[Imaging]

Sports Health Magnetic Resonance Imaging Challenge

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Injuries to the Lisfranc ligament complex are often suspected, particularly in the setting of midfoot pain without radiographic abnormality. Knowledge of the anatomy and magnetic resonance imaging findings of injuries to this region is helpful for the diagnosing and treating physicians.

Keywords: Lisfranc; ligament tear; midfoot sprain; magnetic resonance imaging

CHALLENGE

A male 17-year-old presents with history of pain due to a football injury incurred 3 days prior. Axial T2-weighted (Figure 1) and coronal fat suppressed T2-weighted (Figure 2) images of the right midfoot are provided with relevant findings marked with arrows. What are the findings? What is the diagnosis?

DIAGNOSIS

Lisfranc ligament (complex) tear.

INTRODUCTION

In the general population, injuries to the Lisfranc ligament complex are uncommon, occurring in approximately 1 in 50 000 people.¹⁵ The incidence of Lisfranc joint fracture dislocations is approximately 1 in 55 000 persons each year.³ Thus, these injuries account for fewer than 1% of all fractures.^{7,12}

The injuries typically occur as a result of high-velocity indirect trauma, such as that from a motor vehicle accident, and so result in obvious displacement and disruption of the midfoot anatomy. Midfoot sprains in athletes represent a lower-velocity injury, with no displacement or with only subtle diastasis.¹⁵

Although sprains of the midfoot are not common in the general population, certain athletes suffer a much higher rate of this injury. Midfoot sprains are the second-most common athletic foot injury, after injury to the metatarsophalangeal joint, and they occur in 4% of football players per year, with offensive linemen incurring 29.2% of midfoot sprains in one study.¹³

HISTORY

The Lisfranc joint, or tarsometatarsal articulation of the foot, is named after Jacques Lisfranc (1790-1847), a field surgeon in Napoleon's army. Lisfranc described an amputation performed through this joint because of gangrene that developed after an injury incurred when a soldier fell off a horse with his foot caught in the stirrup.^{7,20}

CLINICAL PRESENTATION

Sprains in the midfoot region have subtle examination findings that can make diagnosis difficult. In one study,¹³ swelling was not a reliable indicator, because it was most often mild. The location of tenderness to palpation to the tarsometatarsal joints and the reproduction of pain localized to the tarsometatarsal region by passive pronation and supination through the midfoot region were found to be the most reliable indicators of the minor sprains. The more severe injuries did not allow weightbearing on the involved foot. The inability of a player to perform a 1-legged toe raise, cutting maneuvers, or jumps suggested a significant injury to the tarsometatarsal region.

ANATOMY

The Lisfranc joint is a complex skeletal and capsuloligamentous structure that provides significant stability while maintaining the transverse arch of the foot.⁶ The Lisfranc joint forms a shallow arc between the medial base of the second metatarsal and the lateral margin of the distal medial cuneiform, a configuration that gives it little bony stabilization.⁴ The bony architecture of this joint—specifically, the “keystone” wedging of the second

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Figure 1. The axial image demonstrates midsubstance disruption of the interosseous component (arrow) of the Lisfranc ligament complex.

Figure 2. The coronal image demonstrates disruption of the dorsal (arrowhead) and interosseous (arrow) components of the Lisfranc ligament complex.

metatarsal into the cuneiform—forms the focal point that supports the entire tarsometatarsal articulation.⁷

To lessen ambiguity, some investigators have suggested that the term *Lisfranc joint complex* be used to refer to the tarsometatarsal articulations and that the term *Lisfranc joint* be applied to the medial articulation involving the first and second metatarsals with the medial and middle cuneiforms.¹⁴

Unlike the other metatarsal bases, there is no intermetatarsal ligament between the base of the first and second metatarsals. This allows the first metatarsal increased sagittal mobility, being tethered by only its attachments to the medial cuneiform.¹⁸ Instead, stability between the first and second rays is achieved by ligaments extending from the lateral margin of the medial cuneiform to the medial margin of the second metatarsal base. In the interest of simplicity and clarity, at least one author⁴ suggested that the ligaments between the medial cuneiform and second metatarsal be referred to as the *dorsal*, *interosseous*, and *plantar* Lisfranc ligaments (Figures 3-6) and that the 3 ligaments in combination be designated the *Lisfranc ligament complex*.

MECHANISM OF INJURY

The anatomic complexity at the Lisfranc joint complex leads to multiple injury patterns.⁹ Sprains are the most common injury, with the midfoot sprain being the least severe.⁵ The severity of the sprain usually depends on the energy absorbed at the time of injury. Most tarsometatarsal ligament injuries are grade I (pain at the joint, with minimal swelling and no instability) or grade II (increased pain and swelling at the joint, with mild laxity but no instability). The more severe grade III sprain represents complete ligamentous disruption and may represent fracture dislocation.¹⁰ Several further classifications of true fracture dislocations are used,¹ but they do not predict prognosis.^{9,19}

Lisfranc joint fracture dislocations and sprains can be caused by high-energy forces in motor vehicle crashes, industrial accidents, and falls from high places.^{7,12,20} These injuries occasionally result from a less stressful mechanism, such as a twisting fall. Because Lisfranc joint fracture dislocations and sprains carry a high risk of chronic secondary disability, physicians should maintain a high index of suspicion for these injuries in patients with foot injuries characterized by marked swelling, tarsometatarsal joint tenderness, and the inability to bear weight.⁷

High-Velocity Injury

The high-velocity injury to the Lisfranc joint typically occurs with major trauma, such as motor vehicle accidents or falls. The force on the Lisfranc joint is abduction and/or plantar flexion. The joint is grossly dislocated, and fractures of the metatarsals or cuneiforms are commonly seen.⁸

Fracture dislocations are classified as either homolateral, with all 5 metatarsals displaced in the medial or lateral direction, or divergent, with a separation of the first and second metatarsals.

Figure 3. This 3-dimensional graphic of the midfoot with the first metatarsal removed demonstrates the dorsal (blue), interosseous (red), and plantar (green) components of the Lisfranc ligament complex.

Figure 4. Coronal T2 image demonstrates normal dorsal (arrowhead), interosseous (long arrow), and plantar (short arrow) components of the Lisfranc ligament complex.

Figure 5. Axial STIR (short TI inversion recovery) image demonstrating a normal interosseous component of the Lisfranc ligament complex (arrow).

Figure 6. Axial T2 image demonstrating a normal plantar component of the Lisfranc ligament complex (arrowhead).

Figure 7. Axial T2 image demonstrating tear of the interosseous component of the Lisfranc ligament complex (arrow) in a 15-year-old following a jet ski accident. The patient also suffered disruption of the other Lisfranc components, as well as a comminuted fracture of the base of the second metatarsal.

Low-Velocity Injury: Midfoot Sprain

Low-velocity injuries can also result in mechanically significant disruption of the Lisfranc joint. Two injury mechanisms have been described. The first is plantar flexion and axial load, sometimes with a component of inversion.¹² It occurs when the patient's foot is plantar flexed and suffers an axial load injury. This injury may occur during running and jumping sports or when a patient trips going downstairs or stepping off a curb. It also may occur when a downward force is applied to the heel when the patient's knee is on the ground and the ankle is dorsiflexed.

The second mechanism is forced forefoot abduction.⁵ This injury may also occur when an athlete wearing cleats plants the foot and turns quickly. In both mechanisms of injury, stress is applied to the Lisfranc ligament complex, and ligament failure referred to as *midfoot sprain* occurs. Midfoot sprain is uncommon in nonathletes, but in athletes it is the second-

Figure 8. Axial fast spin echo inversion recovery image demonstrating tear of the dorsal component of the Lisfranc ligament complex (arrowhead).

most common athletic foot injury, occurring in 4% of football players per year.¹³

MAGNETIC RESONANCE IMAGING FINDINGS

As many as 20% of Lisfranc joint injuries are missed on initial anteroposterior and oblique radiographs.^{12,19} Magnetic resonance imaging (MRI) has been shown to demonstrate the Lisfranc ligament complex reliably in the normal foot.¹⁷ Three distinct structures can be identified: the dorsal, plantar, and interosseous ligaments (Figures 3-6). The interosseous ligament is the strongest and thickest of the 3 ligaments, providing the greatest degree of stability. It is 8 to 10 mm long and 5 to 6 mm thick⁸ (Figures 5 and 6). However, the 3 components of the Lisfranc ligament complex fail sequentially from dorsal to plantar⁴ due to the mechanism of stress applied to the joint (Figures 7 and 9). MRI frequently shows small avulsion fractures that are not visible on radiographs.¹⁶ The fractures usually arise from the base of the second metatarsal, although other midfoot contusions and fractures are often seen as well (Figure 9). Bone bruises without avulsions are seen commonly and are a useful secondary sign raising suspicion for a Lisfranc ligament complex injury (Figure 10).

Figure 9. Axial T2 with fat saturation image demonstrating thickening and increased signal of the interosseous component (arrow) as well as multiple midfoot contusions (asterisks) 3 months following a soccer injury. Dorsal component was torn.

Figure 10. Coronal T2 with fat saturation image demonstrating an intact interosseous component (arrow) of the Lisfranc ligament complex. The dorsal component was disrupted, and multiple midfoot fractures were present (arrowheads).

DISCUSSION

Lisfranc joint injuries are uncommon and often misdiagnosed. Typical signs and symptoms include pain, swelling, and the inability to bear weight. These injuries vary from mild sprains (typically in an athlete) to fracture dislocations (as seen in motor vehicle accidents). On physical examination, swelling is found primarily over the midfoot region. Pain is elicited with palpation along the tarsometatarsal articulations, and force applied to this area may elicit medial or lateral pain.

Subtle midfoot sprains (diastasis of 1 to 5 mm) are difficult to diagnose and can cause significant disability and frustration in athletes. Partial capsular tears result in no diastasis but can result in an inability to play sports at an elite level for many months.¹⁵

A missed diagnosis has serious consequences. An untreated midfoot sprain rapidly leads to osteoarthritis and flattening of the longitudinal arch. Treatment is usually surgical.^{11,15,19}

Radiographs showing diastasis of the normal architecture confirm the presence of a severe sprain and possible dislocation. Negative standard and weightbearing radiographs do not rule out a mild (grade I) or moderate (grade II) sprain. MRI may be necessary if pain and swelling persist days beyond the time of initial injury. Proper treatment of a mild to moderate Lisfranc injury improves the chance of successful healing and reduces the likelihood of complications. Patients with fractures and fracture dislocations should be referred for surgical management.²

CONCLUSION

MRI can prove helpful for the evaluation of injuries to the midfoot, particularly in the setting of normal radiographs. Specific injuries to the components of the Lisfranc ligament complex can be detected. Other injuries to this region that are exclusive of the Lisfranc ligament complex, such as midfoot contusions and fractures, are also well demonstrated. The accurate diagnosis of Lisfranc and related injuries in the patient with midfoot pain allows appropriate conservative or surgical treatment to be instituted.

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