37 Lisfranc ligament injuries

37.1 Introduction

The term Lisfranc injury is used to describe a wide spectrum of injuries from a sprain to fracture dislocations through the tarsometatarsal joints. To lessen ambiguity it has been suggested that the term "Lisfranc joint complex" should be used to refer to tarsometatarsal articulations and that the term "Lisfranc joint" should be used to medial articulation between the first and second metatarsals with the medial and middle cuneiforms.1

Injuries at the Lisfranc joint are relatively rare with a reported incidence of 1 per 55,000 yearly and make up about 0.2% of all fractures. These injuries can range from low-energy, simple ligamentous sprains associated with sports activities to high-energy motor vehicle accidents and industrial crushing injuries leading to complete disruption of normal anatomy through tarsometatarsal (TMT) or Lisfranc joints.2 Lisfranc ligament injuries commonly go undetected and Lisfranc joint dislocations and sprains carry a high risk of chronic secondary disability.3

37.2 Anatomy
These injuries occur at the junction of the tarso-metatarsal bones. Apart from the capsuloligamentous structures which stabilize these joints, there are attachments of posterior and anterior tibial tendons and peroneal tendons that provide dynamic stability. Skeletal stability in the midfoot is provided by the wedge shape of the cuneiforms and adjacent bases of the metatarsals creating a Roman arch and also by the proximal extension of the base of the second metatarsal serving as a key stone.

The Lisfranc ligament is an important soft tissue stabilizer of the "Lisfranc Joint" and originates from the lateral surface of the medial cuneiform and inserts obliquely and downward into the lower half of the medial surface of the base of the 2nd metatarsal. There are other ligaments between the bases of the metatarsals and between the metatarsals and adjacent tarsal bones, but none exist between the base of the first and the second metatarsal bones.

There are neurovascular structures that are important in consideration to the surgical approach to these joints. The dorsalis pedis artery is the continuation of the anterior tibial, passes forward from the ankle joint. In its course forward, it rests over the articular capsule of the ankle joint, the talus, navicular, and second cuneiform bones. It is crossed near its termination by the first tendon of the extensor digitorum brevis. On its tibial side is the tendon of the extensor hallucis longus; on its fibular side, the first tendon of the extensor digitorum longus and the termination of the deep peroneal nerve. It is accompanied by two veins along the tibial side of the dorsum of the foot to the proximal part of the first intermetatarsal space, where it divides into two branches, the first dorsal metatarsal and the deep plantar.

### 37.3 Biomechanics

Solan et al explored the ligamentous restrictions of the second metatarsal joint and reported biomechanical quantification of all the ligaments. They concluded that the plantar and Lisfranc ligaments were significantly stiffer and stronger than the dorsal ligament, and the Lisfranc ligament was significantly stronger and stiffer than plantar ligament.

Kura et al studied the mechanical behavior of Lisfranc and dorsal cuneometatarsal ligaments and reported that the stiffness and load to failure of the dorsal cuneometatarsal ligament were much higher than anticipated, which indicates that it contributes significantly to the stabilization of the second metatarsal with regard to the first cuneiform.

### 37.4 Clinical Presentation

There is a history of injury to the foot. Examples that lead to such an injury include sports such as football when some one lands on back of the foot of a person in a crouched position or a fall from a height on to the foot. A thorough history should include details about the injury to establish the duration and the mechanism of injury and to determine if there are any other associated injuries or co-morbidities that can influence its management. Pain in the midfoot region varies with severity. If patient is bearing weight there is a painful limp to be observed as walking is painful. Single leg stance over toes, running and jumping are not possible. A high index of suspicion is exercised in patients complaining of midfoot pain and in those with polytrauma and distracting injuries.
Plantar ecchymosis associated with Lisfranc ligament injury

37.5 Pathogenesis

Lisfranc injuries involve a disruption at the tarsal-metatarsal joints and most commonly involve the medial and middle columns of the foot. Injuries can vary from those that are purely ligamentous and sometimes subtle to those that cause severe disruption at the tarsometatarsal articulation, depending on the forces involved. Low-velocity injuries typically are associated with sporting activities that require the use of foot straps, such as windsurfing and horse-back riding.

Shapiro et al noted a typical mechanism of injury in football players when the foot is plantarflexed and the metatarsal-phalangeal joints maximally dorsiflexed a force directed down onto the heel by a falling player or tackle from behind can lead to a hyperplantarflexion injury at the Lisfranc joint. High-velocity Lisfranc injuries are commonly seen in high-speed motor vehicle accidents. The foot is usually on the brake pedal or the floor of the motor vehicle braced against the colliding impact.

37.6 Classification (Staging)

A useful classification system has been proposed by Nunley and Vertullo specifically for athletic injuries to the athlete's midfoot:

- 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 to 5 mm because of failure of the Lisfranc ligament but no arch height loss.
- 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.
37.7 Physical Examination

General examination and inquiry should be done to rule out or evaluate and manage concomitant injuries or conditions.

Specific physical examination of the foot should evaluate the condition of soft tissues, presence of swelling, blisters, wounds, vascularity, and neurological status. There may be obvious deformity in severe injuries. Bruising in the plantar aspect of the midfoot, described as the plantar ecchymosis sign, is helpful in recognizing subtle Lisfranc injuries. Another sign that becomes apparent at a later stage when the patient can bear weight on the feet is a wider gap between the big and second toe in the injured foot and has been described as the gap sign. Another finding the author has reported in these injuries is the convex bulge at the midfoot of the medial border of the foot apparent in a weight-bearing posture and when compared with the other foot.

![Figure 2](image.jpg)

**Figure 2.** The medial border of the right foot shows subtle convexity when compared to the left foot in a patient with Lisfranc ligament injury in the right foot

Palpation of the foot pinpoints the area of maximum tenderness at the base of the first and second metatarsals an important finding in subtle diastasis injuries.

Provocative tests have been described to help with diagnosis. The two most frequently used tests are side-to-side compression of the midfoot and dorsal/plantar deviation to the first metatarsal head while stabilizing the second metatarsal. Pain is produced at the midfoot when the tests are positive. Shapiro et al found these two provocative tests to be positive in all patients with a rupture of Lisfranc's ligament. More often, passive pronation and abduction of the midfoot elicits the most pain and reproduces the patient's symptoms.

37.8 Imaging
Initial radiographs of the foot include anteroposterior, 30 degree oblique and lateral views. These are assessed for any fractures or dislocations or incongruity of tarsometatarsal joints or diastasis between bases of first and second metatarsals or between medial and middle cuneiforms. A radiographic finding pathognomonic of Lisfranc injury is the "fleck" sign. This is due to a bony fragment avulsed at the attachment of the Lisfranc ligament and lying between the bases of the first and second metatarsals. On anteroposterior radiographs, alignment of the medial border of the second metatarsal and middle cuneiform and the medial border of the first metatarsal and medial cuneiform is assessed. On the oblique view, alignment of the medial border of the fourth metatarsal and the cuboid is checked. On the lateral view, the superior border of the metatarsal base should align with the superior border of the medial cuneiform.

Weight-bearing radiographs and comparison views of the uninjured foot can unmask a purely capsule-ligamentous injury revealing diastasis or incongruity, especially at a later date when the patient is able to tolerate body weight on the foot. Evaluation under anesthesia and application of manual stress such as abduction stress at the midfoot can unmask a subtle instability if pain prevents evaluation.

If the plain radiographs are negative and the injury is still suspected, computed tomography can reveal occult fractures and magnetic resonance imaging can reveal bone bruising or capsule-ligamentous disruption.

![Anteroposterior radiograph showing diastasis between the base of the second metatarsal and the medial cuneiform bone](image)

**Figure 3.** Anteroposterior radiograph showing diastasis between the base of the second metatarsal and the medial cuneiform bone

### 37.9 Conservative Treatment

Stable undisplaced Lisfranc injuries (Stage I) can be managed conservatively in a non-weight-bearing cast for 4-6 weeks. This is followed by weight-bearing in a shoe with molded insert supported underneath by a carbon insert or a steel shank. If the pain continues or if subsequent studies show signs of instability operative intervention is considered.

### 37.10 Operative Treatment
Operative repair is indicated in patients with Lisfranc injury Stages II & III when instability or displacement of the tarsometatarsal joint is evident on radiographs or unmasked by application of manual stress with or without anaesthesia.

### 37.10.1 Timing of Surgery

Significant soft tissue edema can develop rapidly after a Lisfranc injury. Soft tissue edema can make open reduction and internal fixation a very difficult undertaking and increases risk for wound complications. Measures to reduce the soft tissue edema such as elevation, splint application for immobilization, cryotherapy, and/or foot pumps should be initiated immediately. It can take up to 7--10 days for the soft tissue edema in the foot to reduce and skin wrinkles to reappear, which is when open reduction and internal fixation of these injuries can be undertaken. A 1- to 2-week delay has not been shown to compromise long-term outcomes of open reduction and internal fixation.\(^{12}\) If anatomic reduction cannot be achieved by closed methods, open reduction is necessary to remove interposed soft tissues.

Operative intervention is contraindicated in patients with poor wound healing potential, for example, those with peripheral vascular disease, poor soft tissue envelope, or chronic venous or lymph stasis.

### 37.10.2 Positioning

The operation is performed with the patient lying in a supine position with a bump under the ipsilateral hip.

### 37.10.3 Preoperative Preparation

A popliteal level or ankle level regional anesthetic given preoperatively with ultrasound guidance provides perioperative pain relief. The author coined a term "needle-before-knife" to advocate a practice that possibly has preemptive benefits. Anesthetic injected regionally or locally before nociceptive receptor signals are fired by action of the "knife," possibly has a preemptive effect lowering the dosage and needs of adjunctive medication or modalities.

The entire leg is prepared from the level of the mid thigh down and draped to isolate it in a sterile fashion. A single dose of an antibiotic is administered intravenously for prophylaxis against infection. A sterile tourniquet is applied at the level of the ankle and inflated to about 100 mm Hg above the systolic pressure, usually about 250 mm Hg, after exsanguination. The author uses a triangular support under the knee to get the foot positioned plantigrade on the operating table. Plantigrade positioning of the foot enables the surgeon to get a better orientation for intra-operative imaging and to direct drill holes and insert implants such as screws. This technique tip also helps the surgeon to work on the foot with minimal manual assistance required to hold the foot.\(^{13}\)
A triangular frame under knee helps to lay the foot flat on the operating table aiding orientation of joints and implant insertion.

37.10.4 Incisions and Exposure

Intraoperative fluoroscopy in multiple projections and application of stress in multiple directions at various joints in the midfoot help unmask any instability not otherwise evident. After identifying the joints that need stabilization, incision(s) are planned.

Percutaneous or open methods can be used to achieve reduction and stabilization. The incision for open method is made over the interspace between the first and second metatarsals and provides access to the medial and middle columns. The deeper dissection is just lateral to the extensor hallucis longus tendon. The author avoids going through the tendon sheath. Further dissection should proceed with extreme care so as to protect the sensory branches of the superficial peroneal nerve, the deep peroneal nerve, and the dorsalis pedis artery. After subperiosteal exposure of the involved joints, reduction and stabilization is performed in a sequential manner starting with medial column.

37.10.5 Reduction and Temporary Stabilization

Anatomic reduction of joints can occasionally be achieved by closed manipulation and reduction held with clamps applied percutaneously. However the reduction should be assessed carefully in different projections using intraoperative fluoroscopy. Otherwise, open exposure of the joints and debridement to remove any interposed fragments of bone, cartilage, or soft tissue such as capsule-ligamentous structures or tendons must be conducted to achieve reduction under direct vision.

A large bone clamp is applied with one limb of the clamp inserted over the medial aspect of the medial cuneiform through a small incision and blunt dissection down to bone and the other limb of the clamp inserted through an existing wound or through a small incision and blunt dissection over the lateral aspect of the base of the second metatarsal. This clamp holds the reduction between the medial cuneiform and the base of the second metatarsal. At this stage, stability of tarsometatarsal and intertarsal joints of the first and second ray are tested and temporary stability can be achieved using K wires intended to be used for cannulated screws or for temporary stabilization of plates.
37.10.6 Hardware and Implants

- Cannulated screws: Through the previous exposure, a guidewire for the cannulated drill is inserted between the medial cuneiform and the base of the second metatarsal into the under fluoroscopic guidance. The screws are partial threaded and the sizes used vary between 4.0 and 5.0 mm, depending on the build of the person. They are inserted in compression with threads crossing the joint.

- Cannulated screws: Guidewires for the cannulated screws are driven from the base of the first metatarsal to the first cuneiform and similarly in the second ray if necessary and also between the cuneiforms. Fully threaded screws avoid compression across the joints.

- Staples/locking plates: Extra-articular stabilization can be achieved by implants that do not need to traverse. For spanning adjacent bones a compression staple or mini two-hole plate or staple with locking screws, can then be used across the intercuneiform or tarsometatarsal joints of the medial or middle column. Longer locking plates available in different lengths or shapes such as the letter H are also available to span two or more joints in the medial and middle columns.

![Figure 5](https://orthopaedicsone.com:hidden/orthopenas.com/background_files/orth ICON_1.png)

Figure 5. Open exposure of the Lisfranc joint showing the diastasis and interposed bony fragment
Figure 6. AP radiograph of the patient in Figure 5 showing the fracture subluxation at the Lisfranc joint involving the first and second metatarsals and respective cuneiforms.

Figure 7. Reduction and stabilization with internal fixation.
37.11 Postoperative Management

Measures are initiated to prevent and reduce postoperative swelling, such as elevation, immobilization and cryotherapy. The limb is held in a non-weight-bearing splint, and wounds are checked at 1 week. A cast replaces the splint and the patient continues with non-weight-bearing precautions for 5 weeks. Percutaneously placed K wires are taken out at 6 weeks. During the ensuing 6 weeks, weight-bearing is allowed as tolerated in a removable boot or a bivalved cast. At 3 months, the patient is encouraged to ambulate in a stiff-soled shoe with a carbon plate or a total contact orthotic. The author discusses with patients the possibility of the implants breaking and offers option of removal of the implants at 4 months post-injury.

37.12 Complications and Pitfalls
Superficial sensory nerves and the dorsalis pedis artery encountered during exposure and internal fixation could be damaged. Subsequent neuroma formation on the dorsum of the foot can be very debilitating. Inadvertent damage to the articular surface can occur if the three-dimensional anatomy and the tapering shape of the small midtarsal cuneiform bones are not appreciated or studied in multiple projections under fluoroscopy before insertion of the drill or implants. The extensor tendons can be damaged intra-operatively.

37.13 Controversy

There is controversy regarding use of transarticular fixation between metatarsals and their respective cuneiforms.

Alberta et al, in a cadaver study, evaluated the area of visible articular surface damaged at the tarsometatarsal joints caused by a single 3.5-mm screw varied from 2.0% to 4.8%. Post-traumatic arthritis is a complication associated with Lisfranc joint injuries in approximately 30% of patients. The amount of arthritis is directly proportional to the area of damage on the articular surface. Despite the articular damage, transarticular screw fixation is currently recommended over K-wire fixation for the medial three tarsometatarsal joints because screws provide a more rigid fixation. Furthermore, weight-bearing is delayed to avoid the risk that screws will break in situ. A second operation is necessary to remove the screws; if the transarticular screws break, the distal portion of the screw is difficult to remove and potentially can be left behind. Loss of reduction and recurrence of diastasis can still occur following removal of stainless steel screws. Loss of reduction has been noted even when these screws were removed as late as 6 months after injury, indicating incomplete ligamentous healing. And stainless screw breakage has been noted as early as 3 months following surgery and prior to removal of the cast. In one study, screws across the third tarsometatarsal joint failed most often, followed by screws across the first tarsometatarsal joint. A second operation to remove transarticular stainless screws can be avoided by using absorbable screws. Absorbable screws are less rigid than metal screws, although their insertion still damages the articular cartilage. The amount of time and loss of fixation strength associated with degradation may be variable; further, there can be joint damage resulting from the breakdown products from the screws. Unlike transarticular screws, joint-spanning implants, such as staples, or locking plates, do not cause further damage to the articular surfaces of the joints being preserved. Therefore, they are theoretically less likely to contribute to post-traumatic arthritis.

A larger exposure is required for insertion of extra-articular plates or staples when compared with insertion of percutaneous screws across the tarsometatarsal and intercuneiform joints. However, open reduction has been recommended even in those cases of Lisfranc injury in which anatomic reduction can be achieved by closed means or with the aid of percutaneous clamps. Open reduction allows removal of any interposed intra-articular capsule, cartilage, or bone fragments and the reduction can be confirmed under direct vision. A flexible fixation with suture-button may promote better ligamentous healing when compared to rigid fixation with screws. Panchbhavi et al, in cadaver specimens, compared suture- button to screw fixation and found similar stability provided by both techniques in the laboratory setting. However this has not been corroborated by clinical experience with reports of loss of fixation and recurrence of diastasis at the Lisfranc joint when suture- button was used.
37.13.1 Open Reduction and Internal Fixation vs. Primary Arthrodesis

A clinical study compared open reduction and temporary internal fixation with arthrodesis in patients with severe acute Lisfranc dislocations and found that patients who underwent internal fixation had less pain. Additionally, this study found that stiffness of the forefoot, loss of metatarsal arch, and sympathetic dystrophy occurred more frequently in the complete arthrodesis group. The researchers concluded that primary complete arthrodesis of the tarsometatarsal joint should be reserved as a salvage procedure.

In contrast, a recent prospective, randomized, controlled study appears to show better outcome in short- and medium-term follow-up following a primary stable arthrodesis of the medial two or three rays compared with open reduction and internal fixation of purely ligamentous Lisfranc joint injuries. The long-term effects following primary arthrodesis on foot function or adjacent joint arthritis are not known.

37.14 References

10. Davies MS, Saxby TS. Intercuneiform instability and the “gap” sign. Foot Ankle Int.20:606-609; 1999