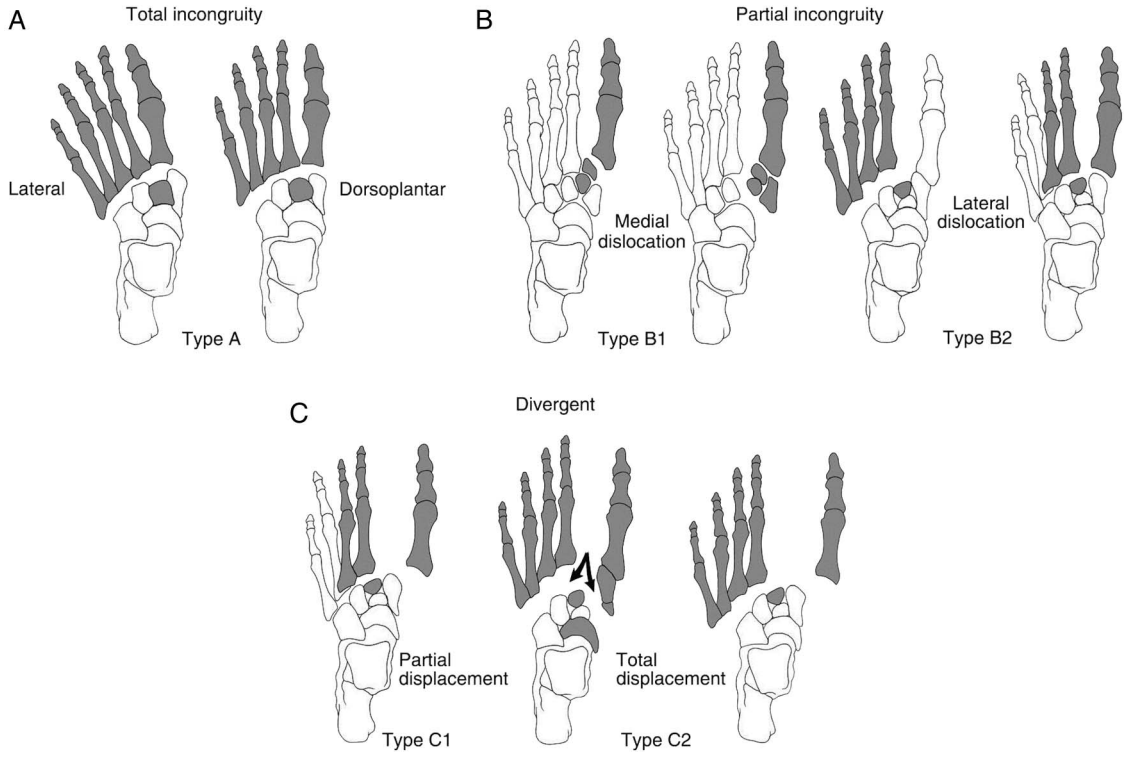

Figure 3 The 1986 Myerson classification for Lisfranc fracture dislocation.[6]

of foot injury is present, plain radiographs should be obtained. Following high velocity trauma, patients may present with severe swelling of the midfoot and associated widening or flattening of the foot. Soft tissue injury such as open fracture with skin deficits and injury to the dorsalis paedis may also be present. In extreme cases, compartment syndrome can occur and this is best assessed via the elicitation of pain out of proportion on passive stretch of the toes. Typically, patients are either too swollen or too tender to examine appropriately for midfoot range of motion.

In subacute or delayed presentations, special tests for Lisfranc injuries include the instability test; where the TMTJ can be dorsally subluxed with application of dorsal forces to the distal aspect of the midfoot. In severe cases there can also be medial and lateral displacement of the first and second metatarsals, and this is generally an indication for urgent surgical intervention. A provocative test can also be used, whereby pronation and abduction of the forefoot reproduces pain (figure 4).

Radiology

Radiological evidence of Lisfranc injuries is initially via plain film Anterior-Posterior (AP), oblique and lateral X-rays of the foot and is typically performed on all patients with a history of trauma and pain in the foot. Ideally, weight bearing or stress X-rays are obtained but this is often difficult immediately post-trauma due to pain and a diagnosis can still be made off non-weight bearing films.

A good approach of the foot radiograph should incorporate a step-wise approach to its interpretation. The ABCS mnemonic of A (alignment), B (bones), C (cartilage) and S (soft tissues) can be used in interpretation of the foot radiograph as well as any other radiographic image in the body.

Begin with assessing alignment (A) of the TMTJ by:

- Drawing a line along the medial shaft and base of the second metatarsal to the medial side of the middle cuneiform on AP film.
- Drawing a line between the medial side of the shaft and base of the fourth metatarsal and the medial side of cuboid.
- Assessing for widening of the interval between the first and second ray of ≥2.7 mm.
- Metatarsal base dorsal subluxation on the lateral view.[15]

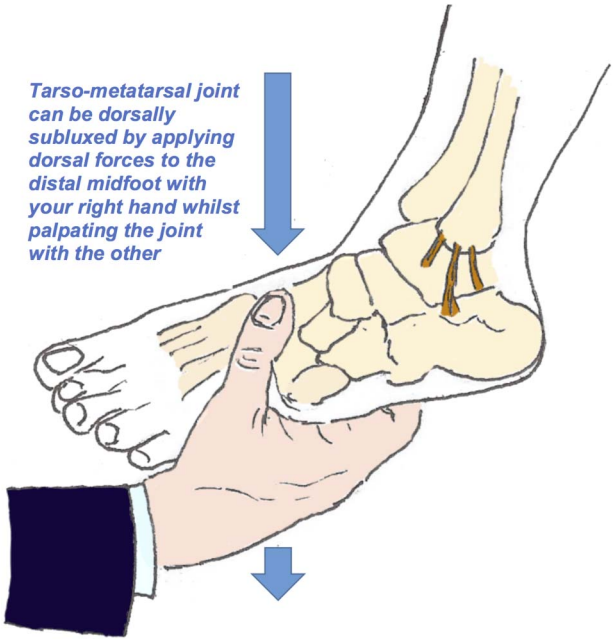

Figure 4 Instability test for subacute Lisfranc injury.

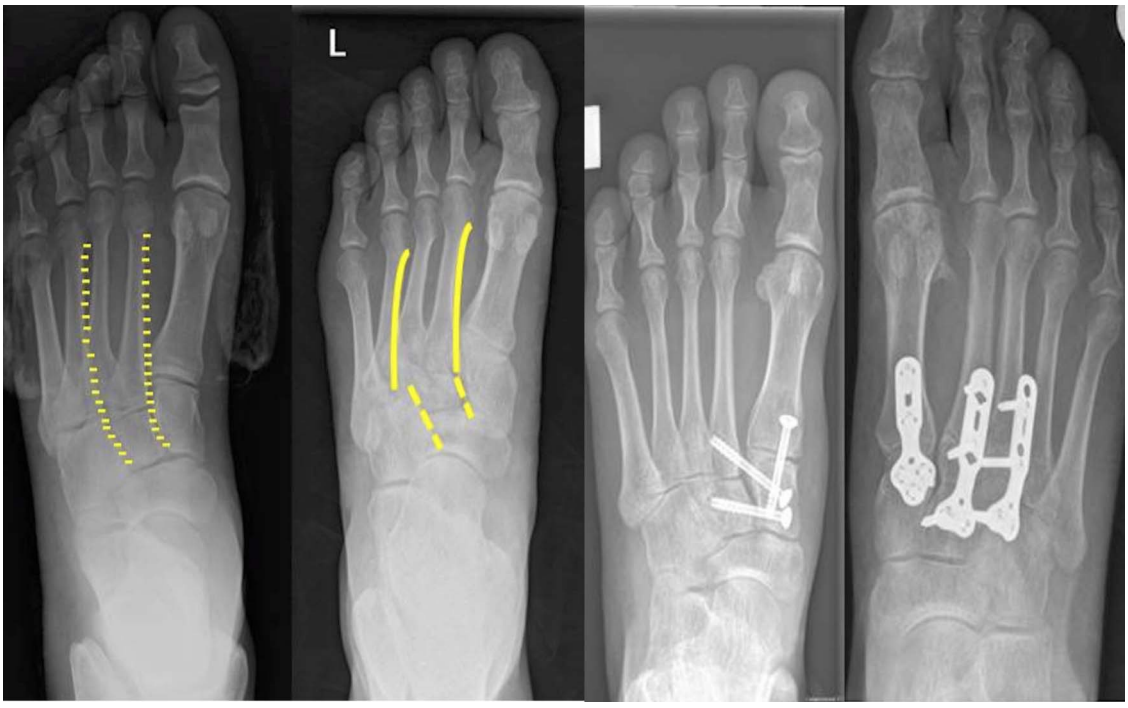

Figure 5 Left image: disruption of the alignment of the tarsometatarsal joint in any of these lines or intervals indicates Lisfranc injury. Right image: surgical fixation by transarticular screws and dorsal bridge plating.

Disruption of the alignment of the TMTJ in any of these lines or intervals indicates Lisfranc injury (figure 5).

Assess every bone (B) in the foot by working distally from the hindfoot to the midfoot to the forefoot. Be sure to check around every cortex looking for irregularities or steps. Particularly assess the area of the base of the second metatarsal or medial cuneiform for fracture, which may indicate a more subtle Lisfranc injury. Associated injuries include 'nutcracker' fractures of the cuboid—which occur with compression of the cuboid by the fourth and fifth metatarsal bases. If seen in isolation, there should be strong suspicion of Lisfranc injury and further radiological imaging obtained. In contrast to other radiographs of the body, there are unfortunately no radiographic changes of cartilage (C), soft tissue (S) swelling or haemarthrosis in the midfoot to aid in diagnosis of Lisfranc injuries. Patients with a low clinical suspicion of Lisfranc injury (low mechanism injury, absence of swelling, can weight bear and/or stand on tiptoes) and have normal plain radiographs can be safely managed in the ED without orthopaedic review.

CT has in more recent times become the gold standard in the diagnosis of Lisfranc injuries. Particularly in high velocity trauma, CT provides excellent information in regards to fracture pattern and helps with surgical planning. However, CT should not replace X-ray as a first line imaging modality in the ED.

CT should be requested by the emergency physician in all patients with radiographic evidence of Lisfranc injury or where there is a high suspicion of injury despite normal plain radiographs (plantar ecchymosis or symptoms such as pain, swelling and inability to weight bear which is out of proportion with radiographic findings).

A finding of a 'fleck sign' on CT is indicative of an avulsion type injury to either the second metatarsal base or medial cuneiform (by the Lisfranc ligament) and is considered an unstable injury (figure 6). Finally, although not commonly employed, MRI can be useful in identifying ligamentous injuries without bony involvement.[16]

To help guide appropriate triage and referral, Lisfranc injuries can be divided into stable and unstable injuries. This is usually based on radiological investigations—particularly CT. The definition of these stable injuries is any fracture/dislocation with <2 mm of displacement (in any plane) at the TMTJ and with no evidence of instability or loss of fracture position on weight bearing X-rays.[8] They include isolated strain type injuries to the Lisfranc ligament or ligamentous complexes of the TMTJ without fracture and injuries with minute fractures that are essentially too small for operative fixation with 2.4 mm screws.

MANAGEMENT

Stable Lisfranc injures can be treated non-operatively; typically in a short non-weight bearing below knee cast for a period of 6 weeks. Stability should generally be rechecked at the 10–14 day mark with weight bearing radiographs and if collapse or loss of position is observed then operative fixation considered. Unstable fracture dislocations, by contrast have been shown to have poor results when treated with reduction and casting. As with most lower limb injuries, immediate management involves elevation and icing of the limb, to try and limit swelling and reduce local inflammation.

Natural history

If stable fractures are not managed appropriately with immobilisation or if unstable fractures are managed non-operatively, the natural history of Lisfranc fracture dislocation is for the development of malreduced and malaligned TMTJs with midfoot post-traumatic arthritis and non-union of fracture. Often, these injuries can fall into malreduction with collapse of the 'Roman Keystone' and a subsequent pes planus deformity of the foot (the so-called flatfoot). Functionally, the patient reports a deformed foot, pain with weight bearing and stiffness that can

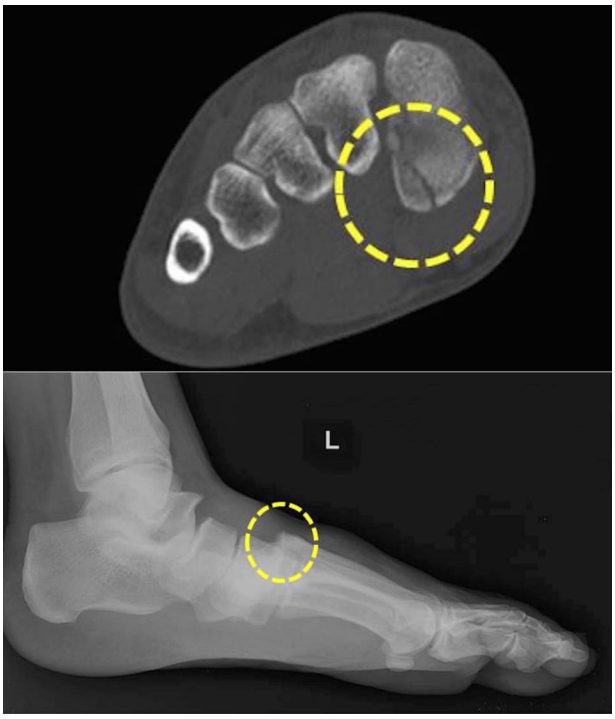

Figure 6 Top: fleck sign on CT is indicating avulsion type injury to the second metatarsal base or medial cuneiform. Bottom: dorsal displacement on lateral plain film.

be extremely debilitating. More specifically, shortening of the medial column tends to lead to a cavus foot, while shortening of the lateral column can end with a planus foot deformity.[17]

Operatively, surgical fixation of Lisfranc injuries includes fixation by either the more traditional transarticular screw or the dorsal bridging plate—or some combination of the two (figure 5). Access for this surgery is typically via a dorsal midline incision. Part of the orthopaedic referral should, therefore, include information about overlying dorsal soft tissue integrity—including open injuries, skin abrasions and gross dorsal swelling.

Timing of referral

A number of patients present to EDs after relatively minor trauma to the foot. These patients may only have subtle radiological changes on plain film and should be considered for Lisfranc injury. While the majority of Lisfranc fracture dislocations do not require urgent surgical fixation, review in outpatient orthopaedic clinic within 1–2 weeks should be arranged. Stable injuries in patients who are otherwise able to care for themselves do not necessarily require orthopaedic review at presentation and temporary fixation in a plaster U-slab and stirrups can be applied prior to discharge. Unstable injuries should have an orthopaedic referral on the day of presentation. Lisfranc injuries requiring urgent surgical review include open injuries or those with severe deformity such that the surrounding soft tissues are endangered, and in instances of compartment syndrome. Closed fracture dislocations of the midfoot should be reduced in the ED to minimise the chance of overlying soft tissue ischaemia by the (dorsally) displaced fracture.

CONCLUSION

Lisfranc fracture dislocations are a relatively uncommon but important diagnosis—of which one in five is missed. It is important for emergency physicians to recognise the characteristic mechanisms and presentations of these injuries to help facilitate appropriate referral and treatment. The risk of misdiagnosis is that it can leave patients with deformity and malalignment of the foot and subsequently significant functional deficits.

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