

Treatment of Lisfranc Joint Injury: Current Concepts

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Abstract

Injuries to the tarsometatarsal joint complex, also known as the Lisfranc joint, are relatively uncommon. However, the importance of an accurate diagnosis cannot be overstated. These injuries, especially when missed, may result in considerable long-term disability as the result of posttraumatic arthritis. A high level of suspicion, recognition of the clinical signs of injury, and appropriate radiographic studies are needed for correct diagnosis. When surgery is indicated, closed reduction with percutaneous screw fixation should be attempted. If reduction is questionable, open reduction should be performed. Screw fixation remains the traditional fixation technique.

The Lisfranc joint, also referred to as the tarsometatarsal (TMT) joint complex, is named for Jacques Lisfranc (1790-1847), a French surgeon who served in Napoleon's army. Lisfranc described an amputation involving the TMT joint secondary to a vascular injury incurred when a soldier fell from a horse with his foot caught in the stirrup.^{1,2} Lisfranc injury has commonly been used to describe injuries to the bases of the five metatarsals (MTs), their articulations with the four distal tarsal bones, and the Lisfranc ligament, a strong interosseous attachment located between the medial cuneiform and the second MT.

Injuries to the TMT joint complex occur in 1 per 55,000 persons each year in the United States, accounting for approximately 0.2% of all fractures.³ Nearly 20% of these injuries are misdiagnosed or missed on initial radiographic assessment.⁴ More Lisfranc injuries are being diagnosed today, likely because of improvements in CT and MRI.^{5,6}

Low-energy trauma accounts for ap-

proximately one third of all Lisfranc injuries,⁵ with the remainder typically the result of high-energy forces sustained in motor vehicle accidents, industrial accidents, and falls from a height.⁷ Midfoot injuries sustained during athletic activity constitute a significant number of low-energy injuries, occurring in up to 4% of American football players per season.^{8,9} A high index of suspicion is needed to accurately diagnose TMT joint injury and attempt to avoid the late sequelae of posttraumatic arthritis.

Anatomy

The Lisfranc complex is made up of bony and ligamentous elements that combine to add structural support to the transverse arch. The bony architecture is composed of nine bones—five MTs and their respective articulations with the cuneiforms medially and the cuboid laterally. The TMT joint complex represents the dividing line between the midfoot and the forefoot.¹⁰

Several osseous relationships con-

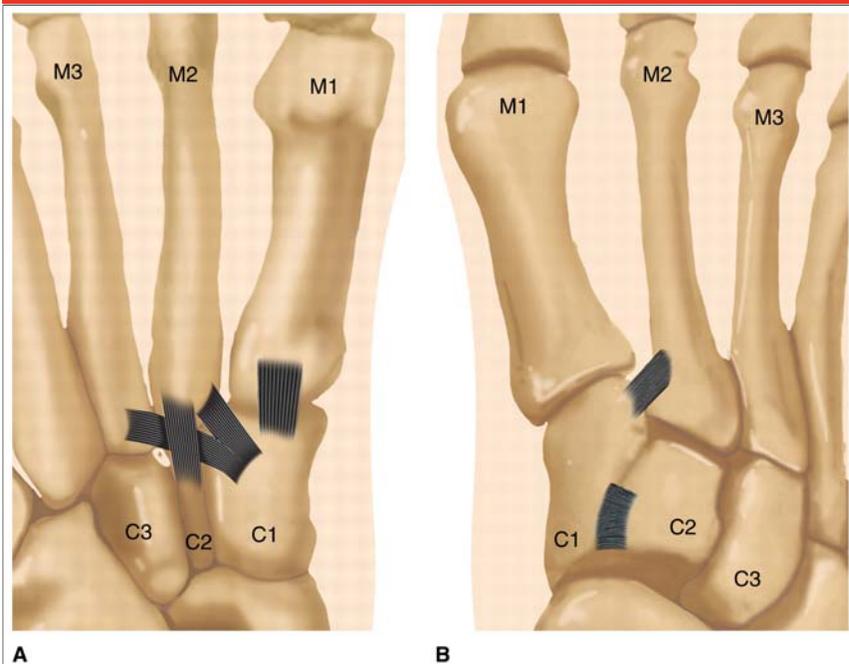
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Figure 1



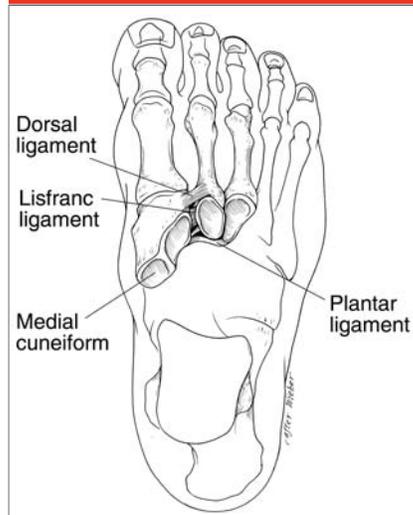
A, The plantar aspect of the midfoot, including the plantar bundle of the Lisfranc ligament (pC1-M2M3), the first tarsometatarsal ligament (pC1-M1), and the second tarsometatarsal ligament (pC2-M2). **B**, The dorsal aspect of the midfoot, including the dorsal bundle of the Lisfranc ligament (dC1-M2) and the medial-middle cuneiform ligament (dC1-C2). C1 = medial cuneiform, C2 = middle cuneiform, C3 = lateral cuneiform, M1 = first metatarsal, M2 = second metatarsal, M3 = third metatarsal. (Adapted with permission from Raikin SM, Elias I, Dheer S, Besser MP, Morrison WB, Zoga AC: Prediction of midfoot instability in the subtle Lisfranc injury: Comparison of magnetic resonance imaging with intraoperative findings. *J Bone Joint Surg Am* 2009;91:892-899.)

tribute to the intrinsic stability of the TMT joint. The trapezoidal shape of the middle three MT bases and their associated cuneiforms produce a stable arch referred to as the “transverse” or “Roman” arch.^{11,12} The keystone to the transverse arch is the second TMT joint, a product of the recessed middle cuneiform, which occupies a position 8 mm proximal to the medial cuneiform and 4 mm proximal to the lateral cuneiform.¹³ This allows five stabilizing structures to articulate with the recessed second MT, thereby enhancing the stability of the TMT joint complex. Anatomic variances frequently predispose to injury. Peicha et al¹⁴ showed that persons with Lisfranc injury had a shal-

lower medial mortise depth compared with control subjects. They suggested that adequate mortise depth provides for greater stability by allowing for a stronger Lisfranc ligament.

de Palma et al¹⁰ organized the supporting ligamentous array into groups defined by their course (ie, longitudinal, oblique, transverse) and location (ie, dorsal, interosseous, plantar). The transverse ligaments attach the second through fifth MT bases; there are no such ligaments between the first and second MT bases^{10,15} (Figure 1). However, situated between the medial cuneiform and second MT base are three oblique ligaments—dorsal, interosse-

Figure 2



Anatomic location of the dorsal, Lisfranc, and plantar ligaments. (Redrawn with permission from Solan MC, Moorman CT III, Miyamoto RG, Jasper LE, Belkoff SM: Ligamentous restraints of the second tarsometatarsal joint: A biomechanical evaluation. *Foot Ankle Int* 2001;22:637-641.)

ous, and plantar—which maintain the crucial mortise osseous relationship. The oblique interosseous ligament, also referred to as the Lisfranc ligament, is the strongest structure supporting the TMT joint complex.¹⁶ The ligament is 8 to 10 mm wide and 5 to 6 mm thick, and it is mirrored superiorly and inferiorly by a dorsal and plantar oblique ligament¹⁰ (Figure 2). The plantar ligament that runs parallel to the Lisfranc ligament originates on the inferolateral aspect of the medial cuneiform and divides into two bands: the deep band, which inserts into the second MT, and the superficial band, which inserts into the third MT.¹³

In a biomechanical evaluation, Solan et al¹⁶ assessed the strength of each ligamentous set—dorsal, interosseous, and plantar—by stressing it to failure. They concluded that the Lisfranc ligament was strongest, followed by the plantar ligaments and

the dorsal ligaments. These results confirmed the observations of de Palma et al¹⁰ and Sarrafian.¹³ Thus, ligamentous disruption typically begins with the weaker dorsal ligaments, followed by the plantar ligaments, and, finally, the Lisfranc ligament.¹⁷ Structural stability to the transverse arch is enhanced by the short plantar muscles as well as by the muscular and tendinous support of the peroneus longus and the tibialis anterior and tibialis posterior.

Mechanism of Injury

Most injuries to the TMT complex can be designated as indirect or direct. Indirect injuries can be high energy, as in motor vehicle accidents and falls from a height, or caused by low-energy forces, such as those incurred during athletic activity.³ Most commonly, indirect injuries are associated with a longitudinal force applied to the forefoot, which is then subjected to rotation and compression.¹⁸ Excessive plantar flexion and abduction forces are the most common individual indirect mechanisms leading to midfoot disruption. As the second MT dislocates or fractures, the MTs move laterally.¹⁹

Two different plantar flexion mechanisms lead to dorsal joint failure. The first occurs in ankle equinus and metatarsophalangeal joint plantar flexion, with the Lisfranc joint engaged along an elongated lever arm.² The joint is “rolled over” by the body; this commonly occurs when a person misses a step or unexpectedly catches the heel or latter half of the foot on the curb as he or she is stepping down.⁸ Dorsal displacement caused by plantar flexion can also occur when a force is applied along the long axis of the foot with the foot plantarflexed and the knee anchored on the ground.¹⁸ This is a common mechanism seen in

American football players when they are lying prone on the ground and another player falls on the prone athlete’s heel. External rotation on a pronated forefoot is responsible for a substantially unstable Lisfranc ligamentous injury.^{7,20} The injuries can be largely secondary to an abduction stress to the midfoot. This injury pattern is best seen in sports that require use of a stirrup, such as equestrian events and windsurfing. In cases such as these, the forefoot is abducted around a fixed hindfoot, causing dislocation of the second MT and lateral displacement of the remaining MTs.

Direct injuries are usually associated with a crush injury. Depending on the location of force applied to the TMT joint complex, the MTs can undergo plantar or dorsal displacement.⁷ These fracture-dislocations are often associated with significant soft-tissue trauma, vascular compromise, and compartment syndrome.^{15,21}

Classification

Several classification systems have been developed and updated in the past century, with the authors displaying a tendency toward using joint incongruity rather than mechanism of injury as a basis for treatment and prognosis.² These classification systems are inherently effective in standardizing terminology and allowing for the description of both high- and low-impact injuries; however, they may fall short in determining management and predicting clinical outcome.

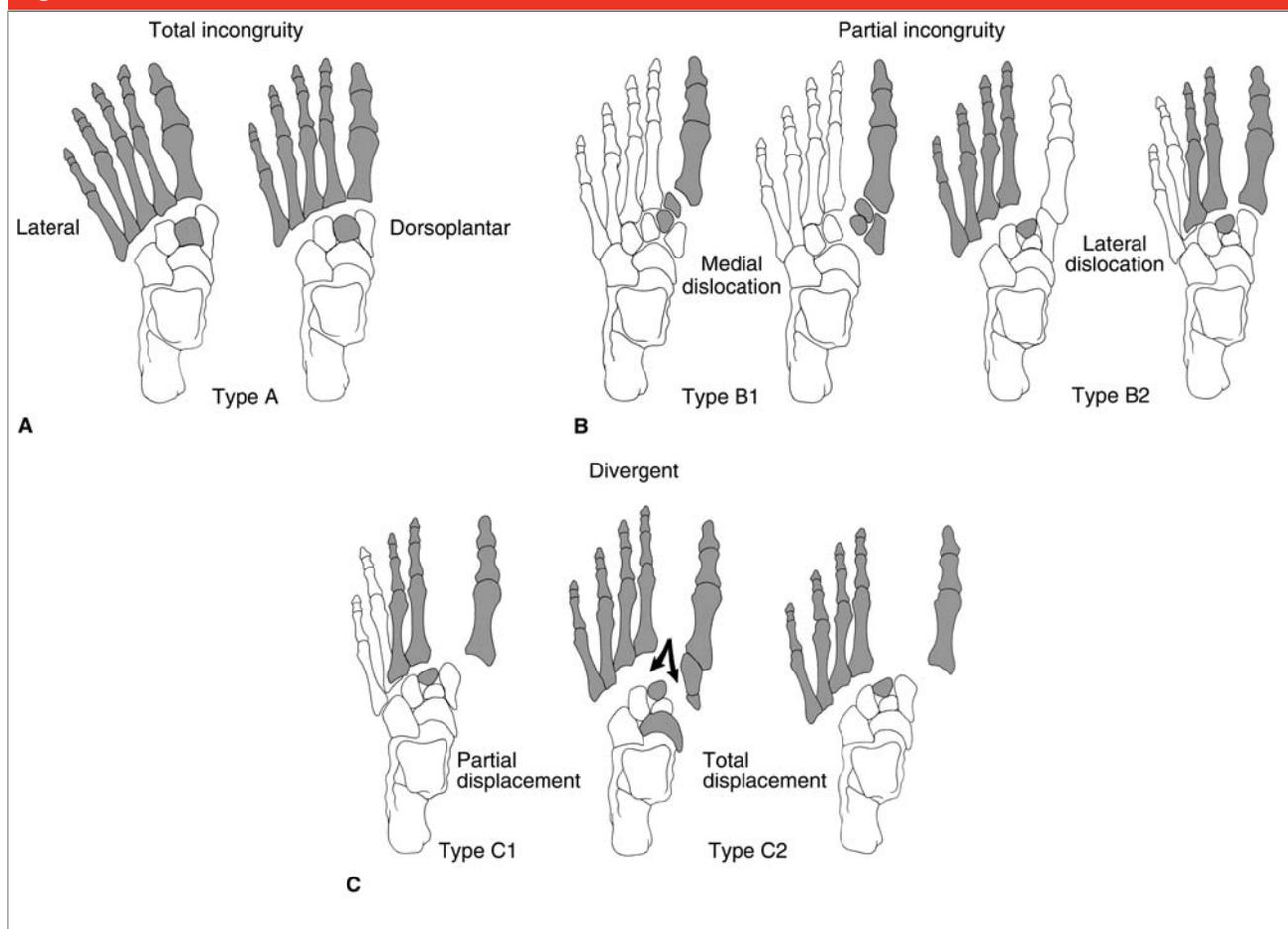
In 1909, Quenu and Kuss²² first described injuries to the TMT joint based on the direction of MT displacement. Several modifications followed, with the most comprehensive being described by Hardcastle et al² in 1982. In their experience with

TMT injuries, prognosis depended more on joint incongruity than on mechanism of injury.

In 1986, Myerson et al⁷ proposed a scheme based on these previous systems to aid in clinical decision making. They classified injuries as follows: type A, total incongruity of the TMT joint; type B1, partial incongruity affecting the first ray in relative isolation (ie, partial medial incongruity); type B2, partial incongruity in which the displacement affects one or more of the lateral four MTs (ie, partial lateral incongruity); and type C1 and C2, a divergent pattern, with partial or total displacement⁷ (Figure 3). These same authors coined the phrase tarsometatarsal joint complex in favor of older designations such as Lisfranc or TMT injuries because the former describes all bones and joints involved in TMT fracture-dislocation, including the intercuneiform and naviculocuneiform joints.⁷

In 2001, Chiodo and Myerson²³ presented a columnar classification of TMT joint injury based on the three mechanical columns of the foot to aid in treatment planning. The first TMT and medial naviculocuneiform joints make up the medial column. The middle column includes the articulations between the second and third TMT joints and those between the middle and lateral cuneiform with the navicular bone. The lateral column consists of articulations between the cuboid and the fourth and fifth MTs. Midfoot motion is highlighted in this system, with strong prognostic implications. Komenda et al¹¹ reported that post-traumatic arthritis is more common at the base of the second MT, suggesting that incongruity is better tolerated at the medial and lateral columns. The lateral column, which has the greatest amount of sagittal plane motion, is the least likely to be involved in posttraumatic arthritis.

Figure 3



Classification of tarsometatarsal joint injury. The shaded areas represent the injured or displaced portion of the foot. **A**, Type A, total incongruity, which involves displacement of all five metatarsals (MTs) with or without fracture at the base of the second MT. The usual displacement is lateral or dorsolateral, and the MTs move as a unit. These injuries are "homolateral." **B**, In type B injuries, one or more articulations remain intact. Type B1 represents partial incongruity with medial dislocation. Type B2 represents partial incongruity with lateral dislocation; the first MT-cuneiform joint may be involved. **C**, Type C injuries are divergent, with either partial (C1) or total (C2) displacement. The arrows in C2 represent the forces through the foot leading to a divergent pattern. (Redrawn with permission from Myerson MS, Fisher RT, Burgess AR, Kenzora JE: Fracture-dislocations of the tarsometatarsal joints: End results correlated with pathology and treatment. *Foot Ankle* 1986;6:225-242.)

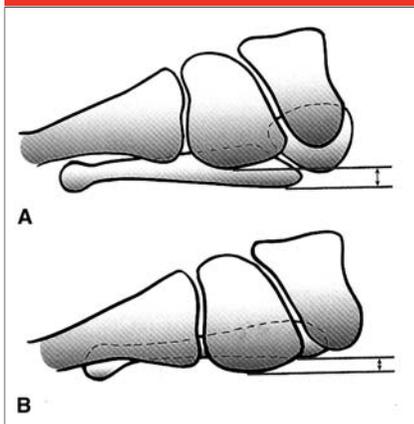
One shortcoming of traditional classification systems is the lack of emphasis on the simple diastasis seen in low-energy athletic injuries. This type of injury may involve the intercuneiform space or the naviculocuneiform joints. In 2002, Nunley and Vertullo²⁴ classified athletic midfoot injuries into three groups based on clinical findings, weight-bearing radiographs, and bone scintigraphy. Athletes with stage I injury had pain only at the Lisfranc complex and in-

creased uptake on bone scan, with negative radiographic findings. Stage II injuries exhibited diastasis between the first and second MTs of 1 to 5 mm greater than that of the contralateral side, without loss of midfoot arch height. Diastasis >5 mm and loss of midfoot arch height signified stage III injury. Nonsurgical treatment of stage I patients and surgical treatment of stage II and III patients led to an excellent result in 93%.

Diagnosis

Lisfranc joint injuries can be difficult to accurately diagnose because gross lateral deviation or subluxation of the forefoot is less common than subtle midfoot injury. Patients often present with inability to bear weight and with swelling in the midfoot region. Examination of the foot reveals forefoot and midfoot edema as well as plantar arch ecchymosis (ie, plan-

Figure 4



Schematic representation demonstrating the method of evaluating the integrity of the midfoot arch on weight-bearing lateral radiographs. **A**, Normal relationship demonstrating the position of the fifth metatarsal plantar to the medial cuneiform (a positive value). **B**, Flattening of the midfoot arch positions the medial cuneiform plantar to the fifth metatarsal (a negative value). (Adapted with permission from Faciszewski T, Burks RT, Manaster BJ: Subtle injuries of the Lisfranc joint. *J Bone Joint Surg Am* 1990;72:1519-1522.)

tar ecchymosis sign), which is considered to be nearly pathognomonic for Lisfranc complex injury.²⁵ When a diastasis is noted between the hallux and second toe, the patient is said to have a positive gap sign.²⁶ Lisfranc injury should be suspected when a patient reports a consistent mechanism of injury and presents with midfoot pain and swelling.

When Lisfranc injury is suspected, it is important to accurately diagnose whether the injury is a sprain or represents an unstable columnar injury resulting from complete ligamentous disruption. The passive pronation-abduction test described by Curtis et al⁸ is performed by eliciting pain on abduction and pronation of the forefoot with the hindfoot fixed. Other signs suggestive of midfoot

sprain or instability include tenderness to palpation along the TMT joints⁴ and the inability to bear weight while standing on the tip-toes.³ A stress test may be performed. The clinician grasps the first and second MTs and moves them in plantar flexion and dorsiflexion (ie, piano key test) as well as abduction and adduction, noting any discomfort or subluxation in the midfoot. The first and second MTs should also be stressed divergently. Compartment syndrome should be ruled out in patients who present with severe traumatic midfoot injuries that are accompanied by significant swelling and pain. The dorsalis pedis pulse should be evaluated because blood flow may be compromised secondary to severe dislocation of the second MT.²⁷

Radiographic Imaging

Lisfranc injuries are a challenge to diagnose; approximately 20% of injuries go unrecognized,²⁸ likely secondary to the difficulty encountered with standard radiographic imaging. Many so-called sprains present with non-weight-bearing radiographs that are difficult to interpret. In a recent study, Nunley and Vertullo²⁴ found that 50% of athletes with midfoot injuries had normal non-weight-bearing radiographs.

Initial imaging of a suspected Lisfranc injury should include routine AP, lateral, and oblique views of the foot, with the image taken parallel to the midfoot joints. To aid in the diagnosis of more subtle injuries, a weight-bearing film with both feet on a single cassette is obtained. This last view serves as a stress view of the foot. It is helpful to explain this to the patient before obtaining the film so that compliance with evenly distributed weight bearing can be obtained. An AP abduction-pronation stress view is occasionally used to

demonstrate instability when initial radiographs are normal.²⁹ However, this may require an ankle block or general anesthesia because of the presence of pain; thus, it is rarely performed.

AP radiographs are used to demonstrate malalignment of the first and second TMT joints, whereas incongruity at the third and fourth joints are better visualized on a 30° oblique view.²⁸ On the lateral view, the dorsal and plantar aspects of the MTs should correspond with the cuneiform and cuboid. A tangential line drawn through the medial aspect of the medial cuneiform and navicular should intersect the first MT base.³⁰ Lateral weight-bearing radiographs can be used to identify flattening of the longitudinal arch³¹ as well as dorsal displacement at the second TMT joint (Figure 4).

Radiographic studies are done to determine whether an injury is stable or unstable. The AP radiograph should show alignment of the medial border of the second MT and the medial border of the middle cuneiform. The oblique view should show alignment of the medial border of the fourth MT and the medial border of the cuboid. Close examination of these lines for displacement will help the clinician with subtle cases. Diastasis between the first MT–medial cuneiform and second MT of 2 mm greater than on the contralateral side, or TMT joint subluxation of 2 mm greater than on the contralateral side, indicates instability and is an indication for surgical intervention²⁹ (Figure 5). Diastasis between the first and second MT in the injured midfoot is considered normal provided that it measures <2.7 mm.³¹ Avulsion of the second MT base or medial cuneiform produces a fleck sign, as described by Myerson et al.⁷ The AP and oblique radiographs should be investigated for this finding. The most common abnormality in Lis-

franc injuries is the lateral step-off at the second TMT joint.

Additional Imaging

Additional studies may be helpful, including bone scans, MRI, and CT. Bone scans are typically reserved for patients with a midfoot injury but with negative radiographic findings.²⁴ When plain radiographs and the physical examination are equivocal, MRI can be used to provide excellent depiction of the soft tissues.^{6,32} Additionally, in the high-level athlete, MRI may provide information to help the treating physician make a determination on return-to-play status. In a recent study evaluating the predictive value of MRI for midfoot instability, Raikin et al⁶ found that MRI demonstrating a rupture or grade 2 sprain of the plantar ligament between the first cuneiform and the bases of the second and third MTs is highly predictive of midfoot instability, and these patients should be treated with surgical stabilization. CT is recommended in patients presenting with high-energy injuries in which improved detection and delineation of fractures is required. However, subtle displacement may not be demonstrated because this is a non-weight-bearing study. These images may demonstrate comminution and intra-articular extension or interposed soft tissues not appreciated on the initial radiographic assessment.³³

Management

The key to successful management is the determination whether to use surgical stabilization. Regardless of the severity of injury, the goal of treatment is a painless, plantigrade, stable foot. Maintenance of anatomic alignment seems to be the critical factor in achieving a satisfactory result, but it does not guarantee it.

Figure 5



A, AP weight-bearing radiograph following injury to the midfoot in a 45-year-old woman. Note the displacement of the second metatarsal (MT) base laterally and the fleck sign between the first and second MT bases. This is a type B2 fracture. **B**, AP weight-bearing radiograph following open reduction and internal fixation. **C**, AP weight-bearing radiograph following hardware removal. Note the reduction of the second MT into the keystone.

Other factors, such as energy of the injury, cartilage damage, and soft-tissue injuries, can compromise the final outcome. Most of the literature supports that anatomic alignment is necessary, and good or excellent results have been achieved in 50% to 95% of patients with anatomic alignment, compared with 17% to 30% of patients with nonanatomic alignment.^{2,7,27,34}

Nonsurgical

Any measurable disturbance in normal radiographic anatomy may be an indication of instability and the need for surgical consideration. The key to selecting a nonsurgical option lies in ensuring that surgical intervention is not necessary. Table 1 lists five steps that can be used to determine whether a patient requires surgical treatment. Evaluation of subtle Lisfranc injury is time-consuming and potentially expensive, but we

feel that, when possible, a diagnosis should be made without subjecting a patient to anesthesia. The last resort, stress examination under anesthesia, is rarely required. Patient consent should be obtained for possible open reduction and internal fixation (ORIF) if a stress examination is deemed to be necessary.

The patient with minimal ambulatory ability, an insensate foot, or pre-existing inflammatory arthritis may be best treated nonsurgically. Reconstruction with midfoot arthrodesis can be performed later if pain persists. The authors prefer to use a CAM walking boot for 6 to 10 weeks in patients with stable injuries that can be managed nonsurgically. Weight bearing is allowed as tolerated, and follow-up weight-bearing radiographs are obtained 2 weeks after injury to ensure there are no changes in alignment. Subsequently, a brief 3- to 6-week course of physi-

Table 1**Stepwise Evaluation of a Patient With Lisfranc Injury to Determine Whether to Perform Nonsurgical or Surgical Treatment**

Step	Study	Result	Recommendation	Rationale
1	Physical examination	Plantar bruising, painful piano key test, midfoot swelling	Obtain weight-bearing radiographs unless injury is obvious with non-weight-bearing images	Weight-bearing radiographs are always useful, but oblique views may be helpful for the tentative patient
2	Radiography	Loss of arch on comparative weight-bearing lateral radiograph, widening between the first and second metatarsal bases on comparative AP views, fleck sign	ORIF is indicated with positive results. External rotation views are necessary when there is uncertainty based on plain radiographs or the patient cannot bear weight. When uncertainty remains, MRI is useful.	Any measurable subluxation is an indication for ORIF. When in doubt, proceed with further tests. On MRI, edema indicates midfoot injury, and subluxation confirms Lisfranc injury.
3	MRI	Edema at the tarsometatarsal joint, bone bruise, subluxation, or ligament tear	If edema but no ligament tear or subluxation, then CT is recommended. Perform ORIF in the presence of subluxation or a clear ligament tear.	MRI is more sensitive to edema in subtle injuries. CT may better illustrate subluxation, but MRI may show both.
4	CT	1 mm of subluxation	Strong evidence for Lisfranc injury when edema is noted on MRI and subluxation on CT. ORIF is indicated.	MRI with edema and no ligament tear combined with normal CT requires stress examination under anesthesia, with possible ORIF
5	Stress examination	Subluxation	ORIF	When negative, treat as a sprain

ORIF = open reduction and internal fixation

cal therapy to work on gait training and balance is often helpful. We have found it of help to transition these patients into a comfort supportive shoe with a full-length total contact orthosis. It typically takes approximately 4 months for these patients to recover from a nonsurgical Lisfranc injury; patients should be informed of this time frame at the onset of treatment.

Surgical

Unstable injuries, even subtle ones, are managed surgically. Subtle Lisfranc injuries are occurring with increasing frequency, likely because of greater participation in high-demand sports. Obvious injuries in multiple trauma patients are not often missed, but more subtle injuries are a common source of continued disability. Careful examination of the trauma patient is required with any foot in-

jury, as there are often distracting injuries that may delay the diagnosis.

The timing of surgery is predicated on resolution of swelling, when the skin begins to wrinkle. In more severe injuries, 3 weeks of bulky Jones splinting and elevation is required before it is safe to perform surgery. Commercially available ice therapy units can be placed over the splint and may help expedite local pain relief and reduction in swelling, before and after surgery. Ideally, Lisfranc injuries are best managed within the first 2 weeks following the inciting event, but we have treated many injuries up to 6 weeks posttrauma with successful anatomic reduction and outcome.

ORIF is our preferred technique for subtle and obvious injuries. The presence of osteochondral fragments, soft-tissue interposition, and clear visualization of the reduction are the

primary factors for our preference for ORIF. The midfoot TMT joints have poor tolerance to mild malalignment³⁵ as joint contact area is reduced, predisposing to arthritis. Moreover, closed reduction may be blocked or inhibited by bone fragments or soft tissue, and the accuracy of assessing 1 to 2 mm of subluxation radiographically is limited. Some authors believe closed reduction under fluoroscopic guidance should be attempted first because percutaneous screw fixation has been used successfully in the past.¹⁹

Dorsal incisions centered over the involved joints are used to approach the midfoot; small bone fragments are excised, and larger pieces may be fixed.^{7,12,27,34} Many forms of fixation are available depending on the nature of the injury and surgeon preference.

For more obvious Lisfranc

fracture-dislocation, screw fixation has been shown to have lower rates of redisplacement^{7,27,34} and faster return to weight bearing^{27,34} postoperatively compared with Kirschner wire (K-wire) fixation. Small-fragment (3.5 mm) cortical screw fixation is recommended for the first, second, and third TMT joints. The fourth and fifth joints may be pinned with K-wires. K-wire fixation is usually removed at 6 weeks postoperatively, whereas screws are left in place for 4 months. A short leg non-weight-bearing cast is used for the first 3 weeks, and a CAM boot is used for the next 3 to 5 weeks, progressing to full weight bearing by 8 weeks postoperatively. Patients are usually allowed to return to a shoe with an orthosis at 3 months after surgery, and screws are typically removed 4 months postoperatively.

Progressive physical therapy, which usually is initiated after full weight bearing has begun, is used for balance, gait training, and edema control. Once the percutaneous incisions have healed following screw removal, physical therapy is recommenced for 4 to 6 weeks, if necessary. Primary arthrodesis may be indicated in cases of severe cartilage damage, preexisting midfoot arthritis, and delayed diagnosis as well as in select patients with neuropathic injuries. Primary arthrodesis has been shown to be a reliable method of surgical treatment.¹⁹

In a randomized prospective study, Ly and Coetzee³⁶ compared ORIF with primary arthrodesis in patients with a primary ligamentous injury. They found that patients treated with primary arthrodesis had a quicker recovery, a higher foot function index score, and a superior return to function than did those who underwent ORIF. In a recent prospective study evaluating all types of Lisfranc complex injuries, no difference was seen in functional outcome

Figure 6



A, AP weight-bearing radiograph demonstrating Lisfranc injury with a comminuted fracture at the second metatarsal base with joint impaction (type B2). The first, second, and third joints were involved at the time of surgery. **B**, AP radiograph following open reduction and internal fixation using a one-third tubular plate demonstrating screw fixation and bridge plating of the second joint with good reduction.

between groups treated with ORIF versus primary arthrodesis.³⁷ However, the reoperation rate was significantly lower in the fusion group than in the ORIF group, in whom routine removal of hardware was performed (17% versus 79%, $P < 0.05$). Additional prospective studies are needed to define what subset of patients will benefit from primary arthrodesis before making this the definitive recommended treatment.

Future Techniques in Surgical Management

Concerns exist regarding the potential damage that may be caused by traditional screw placement across the TMT joints, possibly resulting in the late development of posttraumatic arthritis and a poor outcome. We consider using dorsal plating for bridging fixation of comminuted

fractures with bony fragments in the TMT joints (Figure 6) and total ligamentous injuries (Figure 7), and as an alternative surgical treatment in certain cases, such as joint damage and loss of fixation. We use dorsal plating in approximately 10% of patients with comminuted joint injuries. The concern for joint damage resulting from screw fixation across the TMT joints is eliminated. Although K-wire fixation minimizes the articular damage, redisplacement rates are unacceptably high. Moreover, given the potentially slow healing rate of pure ligamentous injuries,³⁸ plating provides prolonged fixation. Wound problems are not more common with plating than with wire fixation. The postoperative regimen is the same, although the surgeon can elect to leave the plate in place. Hand plating sets are

Figure 7



Preoperative (A) and 2-year postoperative (B) AP weight-bearing radiographs of complete midfoot dislocation with minimal bony involvement (type A). The ligamentous nature of the injury required the use of permanent dorsal plating. A modular hand plate was used. C, Lateral radiograph obtained at 2-year follow-up demonstrating good alignment with minimal degenerative change.

often useful for this technique, and dorsal plate fixation has been shown to be as biomechanically sound as screw fixation.³⁹ Painful hardware has not been a concern, and removal is not common with properly placed low-profile plating systems. Weight bearing is advanced rapidly, similar to screw fixation, and the remainder

of the postoperative course is similar, less the need for hardware removal.

Subtle Lisfranc injuries are the most difficult to diagnose and manage. These injuries often have intercuneiform extension, with the injury exiting through the medial naviculocuneiform facet (Figure 8, A). Most surgeons believe that pure ligamen-

tous injuries take far longer to heal than do their bony counterparts,³⁸ and a novel approach to these difficult cases may improve outcomes with a more rapid return to sports. The authors may use Mini Tightrope (Arthrex, Naples, FL) or EndoButton (Smith & Nephew Endoscopy, Andover, MA) fixation. The EndoButton is placed across the base of the second MT into the medial cuneiform, mimicking the Lisfranc ligament (Figure 8, B). In cadaver specimens, this technique has been found to provide stability similar to that provided by screw fixation.⁴⁰ A small-fragment cortical screw is placed across the intercuneiform joint; alternatively, an additional EndoButton may be used (Figure 8, B) to stabilize the disruption between the cuneiforms. When gross instability remains between the navicular and cuneiform following such fixation, the surgeon may need to add K-wire fixation across this joint. The wiring is removed prior to weight bearing. The postoperative protocol with the EndoButton is the same as that for screw or plate fixation, and removal is not needed.

These alternative treatments have not been used by enough surgeons and for a long enough time to indicate whether they offer results comparable or superior to those of traditional techniques. However, they may offer promise for reducing the incidence of posttraumatic arthritis. Further prospective studies are needed to compare the various techniques.

Summary

The diagnosis of subtle Lisfranc injury may be delayed or missed altogether. Such injuries are predisposed to chronic instability, deformity, and pain.^{12,31,36} Salvage includes ORIF or arthrodesis with the goal of restoring

Figure 8



A, AP weight-bearing radiograph demonstrating subtle Lisfranc injury in a college basketball player whose foot was stepped on while he was falling backward to get a loose ball. Subtle diastasis was noted on the AP radiograph, and minimal loss of arch was seen on the lateral view. The injury was confirmed on MRI. The arrow demonstrates the direction of the ligamentous injury. **B**, AP weight-bearing radiograph obtained following open reduction and internal fixation with EndoButton fixation (Smith & Nephew Endoscopy, Andover, MA). The patient was pain free at 2.5 years postoperatively.

plantigrade alignment and alleviating pain. We have performed ORIF as late as 6 weeks after injury with acceptable results.

Patients expect to have a normally functioning foot that is completely pain free even after the most severe injury. In reality, following ORIF using any of various internal fixation techniques, patients can expect to have a well-aligned foot that is stable but potentially stiff, with a variable amount of residual pain. The patient likely will be able to perform most activities that he or she enjoys, but perhaps not all of them. A thorough discussion regarding the length of recovery, the magnitude of the injury,

and potential complications is essential.

Not all patients who present with a Lisfranc injury require surgery, and it is important for the clinician to sort through the medical history before making a final decision. Relative contraindications for surgical intervention may include insensate feet (eg, Charcot midfoot), inflammatory arthritis, nonambulatory status, and severe medical comorbidity. Even patients treated nonsurgically require appropriate immobilization, physical therapy, and orthotic support.

When surgery is indicated, an attempt at closed reduction under fluoroscopy with percutaneous screw

fixation should be attempted. When the adequacy of the reduction is questionable, the surgeon should not hesitate to perform open reduction. Screw fixation remains the traditional fixation technique, although there is evidence to suggest that primary arthrodesis may be superior for the purely ligamentous midfoot injury.³⁶ Future studies should involve newer fixation techniques and compare them with traditional surgical techniques.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 36 and 37 are level I studies. Reference 6 is a level II study. Level III studies include references 14 and 30-32. References 2, 5, 7-9, 11, 12, 17, 20, 24-26, and 34 are level IV studies. Reference 27 is level V expert opinion.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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