IOP - Images
Answer to case study

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Presentation of the case on page 267.

Diagnosis
Subtle or low-energy Lisfranc injury (lateral type B2) associated with rupture of the Lisfranc ligament (C1-M2).

Discussion
Low energy or impact injuries in tarsometatarsal joints, also known as Lisfranc joints, usually show in sport and recreational activities, what results in midfoot sprains. Differently from what happens in high energy injuries, these low energy injuries are difficult to manage because usually it is difficult to identify the specific structures that have been injured.

This low impact midfoot sprain is called subtle injury or Lisfranc injury, whereas high impact injuries are called Lisfranc fracture-(partial) dislocations.

Distinction is important for the sake of a precise communication between the orthopedist and the specialist in images. Lisfranc fracture-dislocations are hardly frequent, whereas midfoot sprains are relatively common. Up to 35% of Lisfranc injuries are mistakenly diagnosed or overlooked. Diagnosis delay is usually due to multiple factors, which include low suspicion and the subtlety or masking of the radiographic findings. Numerous authors have emphasized the importance of early diagnosis to minimize the risk of long-term complications such as residual ligament instability or post-traumatic degenerative osteoarthritis. Therefore, injuries in tarsometatarsal joints and Lisfranc ligaments injuries pose a challenge to the intervening doctor, because they are difficult to diagnose and outcomes worsen as diagnosis is delayed. Consequently, specialists in images and orthopedists should have a clear understanding of the nomenclature, the anatomy, the mechanisms of injury and the most relevant imaging findings.

The mechanism of injury in the Lisfranc joint can be divided into direct and indirect traumatisms. Low impact injuries generally result from indirect impacts and are usually caused by forefoot sudden abduction or forced plantar flexion. The direct mechanism is usually associated with the direct application of high impact forces to the foot.

From the anatomical point of view, many authors actually prefer to call this joint "Lisfranc joint complex", because it is a multiple articular system with an intricate anatomic configuration which involves skeletal and non-skeletal (capsule-ligaments) elements that give stability to the mid and forefoot. Its name pays homage to Jacques Lisfranc de Saint-Martin (1790-1847), a field surgeon in the French army who described a forefoot amputation through the tarsometatarsal joint in the times of the Napoleonic wars.

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The skeletal elements of the Lisfranc joint (which defines the joint between the midfoot and the forefoot) involve the following joints between nine bones:

- the first cuneiform bone (C1) with the hallux or the first metatarsal bone (M1)
- the second cuneiform bone (C2) with the second metatarsal bone (M2)
- the third cuneiform bone (C3) with the third metatarsal bone (M3)
- the cuboid bone (Cu) with the fourth (M4) and the fifth (M5) metatarsal bones

These joints are organized into three separate synovial compartments. The first tarsometatarsal joint forms the medial compartment. The second and third tarsometatarsal joints share a capsule which communicates with the first and the second intercuneiform and cuneonavicular joints to form the central compartment. The joint between the cuboid bone and the fourth and fifth metatarsal bones share a capsule, creating the lateral compartment. These joints contribute to the columnar description of the foot—the medial column is defined as the first ray, including the first cuneiform joint; the central column includes the second and third rays, and the cuneiform bones; and the lateral column includes the fourth and fifth rays as well as the cuboid bone.

The additional bone relationships are also important in the evaluation of Lisfranc joint injuries and images. These relationships are—the intercuneiform joints, especially C1-C2, the cuneonavicular joint (N-C1-C2) and those at the level of the bases of the metatarsal bones.

The Lisfranc joint itself is represented by a discontinuous line formed by the protrusion of the first and the third cuneiform bones, which create a kind of shroud for the second metatarsal bone (M2). Consequently, the first cuneiform bone (C1) is approximately 8 mm in front of the M2 base, whereas the third cuneiform bone (C3) is approximately 4 mm in front of the M2 base and 4 mm in front of the M4 base and the cuboid bone. Therefore, the second metatarsal bone is key to the stabilization of the Lisfranc joint, and any movement in this joint will affect the second metatarsal bone surroundings causing a fracture in the base of M2 or the interruption of the Lisfranc ligament.

In the short axis of the Lisfranc joint (coronal view) bony structures adopt the form of a "Roman arch", with the second metatarsal bone forming the cornerstone of the arch due to its more dorsal position.

The non-skeletal elements include joint capsules, diverse ligaments, the prolongations of the long plantar ligament (plantar calcaneocuboid ligament) and the tendons and expansions of the tibialis posterior, the tibialis anterior and the fibularis longus muscles.

Anatomic studies have divided the Lisfranc numerous stabilizer ligament structures into plantar, interosseous and dorsal components.

There are seven dorsal ligaments which joint tarsal and metatarsal components. Differently from the other metatarsal bones, the second one receives three dorsal ligaments from each cuneiform bone. The first dorsal ligament, which joins the base of the first metatarsal bone with the first cuneiform bone, is the strongest one.

The interosseous and plantar components give the Lisfranc joint primary ligament stability. Plantar ligaments are variable in number and disposition. The plantar ligament which joins the first cuneiform bone (C1) with the first (M1) and the second (M2) metatarsal bones is the key to the tarsometatarsal arch. There is not any plantar ligament between the second metatarsal bone and the second cuneiform bone. The plantar ligament between the third metatarsal bone (M3) and the third cuneiform bone (C3) is not constant. Plantar ligaments between the cuboid bone (Cu) and the fourth (M4) and fifth (M5) metatarsal bones are usually absent too.

Interosseous ligaments are divided into three groups that account for the first, the second and the third cuneomatatarsal spaces. The Lisfranc ligament (C1-M2) is the strongest ligament and, sometimes, is made up of two bands. There is no interosseous ligament in the fourth intermediate space. Figure 9 shows a simplified version of the complex ligament structure that the Lisfranc joint stands for.

In the context of a traumatism, the first imaging study consists of AP, lateral, and 30º-medially oblique X-rays projections with no weight bearing. If this first evaluation is normal, AP bilateral and lateral weight bearing images can be helpful.

In the AP standing projection:

- The lateral edge of the first metatarsal bone is aligned with the first cuneiform bone. The lateral displacement of the base of the first metatarsal bone with respect to the lateral edge of the first cuneiform bone is a reliable radiographic sign for the diagnosis of the Lisfranc injury.
- The medial edge of the second metatarsal bone is aligned with the second cuneiform bone. A mild lateral displacement of the base of the second metatarsal bone with respect to the medial edge of the second cuneiform bone is the commonest and most reliable sign in Lisfranc sprain.
- The distance between the first and the second metatarsal bones is shorter than 2 mm. However, it depends on the obliquity of the X-rays beam and it is not a reliable radiographic sign in Lisfranc injury.

In the 30º-oblique projection
- The lateral edge of the M3 is aligned with the lateral edge of the third cuneiform bone.
- The cuneocuboid interline is parallel and uniform in width.

In the lateral projection
- The dorsal proximal edge of the second metatarsal bone is aligned with the dorsal edge of the second cuneiform.

In bilateral projections with lateral weight bearing:
- The plantar edge of the first cuneiform bone coincides with the plantar edge of the fifth metatarsal base. A decrease in this distance or the inversion of these two lines in comparison with the uninjured foot stands for the collapse of the medial arch and suggests a significant Lisfranc injury with bad outcomes.

When weight bearing or effort X-rays are equivocal, it is possible to try CT scan or MRI

Multiplanar CT scan is an excellent method to convey subtle fractures and allows us to detect minor lateral displacements of the second metatarsal bone. Such minor partial dislocations can be difficult to identify in X-rays (Figure 8). CT scan also allows us to detect small bone fragments associated with the avulsion of the Lisfranc ligament (Fleck sign) which might not be visible in routine X-rays (Figures 6 and 7).

To evaluate ligament injuries, MRI is much better than CT scan; moreover, it is an excellent method to evaluate bone marrow.

M RI allows us to identify the three components of the Lisfranc ligament: dorsal, interosseous and plantar ligaments in normal feet. However, sometimes it is difficult to separate the three bands in the injured foot, or differentiate a complete rupture from a partial rupture due to the small size of the Lisfranc complex. They are better identified in coronal and axial images. They go from the base of the first cuneiform bone to the base of the second metatarsal bone and show low signal intensity with homogeneous or striated aspect. Sprains are classified on the basis of the status of the Lisfranc ligament: grade I (stable injury): stretch; grade II (stable injury): partial rupture; and grade III (unstable injury): complete rupture.

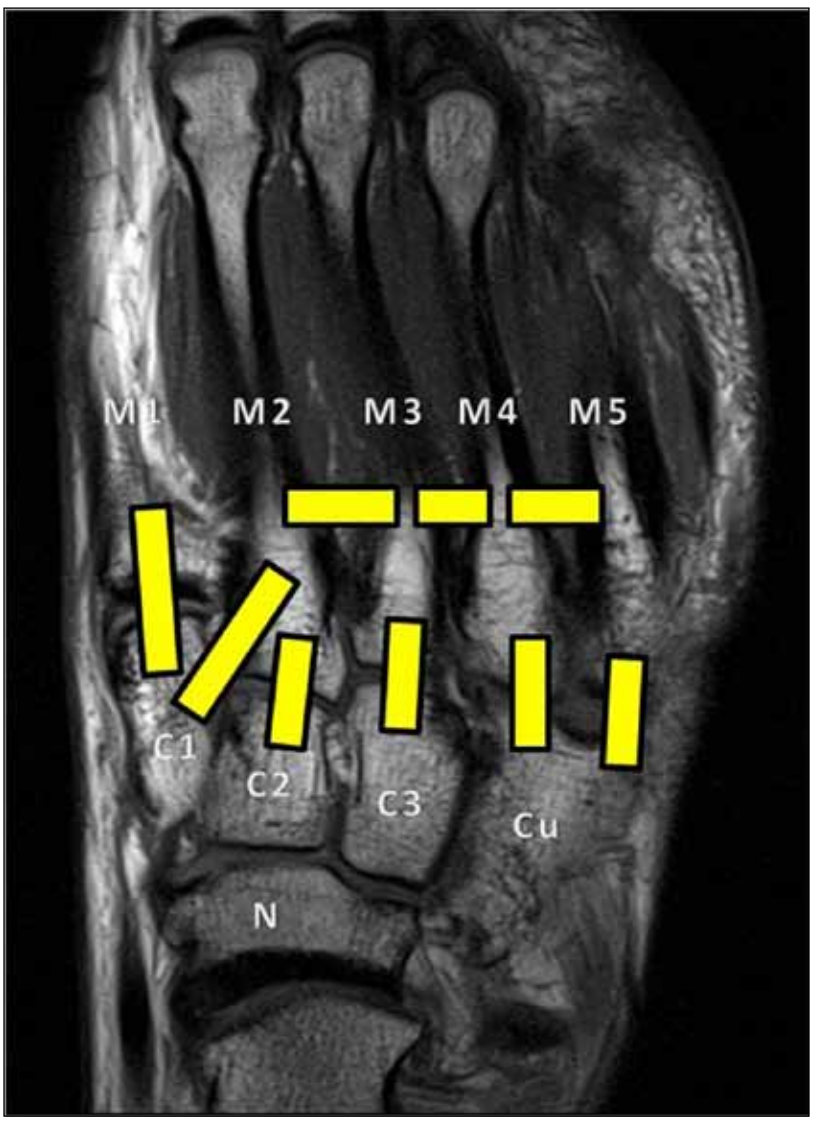

Figure 9. ESimplified sketch of the ligaments in the Lisfranc joint. M= Metatarsal bones, C= Cuneiform bones, Cu= Cuboid bone, N= Navicular bone. The C1-M2 ligament is called "Lisfranc ligament".

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As the degree of ligament disruption at the level of the tarsometatarsal joint progresses beyond the isolated injury of the individual ligament, it is possible to verify variable patterns of bone displacement, as shown in the multiple classification systems that have made progress over the years to describe these injuries. There are three classical displacement patterns: homolateral, in which the 5 metatarsal bones are displaced in the same direction; divergent, in which the first metatarsal bone is displaced oppositely to the 2nd through 5th metatarsal bones, and the isolated dislocation of one or more metatarsal bones. There are classification systems more complete which are based on the same general principle of displacement; the most frequently used is the Quenu and Kuss' method (1909) modified by Hardcastle (1979) and, later on, by Myerson (1986):

- Total incongruence (type A): it can be displaced medial or laterally
- Partial incongruence
  - medial (type B1)
  - lateral (type B2)
- Divergent displacement
  - partial (type C1)
  - total (type C2)

Although the aim of this article is not to set out therapeutic options, generally speaking, stable Lisfranc sprains can be managed non-invasively. Unstable complex Lisfranc injuries require surgical stabilization. The anatomic reduction of the Lisfranc joint complex is the key and is associated with better outcomes, independently of the use of percutaneous or open methods.

Conclusions

Lisfranc injuries account for the bone or ligament injury of the tarsometatarsal and intercuneiform joint complex, and include a range of injuries from stable partial sprains to unstable fractures or fracture-dislocations of the midfoot.

Lisfranc fracture-dislocations are infrequent injuries secondary to high energy traumatisms and they are easily diagnosed by routine X-ray or CT scan.

On the contrary, at low energy traumatisms patients are usually diagnosed midfoot sprains when actually what they suffer are small fractures around the Lisfranc joint (also called Lisfranc subtle injuries) with 20-35% of false negative rates in X-rays— suspicion is key to the diagnosis. As complementary studies, MRI can play a major role because an early diagnosis of the subtleties in bone structures and soft tissues is key to the indication of a proper treatment and also to avoid the important morbidity rates that are associated with late diagnosis.