Operative Techniques in
Sports Medicine

Ligamentous Lisfranc Injuries in the Athlete

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Ligamentous injuries to the midfoot during athletic endeavors are becoming more common and more troublesome as they can take significant time before the athlete is able to return to play. Late changes in alignment or posttraumatic arthritis are complications of inadequate treatment. The mechanism of injury is either direct impact to the dorsal midfoot or a twisting injury to the hindfoot with a plantar-flexed, fixed forefoot. Examination reveals ecchymosis and pain in the midfoot. Rarely is there enough instability to allow detection on physical examination. Provocative tests such as external rotation stress of the midfoot or physical activity (single leg hop or walking on tip toes) can recreate symptoms if the patient's pain allows for it. Weight-bearing anteroposterior and lateral radiographic examination of both feet focusing on the midfoot is essential, allowing comparison between the injured and uninjured extremity. Diastasis between the proximal first and second metatarsal is a classic radiographic finding, but proximal extension between the cuneiforms can also be present. A more severe injury shows loss of the longitudinal arch or subluxation of the midfoot that is identified on a lateral radiograph. A tear or an avulsion of Lisfranc ligament along with other midfoot ligaments is the underlying pathology. Advanced imaging modalities including computed tomography and magnetic resonance imaging are useful in these more subtle injuries or when more specific anatomical detail is required. Nondisplaced injuries are typically treated conservatively with a period of non–weight bearing followed by a gradual return-to-play protocol. Injuries with diastasis or loss of arch height, in addition to cases subluxation or dislocation of joints or displaced fractures require surgical intervention to restore normal anatomical relationships–the most significant factor suggestive of a good result. Arthrodesis of the affected joints is advocated for severe intra-articular injury and has been proposed for purely ligamentous injuries, although this is controversial in an athlete as a primary repair technique.
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Overview

Subtle injuries to the midfoot first drew attention following an article by Faciszewski et al.[1] Before this, most midfoot injuries involved severe trauma such as seen in motor vehicle collisions or falls from a height, resulting in obvious fractures and dislocations. There is still very little literature about the incidence and treatment of ligamentous Lisfranc injuries that occur as the result of athletic endeavors.[3,2,1,5,8]

The modern definition of a ligamentous Lisfranc injury in the athlete is an injury to the ligaments of the tarsometatarsal joints that may extend to the intertarsal joints. These injuries can range from a sprain to avulsion fractures but are usually not the dislocations and fractures seen in higher-energy injuries. A 1992 study of collegiate football players noted an incidence of 4% annually and found that most injuries occurred in offensive lineman.[2] Reviewing the literature on Lisfranc injuries sustained in sports shows that most patients were treated nonoperatively and that the average time to return to play was 3 months.[1-5] Proper diagnosis is critical for these injuries as a delay in treatment can potentially compromise the result and prolong the time to return to play.

Mechanism of Injury

Midfoot injuries in athletes usually occur as subtle diastases or small avulsion fractures. Higher-energy sports injuries can occur and need to be treated with appropriate consideration

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Figure 1 Transverse injury to the Lisfranc complex with arrows pointing to incongruity of the second metatarsal base-middle cuneiform and third metatarsal base and lateral cuneiform.

for the soft tissue envelope and the use of standard fracture fixation techniques.

The most common mechanism of injury is the indirect mechanism. This occurs when the hindfoot is twisted on a fixed forefoot, when the forefoot is planted in the turf. A force concentrated distally creates a midfoot sprain whereas a force concentrated more proximally produces a syndesmosis injury to the ankle.

Another mechanism of injury is direct force applied to the heel of the foot while the forefoot is fixed. This can happen with the forefoot extended or with the athlete in the "tip-toe"–type position. If the first metatarsal phalangeal joint is extended at the time of injury and if the force is sufficiently distal, a "turf-toe" injury can occur. If the force is concentrated over the midfoot, the tarsometatarsal and intermetatarsal ligaments can be injured, causing diastasis. The common radiographic appearances of the misalignment can be classified as transverse or longitudinal.[6]

Clinical Decision Making

The midfoot has substantial bony and soft tissue structural support making this region relatively stable and infrequently injured. Understanding the anatomical relationships is helpful in diagnosing and treating this commonly missed injury.

In the foot, 4 large tendons (anterior and posterior tibial tendons, peroneus brevis, and longus) attach in the midfoot. The Lisfranc ligament traverses the area from the medial cuneiform to the base of the second metatarsal on the plantar aspect of the joint. The first and second metatarsal bases do not possess intermetatarsal ligaments as do the other adjoining metatarsals. This fact helps explain why midfoot injuries most often occur between the first and second metatarsals. Transverse injury patterns involve disruption of the tarsometatarsal capsule and ligamentous structures and are seen as displacement of the metatarsal bones in relation to the cuneiforms. Longitudinal injury patterns involve injury to the capsuloligamentous structures between the medial cuneiform and the second metatarsal base plus injury to the intercuneiform ligaments between the medial and middle cuneiform bones (Figs. 1 and 2). This may even extend to injury at the joint between the navicular bone and the medial cuneiform.

Clinical decisions are aided by understanding the mechanism of injury. Athletic midfoot injuries present with varying degrees of severity from the minor sprain, which commonly produces pain with only exertional activity, to the athlete being unable to bear weight. Ecchymosis in the arch suggests a more significant midfoot injury.[7] Tenderness is usually maximal at the base of the first and second metatarsals. Provocative tests can be done at the bedside by compressing the foot in a medial or lateral direction and producing pain. Clinical tests also

Figure 2 Longitudinal injury to the Lisfranc complex with extension to the medial-middle cuneiform joint (arrows point to diastasis).

Figure 3 Non–weight-bearing image of the injured right foot.

include reproducing dorsal-plantar motion of the first metatarsal head while stabilizing the second. This specific test is reported to be sensitive in athletes with Lisfranc ligament injuries.[5] Abduction of the forefoot while stabilizing the hindfoot can recreate pain and more stressful activities, such as single leg hop, standing on tiptoe, or running and cutting can be used to detect pain and functional loss.[2,8,9]

Radiographic Evaluation

Weight-bearing anteroposterior images of both feet are needed to evaluate the midfoot if a Lisfranc injury is suspected. There can be significant differences in the bony alignment with weight bearing and, hence, these views are needed to help detect subtle diastasis that may not be seen on supine imaging (Figs. 3-6). Care should be taken to direct the x-ray beam parallel to the tarsometatarsal joints, which is 15°-20° caudal. There are 10 commonly discussed radiographic findings indicative of midfoot injury[9-11]:

(1) Diastasis of first and second metatarsal bones
(2) First-second cuneiform diastasis
(3) Widening between second and third metatarsals
(4) Widening between middle and lateral cuneiforms
(5) “Fleck Sign”: Avulsion fracture at the base of the second metatarsal (represents Lisfranc ligament avulsion; Figs. 7 and 8) can be seen more clearly with advanced imaging such as computed tomography with reformatting
(6) Misalignment of tarsometatarsal joints on lateral images
(7) Failure of second metatarsal medial border to align with medial border of middle cuneiform
(8) Failure of fourth metatarsal medial border to align with medial edge of cuboid
(9) Loss of congruity of metatarsal bases
(10) Compression fracture of the lateral edge of the cuboid

Changes in the alignment of the bony structures can be subtle, but these subtle changes can signify a major loss of the ligamentous integrity of the midfoot. The classic cutoff for diastasis between the first and second metatarsal was thought to be 5 mm.[12] Recently, the prevailing feeling is that 2 mm of widening represents a significant ligamentous injury to the midfoot.[1] The most sensitive measurement is an increase of 2 mm or more when comparing the injured and uninjured sides, measuring the distance from the medial cuneiform to the base of the second metatarsal on weight-bearing radiographs.[13]

Stress radiographs, usually forced abduction, can be used to document instability. This can be difficult in the acute setting because of pain or anxiety. A regional ankle block can be performed or this examination can be done under anesthesia in the operating room. Again, comparison views using the uninjured foot are helpful.

Advanced imaging such as computed tomography and magnetic resonance imaging can be used to better define

Figure 4 Closer image of injured right foot: non–weight bearing.

Figure 5 Weight-bearing image of right foot injury: note increased diastasis of the medial-middle cuneiform and the first-second metatarsals.

Figure 6 Closer view of weight-bearing image of right foot injury: note increased diastasis of the medial-middle cuneiform and the first-second metatarsals.

Figure 7 Fleck sign (arrow): avulsion of the second metatarsal base as seen on axial CT imaging. CT, computed tomography.

subtle fractures or soft tissue damage. These imaging techniques are supported in the literature[14] but are non–weight bearing, which can limit their usefulness. A bone scintigram can be useful if the diagnosis is in question, although this has been largely been replaced by high-quality magnetic resonance imaging examination.

Figure 8 Fleck sign (arrow): avulsion of the second metatarsal base as seen on coronal cuts of CT imaging. CT, computed tomography.

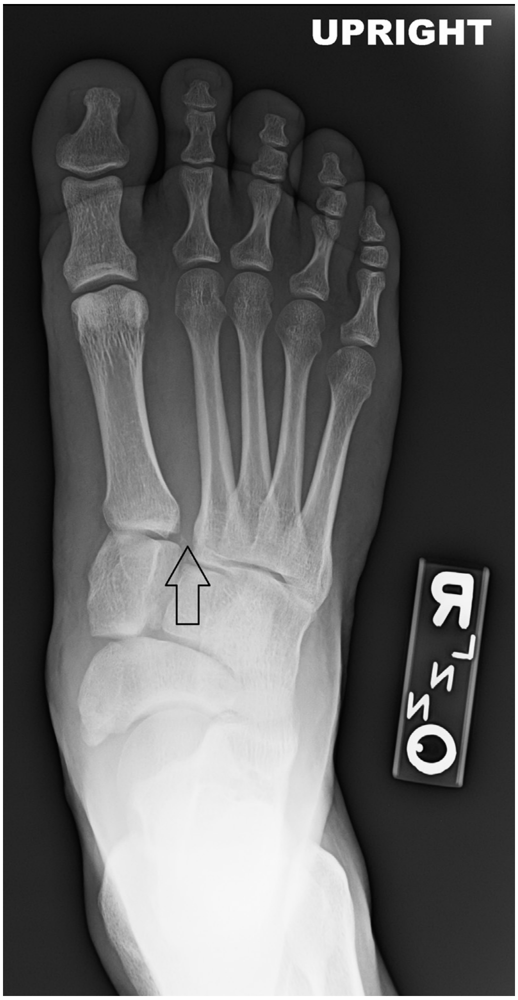

Figure 9 Preoperative weight-bearing image of Lisfranc injury. Arrow indicates abnormal widening between medial cuneiform and second metatarsal base.

Treatment Options

Treatment is based on successful classification of the midfoot injury.[4] Stage I is defined as the observation of injury to the Lisfranc ligament without arch height loss on lateral radiographs and a nondisplaced midfoot on weight-bearing radiographs, but increased uptake on scintigraphy. A scintigram is not routinely performed if a clinical diagnosis can be made or other advanced imaging modalities are used. Stage II injury is defined as diastasis between the first and second metatarsals of 1-5 mm but not loss of arch height. Stage III injuries have first-second metatarsal diastasis and loss of arch height.[4] Arch height is measured as the distance between the plantar aspect of the fifth metatarsal and the plantar aspect of the medial cuneiform on lateral weight-bearing radiographs. This measurement should be compared with the uninjured side. More severe injury patterns can be seen, usually because of high-energy trauma, and often require surgical intervention to restore normal anatomical relationships. Injury to the surrounding neurovascular structures must be evaluated in high-energy injuries and dislocations.

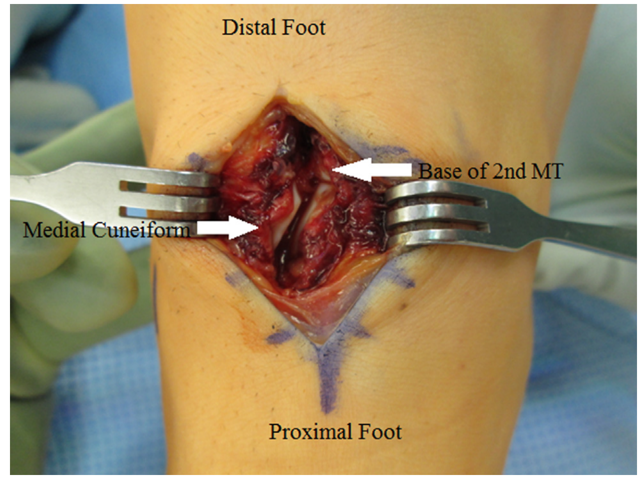

Figure 10 Operative approach: note cuneiform diastasis. MT, metatarsal. (Color version of figure is available online.)

Generally stage I injuries are treated without surgery. Usually, 2-4 weeks of non–weight bearing in a cast or boot is followed by progressive weight bearing in a boot until the athlete is pain free. Once pain free, the athlete can be transitioned out of the boot and into a stiff-soled shoe (carbon fiber insole or custom rigid orthosis). Repeat imaging is needed after weight bearing has commenced to ensure that no changes in alignment have occurred with the weight-bearing progression.

Stage II injuries often require surgical intervention to achieve an optimal outcome. Percutaneous reduction with a bone holding tenaculum and fluoroscopic guidance has been advocated by some,[4] although this does not allow direct visualization of the reduction and removal of any interposed soft tissue.[15] Other authors advocate open reduction to allow for direct, anatomical reduction of the diastasis. Fixation can be carried out with the classic Lisfranc screw from the medial cuneiform to the second metatarsal or with an endobutton.[16,17] The endobutton allows for a small amount of

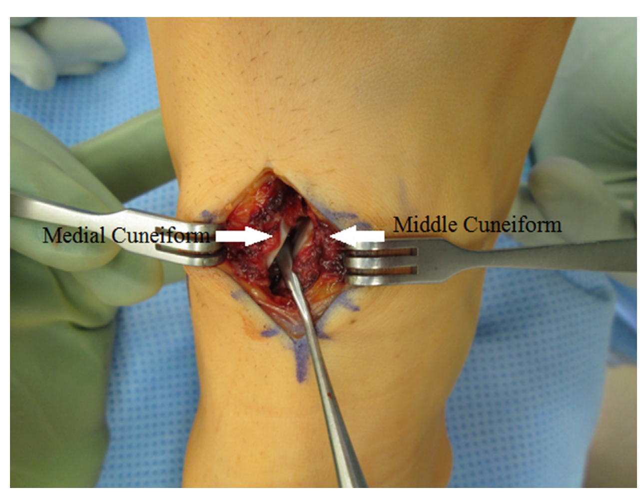

Figure 11 Operative approach: note cuneiform diastasis without stress. (Color version of figure is available online.)

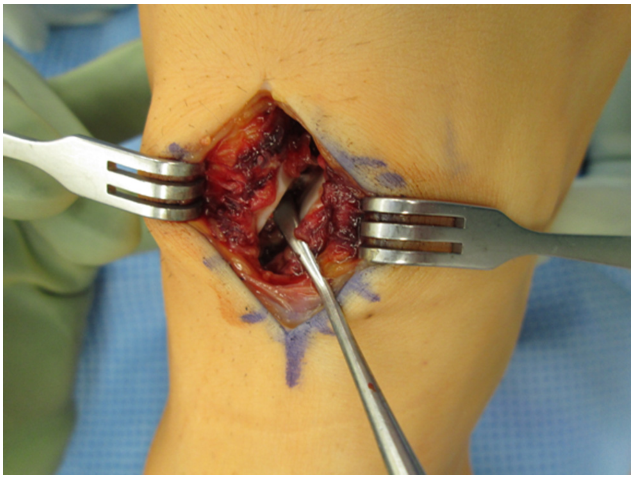

Figure 12 Operative approach: note cuneiform diastasis increasing with stress from the surgical instrument. (Color version of figure is available online.)

physiological movement and does not need to be removed (traditional screws are typically removed at 4 months).

More severe, stage III, injuries require anatomical reduction and maintenance of reduction with adequate fixation. The diastasis is approached dorsally and debris cleaned from the injury site (Figs. 9-12). Internal fixation can take the form of fully threaded 3.5-4.5-mm screws from the medial cuneiform to the base of the second metatarsal (the so-called Lisfranc screw) and a second screw from the medial cuneiform to the middle cuneiform (if medial-middle cuneiform diastasis exists). This configuration is changed as needed, depending on the injury pattern. Fully threaded screws prevent unwanted, excessive compression across the joints.

Alternatively, for tarsometatarsal joint fixation, a dorsal plate can be placed across the tarsometatarsal joints to create rigid internal fixation. More recently, this has been utilized by surgeons who are concerned about articular penetration of the

Figure 13 Preoperative image of the left foot.

Figure 14 Postoperative image of internal fixation used in the left foot.

Figure 15 Immediate postoperative image of isolated Lisfranc ligament injury fixation.

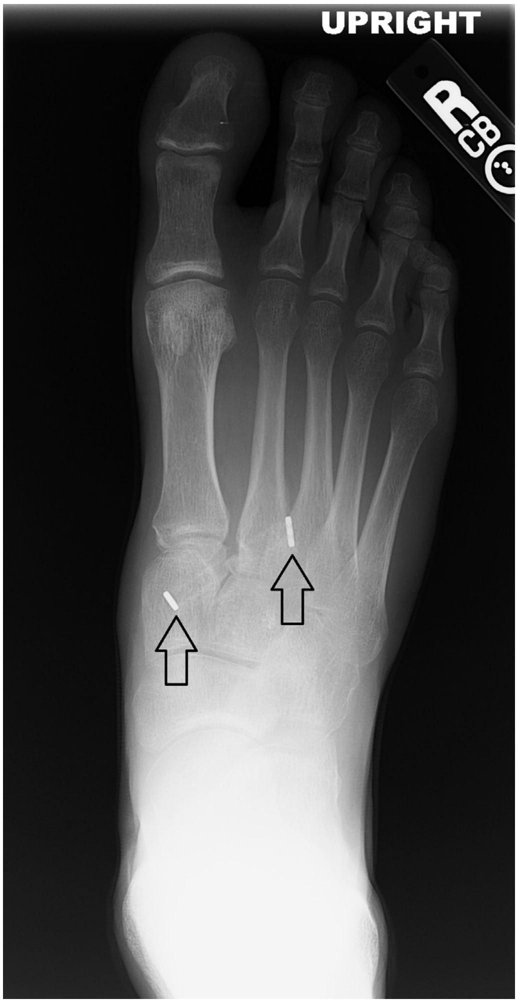

Figure 16 Image after screw removal and placement of endobutton fixation. Arrows indicate ends of endobutton construct with radiolucent suture passing through original screw pathway.

screws or if there is subluxation of the tarsometatarsal joint complex (Figs. 13 and 14). Although it still considered controversial, some authors advocate primary arthrodesis of the medial column in cases of purely ligamentous injury.[18-21] Cases of severe articular injury definitely justify arthrodesis of the medial column, but it is less clear in a younger athlete with no obvious articular cartilage damage.

Stage II and III injuries treated with surgical reduction and fixation are treated with 4-6 weeks of non–weight bearing in a walking boot. Early range of motion is started to prevent soft tissue scarring and stiffness. After 4-6 weeks of non–weight bearing, the athlete is transitioned to full weight bearing over 4-6 weeks. The athlete transitions from a walking boot into a stiff-soled athletic shoe with a semirigid orthotic device or an athletic shoe with a graphite insole added for stiffness. If rigid internal fixation is used, it is typically removed at 12-16 weeks electively. At this time, if there is evidence of Lisfranc widening on intraoperative stress images or concern that the patient is going to return quickly to high-level athletics, a suture with endobuttons can be placed across the joint (Figs. 15 and 16). In the authors' clinical experience, the endobutton has provided adequate fixation for these situations.

No clear treatment algorithm exists for grade II and III chronic (greater than 4 months) injuries. It has been suggested that reconstruction of the ligamentous complex with an allograft is preferable in grade II injuries,[22] but this reconstruction may not hold up to rigorous sporting activities. Therefore, the more common approach in grade II and III injuries is medial column arthrodesis. This can include arthrodesis between the medial and middle cuneiform when there is a chronic Lisfranc injury with proximal extension, in addition to the Lisfranc joint. Without treatment, the common sequela of a chronic Lisfranc injury involves longitudinal arch collapse, abduction of the forefoot, and posttraumatic midfoot arthritis.[23]

Surgical Approach

The midfoot is typically approached via a dorsal incision between the extensor hallucis longus and the extensor hallucis brevis tendon based between the first and second tarsometatarsal joints. The neurovascular bundle is identified, protected, and moved laterally. The medial branch of the superficial peroneal nerve is often found within the incision, and this should be identified and protected. The affected joints are then exposed and evaluated.

The first tarsometatarsal joint is exposed and stressed to determine stability. If needed, a dorsal bridge plate is applied spanning this joint. The Lisfranc joint is then exposed and cleaned of any soft tissue debris that may interfere with

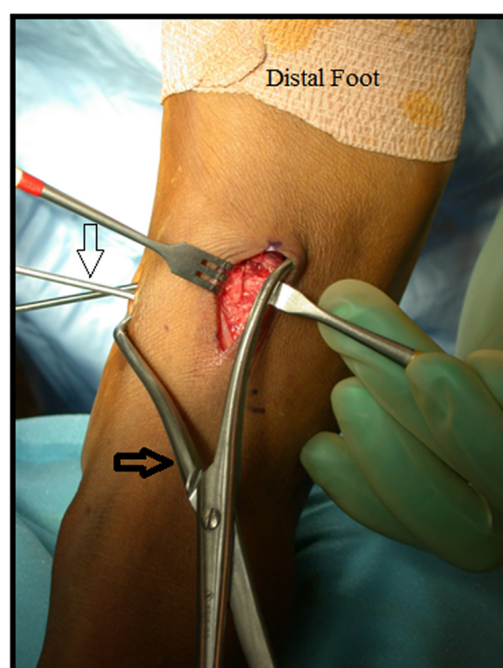

Figure 17 Reduction of Lisfranc diastasis with clamp. Thin arrow shows provisional fixation from medial cuneiform to middle cuneiform and medial cuneiform to base of second metatarsal. Thick arrow points to clamp holding the reduction of the base of the second metatarsal to the medial cuneiform. (Color version of figure is available online.)

reduction. At times, a separate small incision is made on the medial aspect of the foot over the medial cuneiform. The tibialis anterior tendon is exposed and retracted in a plantar direction to allow access to the medial cuneiform. A reduction clamp is applied and an image intensifier is used to check the reduction (Fig. 17). A fully threaded screw is then inserted from the medial cuneiform into the base of the second metatarsal. Care is taken to ensure that the navicular is not affected and that the screw path crosses into the second metatarsal without violating the first and second tarsometatarsal joints.

Stability of the middle and medial cuneiform is then stressed with a Freer elevator. If needed, a clamp is placed to reduce the diastasis and a fully threaded screw is inserted from the exposed medial cuneiform into the middle cuneiform.

If there is an injury to the lateral aspect of the midfoot, an incision is made lateral to the neurovascular bundle between the third and fourth tarsometatarsal joints. This allows access to the lateral midfoot and application of fixation if needed. Treatment of the second and third tarsometatarsal joints with bridge plating or fusion can be accessed in this fashion. Athletic injuries rarely involve the fourth and fifth tarsometatarsal joints and preservation of motion in these joints is preferable, so temporary fixation with pins or bridge plates is done only if it is absolutely necessary to maintain anatomical reduction.

Summary

Ligamentous injury to the midfoot in the athlete can be a serious injury requiring extended time out of competition to heal. Early recognition and aggressive treatment can shorten the recovery time and prevent long-term negative sequelae. Treatment of nondisplaced injuries generally involves non–weight bearing followed by supportive orthotic devices. Displaced injuries require reduction and stable internal fixation. If there is significant articular comminution, a fusion of the medial column tarsometatarsal joints may be necessary.

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