LISFRANC INJURY OVERVIEW

INTRODUCING THE CHARLOTTE™ LISFRANC RECONSTRUCTION SYSTEM

What comprises the Lisfranc joint?

The Lisfranc joint complex is composed of the tarsometatarsal (TMT) joints and the proximal intermetatarsal and anterior intertarsal joint articulations | **Figure 1**. While little motion occurs at the joint articulations, the complex is important in maintaining the structural stability of the midfoot[1].

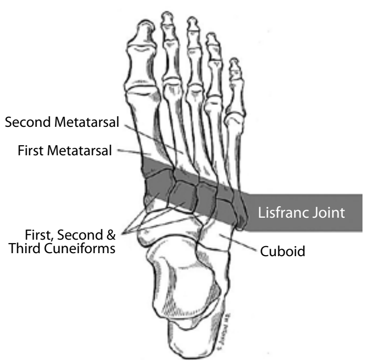

Figure 1 | Lisfranc Joint Complex

Figure 2 | Jacques Lisfranc
photo credit www.forez-info.com

Its name is derived from the work of Jacques Lisfranc, a field surgeon in Napoleon's army, who first described an amputation through the TMT joint for gangrenous injuries of the forefoot[2]. | **Figure 2** In Lisfranc's time, the TMT joints were often severely injured when cavalry officers fell from their horses with their feet still stuck in the stirrups[3]. After these open injuries did not heal, Dr. Lisfranc would be forced to completely amputate the forefoot at the TMT joint.

As a result of its position in the midfoot and architecture, the Lisfranc complex is an extraordinarily intricate structure of osseous and ligamentous elements, which provides critical structural midfoot stability and support by forming the transverse arch of the midfoot[1].

Bony Architecture

Primary stability of the joint is created by the three bony columns that create the transverse arch and are supported by ligamentous elements: the Medial column (articulations of the 1st cuneiform and 1st metatarsal), the Middle column (2nd & 3rd cuneiforms and the 2nd & 3rd metatarsals), and the Lateral column (cuboid and the 4th & 5th metatarsal)[3].

Ultimately, the stability of the Lisfranc joint complex can be attributed to the unique positioning of the 2nd metatarsal, which forms the critical keystone to the entire structure[4]. Proximally recessed and interlocked between the medial and lateral cuneiforms | **Figure 3**, the 2nd metatarsal limits frontal plane translation of the metatarsals[1]. More importantly, the 1st through 3rd metatarsals and their corresponding cuneiforms are dorsally based triangles, which create the unique "Roman arch" structure of the transverse arch, with the 2nd metatarsal forming the apex[2]. | **Figure 4** This configuration imparts stability to the transverse arch of the midfoot by preventing plantar displacement of the metatarsal bases[1]. As the 2nd metatarsal forms the keystone in multiple planes, it is critical to the ultimate stability of the Lisfranc complex, and helps explain the rarity of Lisfranc injuries without a fracture of the 2nd metatarsal base.

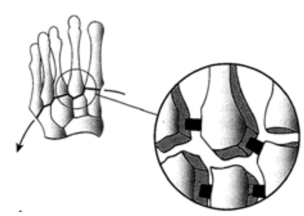

Figure 3 | Dorsal view of recessed 2nd metatarsal that contributes to Lisfranc joint stability[1].

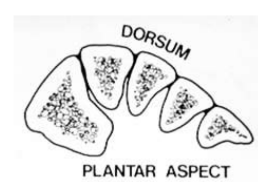

Figure 4 | The "Roman Arch" configuration with the "keystone" of the 2nd metatarsal[5].

Intra-Osseous Ligaments

The primary soft tissue stabilizers of the Lisfranc complex are the intra-osseous TMT ligaments and the intercuneiform ligaments[3]. Together, the Lisfranc ligaments are composed of a complex confluence of three ligament bundles: the plantar, the intraosseous and the dorsal[1]. The structural integrity of the Lisfranc complex can be primarily attributed to the intermetatarsal interosseous ligaments, which are the strongest of all the capsuloligamentous restraints[1]. As the dorsal ligaments are the smallest and weakest of the entire complex, disruption of the ligament frequently occurs with injury[3].

Ligaments are present between each of the lateral four metatarsals (2nd-5th metatarsals)[1]. | **Figure 5** However, importantly to Lisfranc injuries, it is absent between the 1st and 2nd metatarsal. Instead, the base of the 2nd metatarsal is joined to the medial cuneiform by the medial interosseous ligament – appropriately called Lisfranc's ligament. This ligament is the largest and strongest joint in the entire Lisfranc complex. As a result, it is responsible for the avulsion (bone fracture that is torn away from the main mass of bone by the ligament) often seen at the base of the 2nd metatarsal in most Lisfranc injuries.

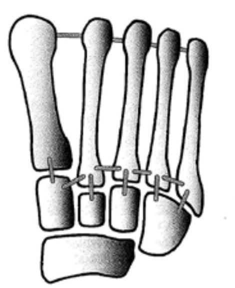

Figure 5 | Intra-Osseous Ligaments[1]
Note the Lisfranc ligament between the 2nd metatarsal and the medial cuneiform

What is a Lisfranc Injury?

Lisfranc injuries involve any bony or ligamentous disruption of the tarsometatarsal (TMT) Lisfranc joint complex | **Figure 6.** Altogether, Lisfranc injuries account for 0.2% of all fractures[6], affecting 55,000 per year[3], although, as many Lisfranc injuries are purely ligamentous in nature, this incidence is likely low.

Figure 6 | Complete incongruity of the Lisfranc joint[5].

What are the types of Lisfranc injuries?

Lisfranc injuries have a myriad of clinical presentations, ranging from subtle involvement of a single, isolated column (frequently the 1st ray) or a complete disruption of the entire TMT joint[1]. The broad array of presentations for Lisfranc injuries are frequently classified based on the descriptions of Hardcastle et al (1982) and Myerson et al. (1986)[1] | **Figure 7.**

- Type A involves the complete dislocation of all five of the TMT joints as one unit.
- Type B involves one or more, but not all, TMT joints, and typically entails the medial displacement of the 1st metatarsal (Type B1) or dorsolateral displacement of one or more of the lateral metatarsals (Type B2).
- Type C occurs when the lateral and medial metatarsals are displaced in opposite directions, with Type C1 affecting fewer of the lateral TMT joints than Type C2.

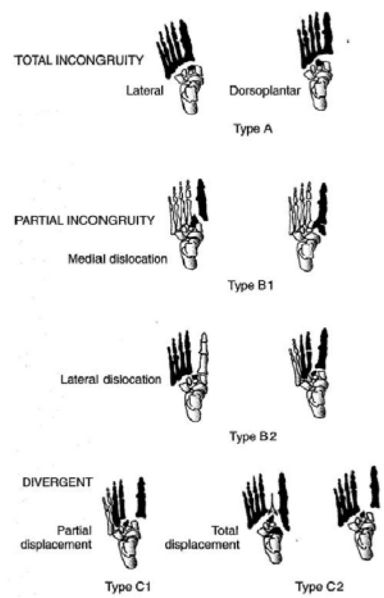

Figure 7 | Classification of Lisfranc Injuries[1].

How do Lisfranc injuries occur?

Because there exist a wide range of clinical presentations of Lisfranc injuries, the mechanisms for injury are comparably varied, ranging from high-energy trauma that result in severely displaced fracture-dislocations to less severe twisting injuries that can cause sprains and subluxations[1,3].

Most Lisfranc injuries are due to high energy trauma, and as a result, are frequently accompanied by other injuries making the subtle diagnostics of Lisfranc injuries frequently overlooked. Motor vehicle accidents account for up to two-thirds of all cases, followed by crush injuries and falls[1].

Mechanisms for injury can be either direct or indirect[2]. Direct mechanisms often involve a crush injury with dislocation, resulting in complete displacement of the metatarsal bases in either a plantar or dorsal direction depending on the forces applied | **Figure 8**. As a result of the often traumatic nature of these injuries, disruption of the joint is not predicated on the bony architecture and soft tissue restraints, but on the direction of the applied forces, which frequently are on the dorsum of the foot, creating a plantar displacement of the MT bases[1].

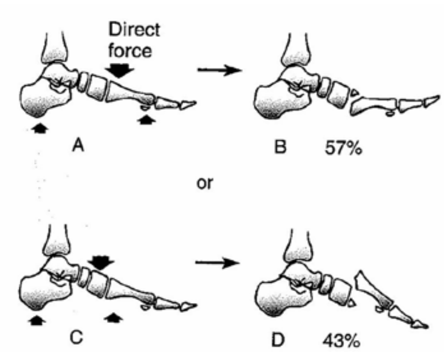

Figure 8 | Direct Mechanisms of Lisfranc Injuries[1]
(A) Application of a direct force dorsally to the base of the metatarsals can elicit plantar disruption of the Lisfranc joint (B). (C) Application of the dorsal force slightly more proximally can create a dorsal dislocation(D)

Indirect trauma is more common, and caused by either rotational forces applied to the forefoot or axial loading of the fixed and plantar-flexed foot[2]. Due to the intricate and complex architecture and resulting stabilizing forces running through the Lisfranc articulations, the amount of force needed to elicit a Lisfranc injury can be trivial, with dislocations typically occurring at the site of least resistance – frequently dorsal dislocations of the metatarsals and the 2nd metatarsal or lateral displacement[1]. When the forefoot is forcefully abducted, a fracture frequently occurs at the insertion of the Lisfranc ligament on the base of the 2nd metatarsal. Alternatively, an axial load that is applied to the heel of a fixed and plantar-flexed foot (which often occurs when the foot impacts the firewall in a motor vehicle accident) can overwhelm the Lisfranc complex, eliciting a dorsal disruption | **Figure 9**.

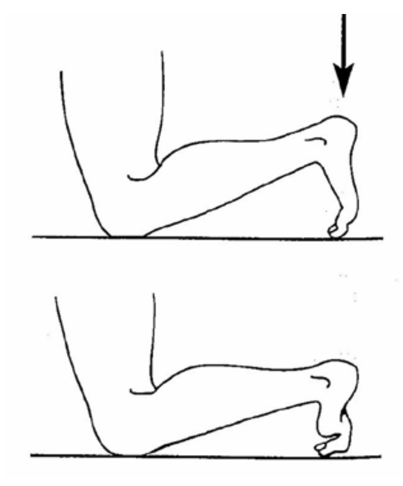

Figure 9 | Indirect Mechanism of Lisfranc Injury Caused by Axial Loading[5].

Why are Lisfranc injuries so hard to treat?

Lisfranc injuries are difficult to diagnose due to the range of clinical presentations, with up to 20% of injuries missed on radiological examination[2]. Once recognized, the difficulties in treatment arise from the complex architecture of the Lisfranc joint.

After most traumatic fractures or dislocations throughout the skeleton, surgeons want to restore the fractured fragment to the correct anatomical alignment through reduction[1]. However, due to the intricacies of the bony architecture within the Lisfranc joint, achieving proper anatomical reduction is tremendously difficult and frequently involves internal fixation. Numerous studies have shown that achieving and maintaining anatomical reduction is critical for optimal outcomes, regardless of the severity of injury[1,4,7,8]. Any delay in reduction can significantly increase the risk of late morbidities like post-traumatic osteoarthritis[3].

Additionally, several studies have shown that purely ligamentous injuries have a poorer outcome, because soft tissues heal in a less predictable manner than bone[6]. This increases the importance of internal fixation, which can maintain the joints' stability while the soft tissues completely heal.

What is the most common treatment method?

The ultimate goal of surgical treatment is a painless, stable, and plantargrade foot[1]. This is often accomplished through open reduction, which allows direct visualization and reduction of the fracture-dislocation and enables debridement of the comminuted fracture fragments, soft tissue, and osteochondral debris that frequently exist due to the traumatic nature of the injury. The almost universal existence of these fragments usually prevents closed reduction.

To maintain this reduction, internal fixation is frequently achieved through transarticular screws or bridging plates. While K-wire fixation does exist, screw and/or plate fixation is currently preferred in the medial three TMT joints, as it provides a stronger and more stable construct to preserve the reduction for the required time of healing[7].

The number and orientation of the screws and bridge plates vary according to the type the dislocation/fracture[1]. | **Figure 10**

Figure 10 | Traditional Lisfranc Reconstruction with a variety of screws[5].

To ensure the complete structural integrity of the transverse arch, a "Home Run" screw is frequently inserted from the middle of the medial cuneiform to the base of the 2nd metatarsal. This orientation is along the direction of the "Lisfranc ligament" which is often damaged, and forms the primary stabilizer of the Lisfranc complex by securing the critical keystone of the 2nd metatarsal into the transverse arch. An intercuneiform screw is also often inserted to secure the cuneiforms that form the tarsal aspect of the transverse arch. Additional screws/plates may be utilized to secure various disrupted tarsal bones to the metatarsals.

References:

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