CHAPTER

106

Lawrence A. DiDomenico
Dawn Y. Stein

Tarsometatarsal (Lisfranc) Joint Dislocation

Fracture dislocations of the tarsal–metatarsal (Lisfranc injuries) can be subtle and may be missed in both initial and later evaluation of midfoot injuries. Injuries to the Lisfranc complex can be difficult to diagnose and may be overlooked in patients who have multiple injuries (polytrauma, i.e., motor vehicle accident) or in patients who experience a simple injury such as a sprain. These injuries encompass a wide spectrum from simple injuries to grossly unstable dislocations. They can cause severe long-term morbidity if not appropriately treated. Dislocations at the tarsometatarsal joint are an uncommon injury, comprising only 0.2% of all fractures (1,2). However, in more recent literature, it has been reported as common as 7.9% of all fractures (3). It is the author's experience that the subtle injuries occur more commonly than reported due to the difficulty of making the appropriate diagnosis. It is not uncommon for foot and ankle surgeons to see patients with a Lisfranc injury days or sometimes weeks later following a visit to the emergency room with an unrecognized injury. Although they are not that common in the general population, they are the second most common athletic foot injury, occurring in 4% of football players per year (4). Twenty (5,6) to thirty-five (3) percent of these injuries are unrecognized or misdiagnosed. Therefore, a high index of suspicion is needed when diagnosing this injury (7).

The injury was previously reported to have a high incidence in equestrian riders whose foot would get caught in the stirrup when falling off. The development of narrow-toe boots prevented the foot from being caught in the stirrup (8). High-energy traumatic injuries, such as in motor vehicle accidents, have been reported to account for the majority of the injuries, resulting in about one-half to two-thirds (9–11) of them. Myerson reported the injury in several windsurfing athletes and more recently in a high-velocity sledding injury by Benejam and Potaczek (12). Lisfranc injuries may also be a result of low-velocity trauma such as a stumble or a fall (12,13).

The Lisfranc joint bears its name from Jacques Lisfranc (1790 to 1847), a French surgeon in Napoleon's army, who performed amputations through the tarsometatarsal joint to treat gangrenous injuries in the foot (14). However, he never described the fracture or dislocation. Lisfranc injury was first described by Quenu and Juss in 1909 who classified the injury based on the deforming force of the foot. Hardcastle et al in 1982 further modified the classification system, followed by Myerson et al in 1986, describing the radiographic injury pattern at the Lisfranc joint.

FUNCTIONAL ANATOMY

The tarsometatarsal joints attach the forefoot to the midfoot and is a weight-bearing structure with numerous ligaments and tendon attachments. Typically, the forefoot is mobile relative to the stable midfoot. The midfoot bones function as a single unit with minimal motion between the individual bones. In nonpathologic feet, these joints are stable and help shape the longitudinal medial arch. The three medial tarsometatarsal joints are very stable. The first tarsometatarsal joint is a deep joint that measures approximately 3 cm in depth. These joints provide varying degrees of dorsal and plantar motion. Based on its shape, size, and strong peripheral ligaments, the first tarsometatarsal joint should provide stability. Additionally, stability is gained through the dynamic tension of its tendon attachments of the peroneal longus and anterior tibial tendon. The second and third tarsometatarsal joints are essentially immobile in normal feet. These joints are stabilized by there osseous configuration and strong plantar intermetatarsal ligaments. The cuboid, which articulates with the fourth and fifth metatarsals, is much more mobile. The fourth and fifth tarsometatarsal joints have immense gliding motion to allow for adjustments to uneven surfaces and align the forefoot with hind foot. Essentially, the fourth and fifth tarsometatarsal joints are mobile adapters (Fig. 106.1).

BONY ANATOMY

The osseous structures consist of the metatarsals, cuneiforms, and the cuboid bone. Two arches are formed on the frontal and transverse planes. The metatarsal and cuneiforms are asymmetric in size and shape. The second and third cuneiforms are situated more dorsally than plantarly; they are wedge shaped, with the base of the wedges situated dorsally and the apex plantarly, which accounts for the naturally occurring intrinsic support (Fig. 106.2A). The second metatarsal is recessed between the adjacent metatarsal–cuneiform joints, contributing to a keystone effect (Fig. 106.2B). The intercuneiform joints are perpendicular to the transverse arch, which accounts for most of the intrinsic support of the arch (8).

LIGAMENTOUS ANATOMY

Each metatarsal base is connected by a strong transverse, oblique, and interosseous ligament, except at the base of the first and second metatarsal where none exists. Instead, an extremely strong, thick ligament extends from the medial base of the second metatarsal obliquely into the medial cuneiform, which has been previously noted as the Lisfranc ligament (15,16) (Fig. 106.3). The Lisfranc ligament is roughly 1.5 cm × 0.5 cm thick, consisting of a longitudinal and oblique portion in 22% of cases (17). The ligaments are stronger plantarly than dorsally (7). The plantar fascia, tendons, and muscles also support the joints on the plantar aspect.

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Figure 106.1 **A:** AP radiograph demonstrates a view with no pathologic changes at Lisfranc joint. **B:** Medial oblique radiograph demonstrating no pathologic changes. Note the alignment of the lateral aspect of the third metatarsal and lateral cuneiform, the medial aspect of the fourth metatarsal, and the medial aspect of the cuboid.

DIAGNOSIS

Many injuries go unrecognized as many appear to reduce spontaneously, although on closer examination they remain displaced. As a result, many patients are misdiagnosed with a foot sprain. Initially, plain radiographs are taken (Fig. 106.4A and B). Significant fracture, subluxation, and/or dislocation at the tarsometatarsal joints can be seen on plain radiographs. In cases with distinct injury, it is important to review the surrounding anatomy to evaluate for further injury (Fig. 106.4C). Although many injuries go undiagnosed or overlooked, a high index of suspicion is necessary to properly diagnose a patient with a Lisfranc injury. An individual may present with swelling and tenderness along the tarsometatarsal joints with additional instability. Weight-bearing radiographs can be difficult to obtain as most of these injuries will prevent patients from full weight-bearing. A stress test may be performed by grasping both the first and second metatarsals and performing both dorsiflexion and

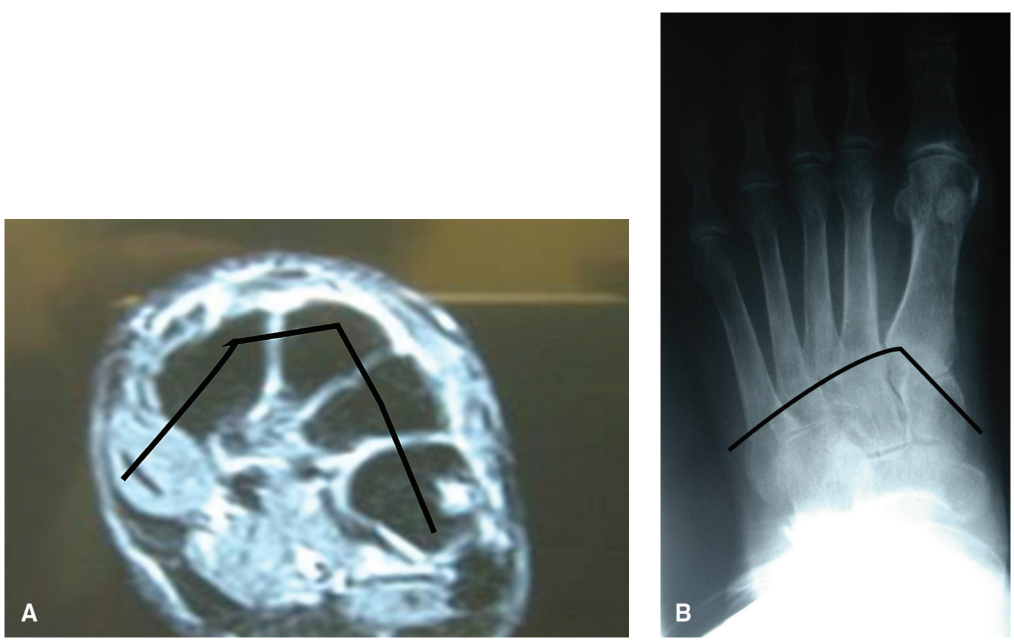

Figure 106.2 **A:** The second and third cuneiforms are situated more dorsally; they are wedge shaped, with the base of the wedges situated dorsally and the apex plantarly, which provides for the naturally occurring intrinsic support—notice the arch in the frontal plane. **B:** The second metatarsal is recessed between the adjacent metatarsal–cuneiform joints, providing stability and a keystone effect. The medial and lateral columns form an arch away from the second metatarsal tarsal joint.

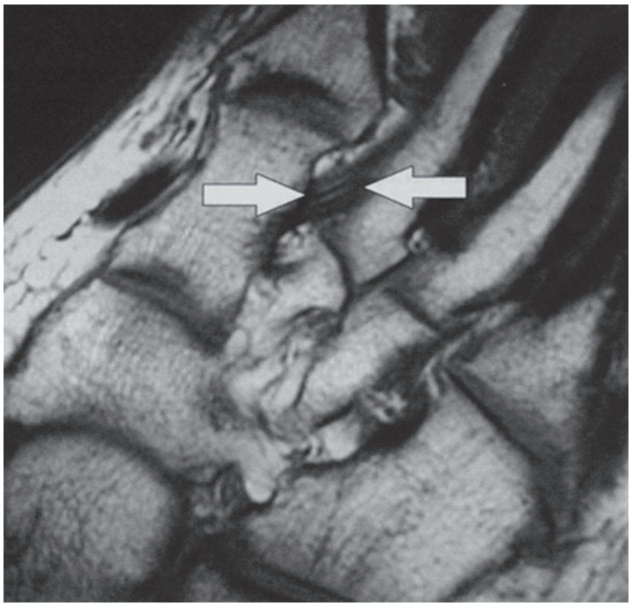

Figure 106.3 Lisfranc ligament runs longitudinally and obliquely from the lateral aspect of the medial cuneiform to the medial aspect of the base of the second metatarsal.

plantarflexion motions. Also, performing simultaneous pronation and abduction of the midfoot and forefoot can reproduce symptoms. A positive test result is one that elicits pain with minimal stress (18). Harwood and Raikin (19) suggest maintaining the hindfoot in a position of inversion when performing the stress test to eliminate subtalar motion (Fig. 106.4D and E)

DIAGNOSTIC STUDIES

Diagnostic tools are very helpful in the diagnosis of a Lisfranc injury. A study by Foster and Foster (20) in 1976 reviewed 200 normal radiographs and compared the findings with those diagnosed with a Lisfranc injury. Normal radiographic findings are alignment of the medial aspect of the base of the second metatarsal with the medial border of the intermediate cuneiform on the anterior–posterior view and, on the oblique view, medial border of the base of the fourth metatarsal aligned with the medial aspect of the cuboid (see Fig. 106.1). In addition, a space between the base of the first and second metatarsal bases may be normal; however, if there is a "step-off" at the base of the second metatarsal and intermediate cuneiform, there may be evidence of an injury. A distance between the first and second metatarsals greater than 2 mm is suggestive of injury (21). Myerson identified a "fleck sign" that can be seen at the medial

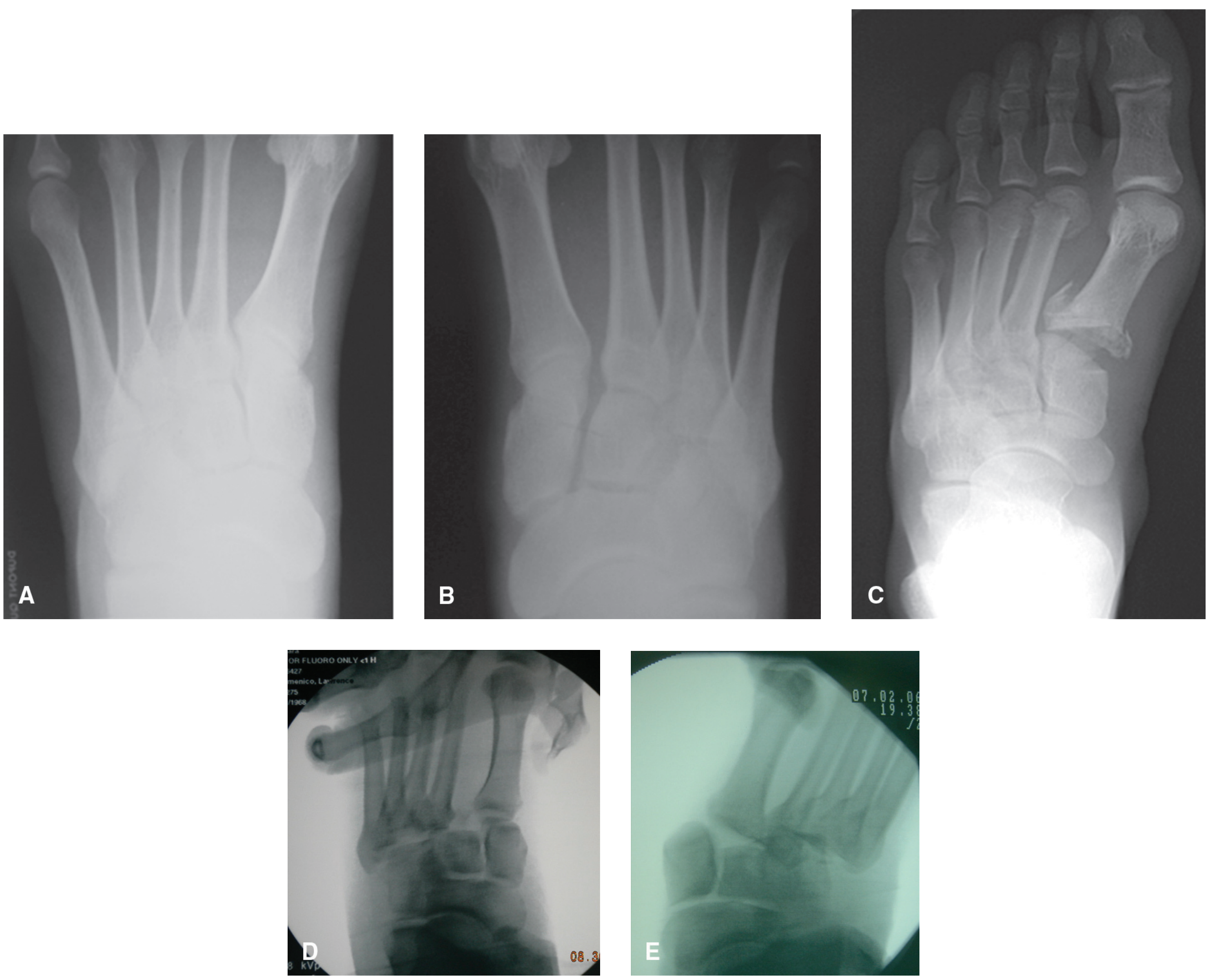

Figure 106.4 **A,B:** Bilateral weight-bearing radiographs demonstrating a small "fleck sign" on the right with a gapping noted at the intercuneiform and Lisfranc joint. **C:** AP radiograph demonstrating trauma to Lisfranc joint as well as the second and third metatarsal heads. **D,E:** Abduction stress radiographs demonstrating Lisfranc instability.

base of the second metatarsal or lateral base of the first metatarsal as an avulsion fracture (Fig. 106.5A), as seen in 90% of the 72-patient Lisfranc injury study (22). Other authors, such as Faciszewski, suggested that a diastasis of 2 to 5 mm between the bases of the first and second metatarsals, as seen on the AP radiographs, is consistent with injury. Also noted in subtle injuries of the Lisfranc joint was a flattening of the longitudinal arch, which could be identified on a lateral radiograph by observing the medial cuneiform at a more plantar attitude to the fifth metatarsal (23) (Fig. 106.5B). Lu suggests that a 1-mm diastasis between the first metatarsal and second metatarsal on CT image as well as an increase of more than 15 degrees in the tarsometatarsal angle results in a chronic Lisfranc joint failure (24).

Radiographs should also be assessed for fractures associated with Lisfranc dislocation (Fig. 106.6). Depending on the force and direction of dislocation, fractures of the metatarsals and dislocations of the metatarsophalangeal joints have been reported along with compression fractures of the cuboid and navicular (10,25–27).

In cases with subtle injuries, the authors additionally recommend obtaining bilateral weight-bearing radiographic films for comparison as well as advanced imaging such as CT scans and MRI (Fig. 106.7).

MECHANISM OF INJURY

There have been two suggested mechanisms of injury described by Aitken and Poulson. They reported on both direct and indirect force resulting in dislocation of the tarsometatarsal joint (25).

DIRECT INJURY

Dislocations of the tarsometatarsal joint due to direct injury occur when struck by a heavy object. Metatarsals are displaced plantarward with additional displacement medially or laterally. Often, extensive soft tissue damage is observed and even possibly open wounds (25). In cases of closed injuries and extensive soft tissue damage, one must also consider and/or rule out a compartment syndrome.

INDIRECT INJURY

Fractures are usually caused by indirect forces such as hyperflexion through the joints Indirect injury may involve a simple stumble or fall off a curb and can result in a dislocation of the tarsometatarsal joint primarily dorsally with secondary displacement medially or laterally. Fractures at the base of the second metatarsal are common; however, little soft tissue damage is noted and open wounds are rare (25). The mechanism of indirect injury consists of an axial force applied to a plantarflexed and inverted foot with an additional rotational force, which can cause disruption of the Lisfranc ligament resulting in destabilization of the entire joint complex (28).

Despite the mechanism of injury, most would agree that restoration of the normal anatomy and joint congruity is critical for functionality and optimal results (11,15). Subtle Lisranc injuries caused by low-energy forces such as running or other sporting activities usually show minimal evidence on plain radiographs.

CLASSIFICATION

Previous classification systems have been based on the mechanism of injury, direction of force applied, and the result of injury pattern. The classification described by Quenu and Kuss (28a) described the injury quite simply: homolateral, isolated, and divergent dislocation. Hardcastle et al in 1982 further elaborated on that classification to include a variety of displacements based on radiographic presentation.

Type A or total incongruity: The entire tarsometatarsal joint is dislocated, and all five metatarsals are displaced. Displacement

Figure 106.5 **A:** AP weight-bearing radiograph demonstrating significant gapping at the base of the first and second metatarsal. Please note the "fleck sign" and the diastasis. **B:** Lateral radiograph demonstrating an elevated first ray, a step-off at the tarsometatarsal joint, and flattening of the arch.

Figure 106.6 Non-weight-bearing radiograph demonstrating disruption at Lisfranc ligament and joint.

may occur in the sagittal place as a dorsoplantar displacement or in the transverse plane as a lateral displacement.

Type B or partial incongruity: Only part of the joint is displaced. Displacement is in one plane, which may be either the sagittal and/or transverse planes. Partial injuries include two types: medial displacement of the first metatarsal, either alone or combined with one or more of the remaining metatarsals, and lateral displacement, which involves one or more of the lesser metatarsals, but the first metatarsal is unaffected.

Figure 106.7 A CT scan demonstrating instability in the intercuneiform and Lisfranc joints.

Type C or divergent: Partial or total dislocation of the tarsometatarsal joint. The first metatarsal is displaced medially, while a combination of lesser metatarsals are displaced laterally in either the sagittal or transverse place or both.

TREATMENT

REDUCTION

The goal of the treatment is a stable, painless, plantigrade foot. The goal is achieved by anatomical reduction and alignment and, if needed, stable fixation. The choice of procedure for Lisfranc injuries to the tarsometatarsal joint are closed and open reduction procedures.

Low-energy injuries are typically limited to hyperflexion and partial tear of dorsal ligaments. Rarely do these types of injury progress with a subluxation or a fracture, making the diagnosis difficult. Detailed information regarding the mechanism of injury followed by clinical tenderness around Lisfranc joint assists in making the diagnosis. Nondisplaced injuries with negative weight-bearing radiographs and stress test are managed well with a walking fracture boot.

If there is any portion of Lisfranc complex with displacement of 2 mm or greater, anatomical reduction is required. If the fracture dislocation is mobile and reducible, closed reduction may be attempted. Postreduction radiographs are needed to ensure adequate reduction and to ensure there is no residual subluxation. If closed reduction can be maintained, then a below-the-knee cast can be utilized as treatment alone (14,20,28,29). Many authors have debated this area, stating that closed reduction without fixation, either open or closed, does not maintain adequate reduction and oftentimes requires surgical stabilization (4,11,15,16). However, most authors do agree that closed reduction should be attempted; however, if it cannot be maintained due to instability, reduction and fixation may be considered (10,30). In cases in which closed reduction cannot be maintained, closed reduction should be accompanied by screw/pin fixation. This can be done via percutaneous pin and/or screw fixation (the authors routinely use screw fixation and do not believe Kirschner wire [K-wire] fixation can provide as stable of a construct). Placement of the percutaneous pin/screws depends on the type of injury. Fixation of the medial cuneiform to the second metatarsal base reconstitutes the Lisfranc ligament (Fig. 106.8). If using K-wires, threaded K-wires afford better purchase than smooth K-wires but are more difficult and more painful to remove.

If closed reduction is not achievable, one may consider Lisfranc ligament (most common); bony fragments or soft tissue impingement, such as the tibialis anterior tendon (10,31–33); or excessive edema (8); therefore, open reduction internal fixation should be considered (34) within 6 weeks of injury (10). Surgical correction after 6 weeks of injury generally results in poor functional outcomes (28). Curtis et al (35) recommend surgical treatment for all athletes and any active persons. An absolute indication for open reduction is vascular insufficiency that does not improve after closed reduction (29). In cases such as this, the authors believe open reduction and screw fixation provides the best predictable outcome.

Fractures with bony displacement are treated with open reduction and internal fixation. Open reduction is the best method of achieving an anatomical reduction. Edema may

Figure 106.8 An intraoperative view utilizing a reduction forceps (large Weber clamp) prior to fixating Lisfranc joint. Placement of the percutaneous K-wire is from the medial cuneiform to the second metatarsal base in attempt to reconstitute the Lisfranc ligament.

dictate a delay in open reduction of up to 14 days. The basic fixation technique consists of open reduction and lagged screw (3.5- or 4.0-mm fully threaded cortical screws) fixation of the second tarsometatarsal joint from the proximal superior–medial corner of the medial cuneiform to the base of the second metatarsal and occasionally the third metatarsal. The first lagged screw is the key to the reduction and fixation of the injured complex. This is followed by multiple lagged screws placed from the bases of the involved metatarsals to their respective cuneiform bones. If cuneiform instability is present, the authors have utilized reduction and screw fixation between the cuneiforms. In cases in which comminution of the metatarsal bases are involved, this can be treated with a plate spanning the fracture.

The standard incisional approach consists of one or two incisions. The first is slightly lateral and parallel with the second metatarsal shaft starting at the distal one-third metatarsal extending to the navicular. The authors recommend making the incision curvilinear over the first tarsometatarsal. This provides excellent exposure to the first, second, and third tarsometatarsal joints while avoiding the deep peroneal nerve and dorsalis pedis artery. Additionally, this prevents unnecessary traction on the skin and neurovascular structures. The second incision should be over the fourth metatarsal shaft. It should be noted that the soft tissue island between the incisions needs to be adequate in size to prevent tissue necrosis. If only the medial tarsometatarsal joints are involved, it has been the experience of the authors to make a large dorsal curvilinear incision starting at the dorsal lateral first metatarsal and extending to the navicular–cuneiform joint. Care should be taken not to undermine/separate the tissues in order to prevent soft tissue injury. The incision is deepened to the extensor hallucis tendon, which runs over the neurovascular bundle. The neurovascular bundle should be retracted to whichever side is easiest to allow the best exposure. This provides excellent visualization to the base of the second metatarsal to the medial cuneiform as well as the second tarsometatarsal joint. Identifiable bony fragments that are too small to be fixed are removed. Next, smooth K-wire is used for temporary fixation until confirmation of anatomical alignment under fluoroscopy. A 3.5- or 4.0-mm fully threaded cortical screw with a lag technique should enter from the medial cuneiform and directed in an oblique fashion into the base of the second metatarsal. If instability is noted between the intercuneiforms (the more stabile proximal base), then intercuneiform lag screw should be utilized from medial to lateral (Fig. 106.9). If the lateral segments are disrupted, the second incision is used. The incision is deepened and attention should be directed to the third metatarsal tarsal base. Soft tissue or bony fragments that may be blocking the reduction is resected. A smooth K-wire is utilized for temporary fixation beginning at the third metatarsal base into the lateral cuneiform. Just as the Vassal principle applies to ankle fractures, the same principle applies to the Lisfranc complex. Once reduction of the medial (dominant segment) tarsometatarsal is successfully reduced, the remaining lesser tarsometatarsal joint will become well placed. Unless there has been severe ligament disruption, the fourth and fifth metatarsal–tarsal joints will go into good anatomical alignment.

Postoperative course varies per surgical protocol; the patient is placed in a dorsally slotted non-weight-bearing plaster cast for 2 weeks and instructed to keep the extremity elevated. Provided there are no wound problems and the reduction and construct is stable, a below-the-knee fiberglass cast is applied for an additional 4 to 6 weeks. Full weight-bearing in a fracture boot with physical therapy is then prescribed for 4 weeks. If percutaneous smooth or threaded K-wires have been used, they can be removed at approximately 8 weeks. If screws have been used, the screws can be removed at approximately 12 weeks. Full unprotected weight-bearing is typically not permitted until hardware is removed (19).

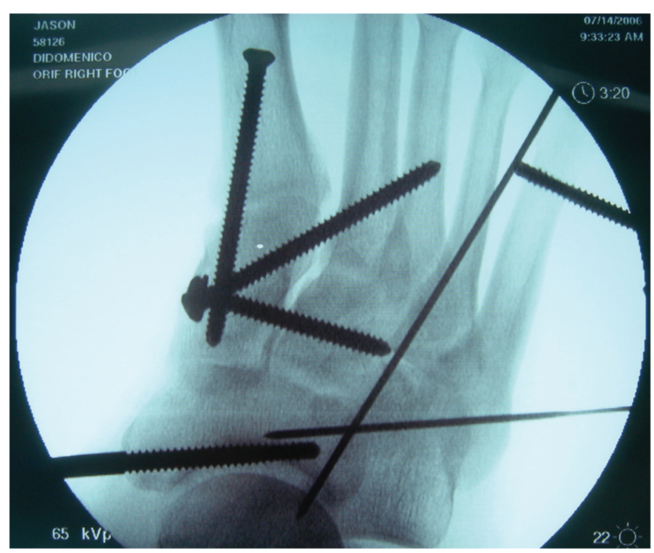

Figure 106.9 A 3.5- or 4.0-mm fully threaded cortical screw with a lag technique is used, entering from the medial cuneiform and directed in a oblique fashion into the base of the second metatarsal. If instability is noted between the intercuneiforms, an intercuneiform lag screw should be used from medial to lateral.

TREATMENT

PRIMARY ARTHRODESIS

Open reduction and internal fixation is the traditional accepted treatment for displaced Lisfranc joint injuries. However, even with anatomic reduction and stable internal fixation, treatment of these injuries have not consistently provided excellent outcomes. Malalignment of Lisfranc joint complex and posttraumatic arthritis greatly increases the risk of deformity and degenerative changes. Additionally, diabetes mellitus with secondary Charcot neuropathic changes is responsible for most neuropathic fracture dislocations. Joints that are unstable secondary to the neuropathic changes have a high rate of pseudoarthrosis, resulting in the need to attempt a fusion.

As the result of the poor healing potential of the ligament–osseous interface, correction loss, increasing deformity, and degenerative arthritic changes, the authors believe that stable arthrodesis is a better primary treatment for many of these injuries. Coetzee et al (36) suggests that a primary stable arthrodesis of the medial two or three rays has a better outcome than open reduction and internal fixation of ligamentous Lisfranc joint injuries.

Typically the first, second, and third tarsometatarsal joints are fused. The single curvilinear incision as described earlier is utilized. The neurovascular bundle is identified and retracted. The first, second, and third metatarsal cuneiform joints are exposed. The articular surfaces are débrided to bleeding bone while attempting to preserve as much bone as possible, which will minimize the size of the bone voids. Osteotomes, mallets, pics, rongeurs, drills, and curettes are instruments utilized for the débridement. Much time is spent with the joint preparation as the authors believe the success of an arthrodesis is in the joint preparation and fixation construct. Following adequate articular débridement, the reduction is performed using temporary K-wire fixation. The stabilization is begun from proximal to distal with the cuneiforms. Once the cuneiforms are stabilized, the first tarsometatarsal is temporary fixated. It is extremely important that the first metatarsal is in a neutral position and any valgus position is corrected. In some scenarios, a temporary external fixator may need to be used for distraction. Next, the base of the second metatarsal is positioned appropriately followed by the third tarsometatarsal. If the fourth and fifth metatarsal tarsal joints are involved, it has been the author's experience that once the first three tarsometatarsal joints are positioned, the fourth and fifth metatarsal tarsal joints will be reduced anatomically. Fixation is achieved using a lag technique involving solid 3.5- or 4.0-mm cortical screws and/or plating techniques. A screw hole technique as described by Manoli and Hansen (37) allows for a difficult angulation, and the first screw is inserted from the first metatarsal to the medial cuneiform, creating interfragmentary compression. The next screw is inserted from the stable superior proximal medial cuneiform obliquely oriented into the second metatarsal base. This also employs interfragmentary compression. Additional screws can be inserted from the proximal metatarsal base into the cuneiform and from the base of the first metatarsal into the base of the second metatarsal (Fig. 106.10). All bone voids are then packed with autogenous or allogenic cancellous bone graft for a shear strain relief graft as described by Perren (38).

Postoperatively, the patient is placed in a dorsally slotted non-weight-bearing plaster cast for 2 weeks and is to keep the extremity elevated. Provided there are no wound problems and the reduction and construct is stable, a fiberglass below-the-knee cast is applied for an additional 4 to 6 weeks. Full weight-bearing in a fracture boot with physical therapy is then prescribed for 4 weeks.

Figure 106.10 AP radiograph demonstrating a solid union following an arthrodesis of Lisfranc joint.

PEARLS, TIPS, AND PITFALLS

There can be spontaneous reduction of the subluxation/dislocation, making the diagnosis difficult. Therefore, it is essential that the physician evaluate Lisfranc joints closely and perform stress radiographs. Evaluation of the vascular supply is important. If the dorsalis pedis or posterior tibial artery cannot be palpated, one should obtain Doppler ultrasound studies. Depending on the extent of injury, damage to the surrounding tissues may compromise the blood supply. Depending on the degree of necrosis, amputations may be considered (29). If a closed injury with significant edema is present, the soft tissues should be examined closely and the patient needs to be evaluated for a compartment syndrome. Compartment syndrome can develop following trauma with displacement, particularly when fractures are involved. Associated injuries and differential diagnosis should be included for compartment syndrome, cuboid fracture, medial cuneiform fracture, and avulsion fracture of the navicular tuberosity.

COMPLICATIONS

Injuries to the deep peroneal nerve or dorsalis pedis artery are possible. Postoperative edema can be present for a significant period of time. In cases in which K-wires have been used, loss of fixation and/or reduction is possible. Other complications consist of cellulitis/wound infection, contractures, complex regional pain syndrome, posttraumatic arthritis, hardware failure, broken screws, deep vein thrombosis, pulmonary embolism, incomplete reduction, redislocation, chronic pain, posttraumatic deformity (planovalgus), difficulty wearing shoes, chronic pain, and malalignment.

Short-term complications may consist of redislocation and circulatory compromise (7,8). Goosens and De Stoop (16) reported 5 out of 20 patients developed Sudeck atrophy, mainly in those who were misdiagnosed and inappropriately treated. An inevitable and most common long-term complication is arthrosis (5,8,15). However, not all patients who develop radiographic degenerative changes are symptomatic (22). Kuo reported 12 of 48 (25%) patients having symptomatic arthritis at final postoperative visit. Only half (six) of the symptomatic patients went onto an arthrodesis (39). Arntz et al reported 41 tarsometatarsal injuries that were treated with open reduction and screw fixation. Intra-articular or periarticular comminution was noted in 22 out 41 patients (54%), and anatomic reduction was achieved in 36 out of 41 of the cases (88%). The authors concluded that injuries to the articular surface and anatomic reduction were the most important determinants in the development of posttraumatic arthritis (15).

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