The tarsometatarsal joint complex, commonly referred to as the Lisfranc joint, is named for Jacques Lisfranc (1790-1847), a field surgeon in Napoleon’s army. Lisfranc described an amputation involving the tarsometatarsal joint due to a severe gangrene that developed when a soldier fell from a horse with his foot caught in a stirrup. The tarsometatarsal joint complex is an osseous and capsuloligamentous network that includes the 5 metatarsals, their articulations with the cuneiforms and cuboid, and the Lisfranc ligament, a strong interosseous attachment between the medial cuneiform and second metatarsal. A multitude of injury patterns exist involving the tarsometatarsal joint complex; a Lisfranc injury does not delineate a specific injury, but instead a spectrum of processes involving the tarsometatarsal joint complex.

Injuries to the Lisfranc joint occur in 1 per 55,000 individuals each year in the United States and are 2 to 3 times more common in men. Approximately 20% of these injuries are missed or misdiagnosed on initial radiographic assessment. This can have devastating consequences because Lisfranc injuries lead to degenerative arthritis, loss of arch and chronic instability, and pain at the midfoot–forefoot articulation. High-energy mechanisms are the most commonly cited causes of Lisfranc injury, with motor vehicle accidents accounting for 40% to 45% of the injuries. Low-energy mechanisms, such as those sustained in athletic competition, account for approximately 30%. It is these that may initially go undiagnosed.

**ANATOMY**

The Lisfranc joint divides the midfoot and the forefoot, forming an oblique line running from the lateral aspect of the proximal forefoot to the medial aspect of the distal forefoot. Bony elements provide the primary structural support to this articulation, with ligamentous contributions adding additional stability. The 3 medial metatarsals articulate with the 3 cuneiforms; the fourth and fifth metatarsals articulate with the cuboid. In the coronal plane, the 3 cuneiforms form a recess in which the second metatarsal sits, locking it into place. In sagittal and transverse sections, the medial 3 metatarsals are broader dorsally than plantarly. Their bases are trapezoidal and appear wedge-shaped, producing a stable configuration in conjunction with their associated cuneiforms resembling a Roman arch. The second metatarsal is the longest of the metatarsals. The middle cuneiform–second metatarsal articulation forms the keystone of the arch, preventing mediolateral metatarsal motion at the Lisfranc joint. This transverse arch also prevents plantar displacement of the 3 medial metatarsals.

There is limited soft tissue support to the Lisfranc joint, provided by the joint capsule and ligaments. Ligaments are...
grouped according to anatomic location (dorsal, plantar, and interosseous). In addition, the lesser metatarsals are bound together by intermetatarsal ligaments. There are no ligamentous connections between the first and second metatarsal bases. The most significant and strongest ligamentous structure is the oblique interosseous ligament, referred to as the Lisfranc ligament. Originating on the lateral surface of the medial cuneiform, it passes in front of the intercuneiform ligament and ultimately inserts on the medial aspect of the second metatarsal base near the plantar surface. In a biomechanical study by Solan et al,6 the dorsal, plantar, and interosseous ligamentous strength was evaluated by stressing each to failure. The Lisfranc ligament was strongest, followed by the plantar and then the dorsal ligaments.6

**Mechanism of Injury**

Direct and indirect injuries occur at the Lisfranc joint. Direct injuries, most commonly crush injuries, are due to high-energy blunt trauma to the dorsum of the foot. These often result in worse clinical outcome as compared to indirect types, secondary to the associated soft tissue trauma. Indirect mechanisms are stratified into high-energy and low-energy subtypes. Motor vehicle accidents are the most common cause of high-energy Lisfranc injury. Low-energy injuries include those incurred during athletic competition.

The indirect mechanism usually involves axial loading of a plantarflexed foot. This is demonstrated in football, when one player falls onto the heel of another whose foot is in equinus and planted. Of note, approximately 4% of professional football players sustain Lisfranc injuries each year.1

Indirect Lisfranc injuries have also been observed in gymnasts and soccer and basketball players.7 Less common low-velocity mechanisms include forced forefoot abduction and nonspecific twisting or falling.5

The fracture pattern and direction of dislocation in direct injuries is dependent on the force vector applied. Indirect injuries are more predictable and most commonly involve failure of the weaker dorsal tarsometatarsal ligaments in tension with subsequent dorsal or dorsolateral metatarsal dislocation.5

**Classification**

Several classification systems exist, the earliest of which was published in 1909 by Quenu and Kuss9 and subsequently modified by Hardcastle et al in 1982 and Myerson et al10 in 1986. These classifications are all based on tarsometatarsal joint congruency and displacement of the metatarsal bases. Although effective in standardizing descriptions of Lisfranc injuries, these classifications have not been found to be helpful in regard to management and prognosis (Figure 1).5,10

In an attempt to develop a classification scheme with strong prognostic implications, Chiodo and Myerson11 established a columnar classification in 2001 based on the 3 mechanical columns of the foot. The medial column consists of the first tarsometatarsal and medial naviculocuneiform joints. The middle column consists of the second and third tarsometatarsal joints and the articulation of the middle and lateral cuneiforms with the navicular. The lateral column is formed by the articulations between the fourth and fifth metatarsals and the cuboid. It has been shown that posttraumatic arthritis following tarsometatarsal joint complex injury is most common at the base of the second metatarsal and that incongruity is best tolerated by the medial and lateral columns.12

Similar to the traditional classifications, the Chiodo and Myerson11 columnar system fails to emphasize the subtle Lisfranc injury, specifically the low-energy process leading to simple diastasis between the first and second metatarsals and the intercuneiform and naviculocuneiform spaces. Commonly referred to as a midfoot sprain, the subtle Lisfranc injury is often undiagnosed at first, but can progress to, like more obvious tarsometatarsal complex injuries, posttraumatic arthritis.

In 2002, Nunley and Vertullo13 classified subtle Lisfranc injuries into 3 types based on clinical findings, weight-bearing radiographs, and bone scintigraphy of 15 athletes. In stage I injury, there was pain at the Lisfranc complex and increased uptake on bone scan, with negative radiographic findings. In stage II injuries, radiographic diastasis of 1 to 5 mm greater than the contralateral foot was observed, with no loss of midfoot arch height. A stage III injury was classified as diastasis and an associated loss of midfoot arch height.13

**Diagnosis**

The diagnosis of high-energy Lisfranc injuries is straightforward; physical examination will reveal swelling and obvious deformity, including widening or flattening, of the forefoot. Additionally, it might be an open injury with disruption of the skin and subcutaneous tissue. Tarsometatarsal joint injury and intercuneiform diastasis is suggested in the presence of a gap between the first and second toes, known as a positive gap sign.14 While associated vascular injury is rare, it may be difficult to palpate a dorsalis pedis pulse secondary to swelling.15 The clinician must also consider a concurrent compartment syndrome with severe swelling and pain.

![Figure 1: AP radiograph showing a divergent type Lisfranc injury as classified by Myerson et al.10](image-url)
with passive dorsiflexion of the toes. If unsure, measurement of pressures is warranted.

In the setting of a low-energy injury, physical examination may only reveal a patient with inability to bear weight and possibly midfoot and forefoot swelling. To avoid misdiagnosis, the clinician must be diligent in the assessment of these injuries. Paying attention to the reported mechanism and the clinical appearance of the foot is pivotal to making the correct diagnosis. An additional finding may be plantar arch ecchymosis, which is considered pathognomonic for Lisfranc injury. To increase the accuracy of diagnosis, various tests and stress maneuvers have been described to aid in the diagnosis of subtle injury. Of note, pain on passive abduction and pronation of the forefoot is suggestive of injury to the tarsometatarsal complex.

**IMAGING**

Initial imaging includes nonweight-bearing anteroposterior (AP), lateral, and 30° oblique views of the foot, with the images taken parallel to the midfoot joints. However, 50% of subtle Lisfranc injuries will have normal nonweight-bearing imaging. Thus, to diagnose these injuries, a weight-bearing radiograph with both feet on a single cassette or an abduction–pronation stress view should be obtained. Admittedly, these are rarely obtained secondary to pain, necessitating a bone scan or magnetic resonance imaging. Computed tomography (CT) scan is useful in confirming the diagnosis in subtle injuries, helping to determine treatment options if the fractures are displaced or the joints subluxed, and also helping to fully delineate the fracture pattern in more severe injuries.

On the AP radiograph, findings suggestive of a Lisfranc injury include incongruity at the first and second metatarsal joints, misalignment of the medial border of the second metatarsal and medial border of the middle cuneiform, and diastasis of ≥2 mm between the first and second metatarsals as compared to the contralateral foot. It is important to note, however, that on AP view, the first-second metatarsal interspace has been shown to be variable amongst individuals, with up to a 3-mm diastasis at times considered normal. This elucidates the need for radiographic comparison with the contralateral foot when there are no other findings suggestive of tarsometatarsal complex injury.

The oblique radiograph should show alignment of the medial border of the fourth metatarsal and the medial border of the cuboid in a normal foot. Misalignment may suggest a tarsometatarsal joint complex injury. Potentially seen on this view, as well as the AP view, is the fleck sign as described by Myerson et al. It refers to the presence of a small bony fragment between the base of the second metatarsal and the medial cuneiform and represents an avulsion of either the proximal or distal attachment of the Lisfranc ligament.

The lateral radiograph will show flattening of the longitudinal arch and dorsal displacement at the second tarsometatarsal joint. The fifth metatarsal is normally plantar in relation to the medial cuneiform. Flattening of the midfoot arch positions the medial cuneiform plantar to the fifth metatarsal.

These radiographic findings are those most commonly encountered with Lisfranc injuries. However, the absence of these radiographic findings does not definitively rule out a Lisfranc injury. Other radiologic signs suggestive of tarsometatarsal instability exist and are less frequently encountered. Associated injuries of the forefoot, such as metatarsal neck fractures, should not fool the practitioner into thinking that these are isolated injuries.

**MANAGEMENT**

Indications for both operative and nonoperative treatment exist, all with the goal of reestablishing a painless and stable foot. Any disruption of normal anatomy warrants surgical correction. Nonoperative treatment is limited to stable tarsometatarsal joint complex injuries.
injuries and include those that are nondisplaced, with no fracture, and stable under radiographic stress examination. Nonoperative management is also indicated for those with a preexisting insensate foot, minimal to no ambulatory ability, or inflammatory arthritis. Treatment involves protected weight bearing in a controlled ankle motion (CAM) walking boot, with frequent follow-up radiographs to ensure no change in alignment. It takes approximately 4 months to recover from a nonoperative Lisfranc injury.

In unstable Lisfranc injuries, open reduction internal fixation (ORIF) is performed to restore anatomic alignment. In most cases, screw fixation is used to fix the first, second, and third tarsometatarsal joints, while the fourth and fifth may be pinned with Kirschner wires. Although this is a common approach to operative management, many forms of fixation are available and depend on both the nature of the injury and the surgeon’s preference. Additional options include bridge plating and primary fusion. A period of non-weight bearing follows surgery, with progression to protected and then full weight bearing at approximately 3 and 8 weeks, respectively.

Regardless of the modality, anatomic alignment is the standard to decrease the risk of posttraumatic arthritis, chronic instability, and pain; dorsolateral displacement of the second metatarsal base of 1 or 2 mm results in reduction of the tarsometatarsal articular contact area by 13.1% and 25.3%, respectively. Good or excellent results have been accomplished in 50% to 95% of patients with anatomic alignment, compared with 17% to 30% of patients with nonanatomic alignment following injury. In a retrospective study by Kuo et al, American Orthopaedic Foot and Ankle Society Midfoot Scores and long-form Musculoskeletal Function Assessment scores were used to evaluate patient outcomes at an average of 52 months following ORIF for a Lisfranc injury. Good results on these surveys correlated most with anatomic reduction.

**Case Reports**

**Patient 1**

An 18-year-old man presented to the emergency department with severe and diffuse right foot pain and an inability to bear weight after being run over by a slow-rolling golf cart (<5 mph). The patient’s foot was moderately swollen and was neurovascularly intact. Nonweight-bearing AP, oblique, and lateral radiographs revealed tarsometatarsal joint alignment but slight widening at the first intercuneiform space, widening of the first and second intermetatarsal spaces, and an avulsion fracture at the base of the second metatarsal (Figures 2A-C). The patient was placed in a splint, made nonweight bearing, and subsequently discharged from the emergency department.

Two weeks later, follow-up radiographs showed no significant change from the initial radiographs, but the patient continued to report severe foot pain. The patient was followed closely, and subsequent radiographs demonstrated late diastasis of the tarsometatarsal joints. Approximately 6 weeks from the injury, the patient underwent ORIF of the first, second, and third tarsometatarsal joints.

Intraoperative findings demonstrated instability of the first, second, and third tarsometatarsal joints and mild diastasis of the first intercuneiform space with no instability. The joints were reduced, and transarticular screw fixation was performed (Figures 2D, E). The patient was kept nonweight bearing for 10 weeks, at which time he was advanced to a CAM walker and allowed to weight bear to tolerance. He had advanced to regu-
lar shoe wear with an orthotic at approximately 3 months postoperatively. He underwent screw removal 6 months postoperatively.

In this case, the patient lacked significant swelling of his foot but experienced severe pain. This is a common presentation for a tarsometatarsal joint complex injury in the setting of a low-energy mechanism, such as a golf cart slowly rolling over the dorsum of one’s foot. Given these clinical findings, appropriate imaging was obtained. Although radiographs depicted the fleck sign, as well as other findings consistent with subtle Lisfranc injury, there was an appropriate middle cuneiform–second metatarsal and cuboid–fourth metatarsal relationship. Thus, given the absence of an obvious fracture-dislocation of the Lisfranc joint, tarsometatarsal joint complex disruption was not immediately apparent. This case underscores the importance of surveillance because latent diastasis was detected 4 weeks postinjury.

Patient 2
A 12-year-old boy presented to the emergency department with significant midfoot swelling and painful weight bearing of his left foot. He reported injuring his foot while landing from a jump at Taekwondo class. Clinical examination demonstrated profound swelling of the foot with associated plantar ecchymosis suspicious for injury to the tarsometatarsal complex.

His initial imaging included nonweight-bearing AP, oblique, and lateral radiographs, which displayed fractures of the distal third and fourth metatarsals, slight widening of the third through fifth tarsometatarsal joints, and a small bony fragment between the second and third metatarsal bases (Figures 3A–C).

Operative repair was indicated to repair the displaced metatarsal neck fractures. Intraoperative stress views were performed, demonstrating instability of the first tarsometatarsal joint (Figure 3D). The patient underwent transarticular crossed K-wire fixation along with pinning of the metatarsal neck fractures (Figures 3E, F).

Postoperatively, the patient began protected weight bearing at 6 weeks and was allowed to return to full activities at approximately 10 weeks postinjury.

This case illustrates the spectrum of tarsometatarsal injuries associated with forefoot trauma. The clinical appearance suggested involvement beyond what was radiographically evident. It is critical to explain the nature of these injuries to the patient and family members so that the appropriate steps for management are taken.

Patient 3
A 27-year-old man presented several days after a 10-foot jump off a wall. He immediately had right midfoot swelling and pain. Physical examination of both the injured and contralateral foot was consistent with an unstable tarsometatarsal complex. His initial imaging included nonweight-bearing AP, oblique, and lateral radiographs, which displayed fractures of the distal third and fourth metatarsals, slight widening of the third through fifth tarsometatarsal joints, and a small bony fragment between the second and third metatarsal bases (Figures 3A–C).

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joint complex injury. Plain radiographs were suspicious for fractures of the middle and lateral cuneiforms, as well as diastasis between the medial and middle cuneiforms (Figures 4A-C). Computed tomography scan confirmed the diagnosis of a Lisfranc injury to the first and second rays, but the third cuneiform and tarsometatarsal joint were intact (Figures 4D, E).

Intraoperatively, tarsometatarsal joint complex instability was confirmed because capsular tears of the first and second tarsometatarsal joints were noted, as was Lisfranc joint instability on fluoroscopic stress views. Accordingly, the first and second tarsometatarsal joints, as well as the intercuneiform space, were reduced and internally fixed (Figures 4F, G).

The patient’s mechanism of injury is one commonly associated with a Lisfranc injury. Based on his description, there was likely a significant axial load placed on his plantar flexed foot. Initial physical examination was also consistent with a Lisfranc injury, but imaging lacked the aforementioned obvious signs of an unstable tarsometatarsal joint complex process. Instead, both radiographs and CT elucidated signs of a subtle Lisfranc, including intercuneiform diastasis and fractures of the middle and lateral cuneiforms. These radiographic findings may not correlate with a tarsometatarsal joint complex process; this is why the subtle Lisfranc injury is often initially undiagnosed up to 20% of the time.5 In this case, it was diagnosed early and the patient underwent appropriate operative intervention to reestablish alignment of the tarsometatarsal joint complex.

**Conclusion**
Diagnosis of subtle Lisfranc injuries requires careful evaluation of the history for a mechanism consistent with the injury as well as physical findings (significant midfoot pain and swelling and plantar ecchymosis). Imaging studies, especially CT scan, can confirm the diagnosis and further guide treatment decisions.

**References**

**Coming next issue...**

**Sports Medicine Update**