Diagnosis and Management of Lisfranc Injuries and Metatarsal Fractures

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ABSTRACT

Forefoot and midfoot injuries are relatively common and can lead to chronic disability, especially if they are not promptly diagnosed and appropriately treated. A focused history and physical examination must be coupled with a thorough review of imaging studies to identify the correct diagnosis. Subtle radiographic changes can represent significant ligamentous Lisfranc injury. Midfoot swelling in the presence of plantar ecchymosis should be considered to be a Lisfranc injury until proven otherwise. While most metatarsal fractures can be treated with some form of immobilization and protected weight-bearing, this article will distinguish these more common injuries from those requiring surgical intervention. We will review relevant anatomy and biomechanics, mechanisms of injury, clinical presentation, imaging studies, and diagnostic techniques and treatment.

KEYWORDS: Lisfranc joint injury, metatarsal fracture

INTRODUCTION

Injuries to the midfoot and forefoot can result from both high- and low-energy trauma and can lead to chronic disability. A thorough history and physical examination as well as careful interpretation of imaging studies are necessary to make the appropriate diagnosis. Plain radiographs are not always diagnostic because of multiple overlapping bones in the foot, particularly on the lateral view. This article will provide an overview of common traumatic foot injuries, focusing on Lisfranc joint injuries and metatarsal fractures. We will review relevant anatomy and biomechanics, mechanisms of injury, clinical presentation, imaging studies, and diagnostic techniques.

LISFRANC INJURIES

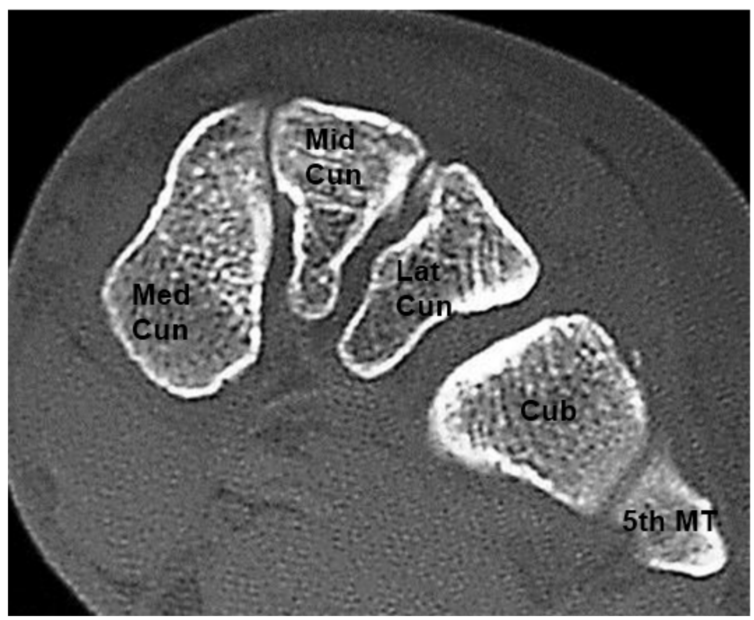
Injuries to the Lisfranc, or tarsometatarsal (TMT), joint complex occur in 1 in 55,000 persons each year in the United States, approximately 0.2% of all fractures.[1] Low-energy trauma, including falls from standing and athletic injuries, accounts for approximately one-third of Lisfranc injuries. The remaining two-thirds occur as a result of high-energy trauma (eg, motor vehicle collision, industrial accidents and falls from heights).[2,3] Overall, it still remains difficult to quantify the exact incidence of these injuries as nearly 20% are not accurately diagnosed on initial radiographic assessment.[4]

Anatomy and Biomechanics

The forefoot is comprised of five metatarsal bones and the phalanges of each toe. The midfoot consists of five bones: three cuneiforms (medial, middle and lateral), the cuboid, and navicular.

The Lisfranc joint consists of the articulations between the metatarsals and the three cuneiforms and cuboid. Its osseous architecture and soft-tissue connections are critical to the stability of the foot. The Lisfranc articulation can be divided into three longitudinal columns.[5] The medial column consists of the medial cuneiform and first metatarsal. The middle column is composed of the middle and lateral cuneiforms and the second and third metatarsals. The lateral column is made up of the cuboid and fourth and fifth

Figure 1. Coronal computed tomography (CT) image demonstrating the Roman arch



Med Cun = medial cuneiform
Mid Cun = middle cuneiform
Lat Cun = lateral cuneiform
Cub = cuboid
5th MT = fifth metatarsal

metatarsals. There is limited motion in the medial and middle column, but the lateral column exhibits significantly more motion. The cuneiforms are trapezoidal, wider dorsally than plantarly, providing stability similar to a "Roman arch" (Figure 1). The second metatarsal is recessed proximally , serving as the "keystone" of the Lisfranc joint.

Soft tissue support of the TMT articulation consists primarily of capsular and ligamentous structures. The Lisfranc ligament is the most important and runs from the plantar medial cuneiform to the base of the second metatarsal. While the second through fifth metatarsals are interconnected by inter-metatarsal ligaments, there is no inter-metatarsal connection between the first and second metatarsals. Thus, the Lisfranc ligament effectively connects the medial column to the lateral four metatarsals. Injury to this ligament can destabilize the entire forefoot as well as the Lisfranc articulation.[6]

Mechanism of Injury

Lisfranc injuries result from both indirect and direct trauma. Direct injuries, including crush injuries and other high-energy mechanisms, are frequently associated with significant soft-tissue trauma, vascular compromise, and compartment syndrome. Therefore, one should have a high suspicion for Lisfranc injuries and these other entities in patients presenting with a history of crush injury to the foot.

There are two common indirect mechanisms of Lisfranc injury: forced external rotation, or twisting of a pronated foot and axial loading of the foot in a fixed equinus position. In a twisting injury, forceful abduction of the forefoot causes dislocation of the second metatarsal and lateral displacement of the lateral metatarsals. This type of injury is in sports involving use of a stirrup, such as at equestrian events. Associated "nutcracker" cuboid fractures can occur due to compression by the fourth and fifth metatarsal bases. Patients presenting with such a cuboid fracture of this nature should be suspected of having an associated Lisfranc injury. Metatarsal base fractures, particularly of the second, are not uncommon with an abduction mechanism.

Axial loading of the foot with the ankle and metatarsophalangeal (MTP) joints in plantarflexion is another mechanism for a Lisfranc injury. Examples include missing a step, catching one's heel on a curb while stepping down, or force applied when the foot is plantarflexed and the knee is anchored on the ground. The latter usually occurs in American football players when they are kneeling or lying in a prone position and another athlete falls directly onto the heel.[6,7]

Signs and Symptoms

Patients with Lisfranc injuries tend to present with midfoot swelling and inability to bear weight. Classic findings include forefoot and midfoot edema, and plantar arch ecchymosis, which are considered pathognomonic for Lisfranc injury. Additional findings suggestive of Lisfranc injury include diastasis between the hallux and the second toe on an anteroposterior (AP) foot radiograph – a "positive gap sign." Tenderness to palpation and inability to bear weight on the tiptoes also suggest injury to the TMT complex.[6,7]

Figure 2. Anteroposterior foot x-ray demonstrating Lisfranc injury (the medial border of the second metatarsal does not line up with that of the middle cuneiform)

Stability of the TMT articulation may be assessed with maneuvers such as the "piano key test" (moving the first and second metatarsals into plantarflexion/dorsiflexion and abduction/adduction). Subluxation or discomfort with this test suggests TMT joint injury. The first and second metatarsals should also be stressed divergently.[8] Of note, stress tests in the acute setting may be limited by patient discomfort and swelling of the foot.

Imaging

An AP view assesses the alignment of the first and second TMT joints, while the oblique view evaluates the other TMT joints; the medial border of the second metatarsal should line up with that of the middle cuneiform. On the 30-degree oblique view, the medial border of the fourth metatarsal should line up with that of the cuboid. Any displacement of these lines is diagnostic for Lisfranc injury (Figure 2). Other signs of Lisfranc injury include avulsion fractures of the second metatarsal base or medial cuneiform ("fleck sign") and more than 2.7 mm of diastasis between the first and second metatarsals.[9] Lateral radiographs may reveal dorsal dislocation or subluxation of the TMT joints.[6]

If a Lisfranc injury is suspected despite normal imaging, "stress views" of the foot should be obtained: an AP weight-bearing radiograph with both feet on a single cassette, as well as oblique and lateral weight-bearing radiographs of the injured extremity. One should explain the rationale behind these painful radiographs to improve compliance with equal weight distribution on both feet. The alignment of all columns should be reassessed, and any displacement is diagnostic of TMT joint instability. Diastasis between the first and second TMT joints, if greater than 2 mm compared to the contralateral side, is indicative of ligamentous Lisfranc injury.[10] Lateral weight-bearing films should be examined for loss of arch height and subluxation of TMT joints.

Treatment

Unstable Lisfranc injuries should be treated with either transarticular fixation or arthrodesis, depending on age, degree of underlying arthritis, ligamentous or bony injury, and comminution. Post-operatively, patients are usually placed in a short leg cast for 3 to 4 weeks and then transitioned to a controlled ankle motion (CAM) boot, which allows ankle ROM exercises, for 3 to 5 weeks. Typically, patients do not bear weight for 8 to 12 weeks, depending on surgeon preference and patient symptoms. Patients can be transitioned to a shoe with an orthotic insert at 3 months post-operatively. Physical therapy should be initiated for balance and gait training once the patient's cast is removed.[6,7]

Patients with stable injuries can be managed non-operatively and can bear weight as tolerated in a CAM boot for 6 to 10 weeks. After 2 weeks in the boot, weight-bearing images are obtained to monitor for any changes in alignment. A brief course of physical therapy to regain balance, strength, and ROM is recommended. After discontinuing the CAM boot, comfortable, supportive shoes should be worn and some authors also advocate the use of full-length orthotic inserts.[6]

METATARSAL FRACTURES

Forefoot Anatomy and Biomechanics

The forefoot serves two major purposes during gait: (1) the five metatarsals and two sesamoids provide a broad plantar surface for load sharing, and (2) the mobile forefoot allows the metatarsal heads to accommodate uneven ground and maintain even load distribution.[11] Displaced metatarsal fractures can disrupt the major weight-bearing complex of the foot. It is critical to correct both displacement in the sagittal plane and excessive shortening of any individual metatarsal. These injuries can result in metatarsalgia due to excessive pressure on one or more metatarsal heads.[7]

Metatarsal Shaft Fractures (Acute Traumatic)

In a study of the epidemiology of metatarsal fractures, 68% were found to involve the fifth metatarsal, most commonly resulting from a torsional mechanism.[12] Metatarsal shaft fractures can also occur from a direct blow to the foot, such as dropping a heavy object onto the forefoot, causing a transverse or comminuted fracture pattern. In the setting of crush injuries, second, third and/or fourth metatarsals are usually involved.

Patients with acute metatarsal shaft fractures present with pain and swelling of the forefoot, with point tenderness over the fracture site. With multiple metatarsal fractures, a neurovascular exam and soft tissue injury assessment are essential to monitor for foot compartment syndrome.[7] Radiographic evaluation includes standard, three-view foot x-rays. Weight-bearing x-rays should be obtained if tolerated, to assess the extent of displacement, angulation and shortening on each view. As previously mentioned, fractures at the base of the second metatarsal should raise suspicion for Lisfranc injury.

Treatment

Operative indications for metatarsal shaft fractures include greater than 10 degrees of angulation in the sagittal plane, more than 3 to 4 millimeter translation in any direction, rotational toe malalignment, and shortening that alters the distal parabolic relationship of the metatarsal heads.[13] These structural changes can lead to metatarsalgia and painful calluses. Transverse plane displacement can lead to interdigital nerve irritation. Additionally, persistent medial or lateral displacement of a 1st or 5th MT shaft fracture can widen the foot and create shoe-wear problems, so they should be reduced and fixed.[7]

Shaft fractures with minimal or no displacement can be treated either in a short-leg walking cast for several weeks or in a hard-soled shoe if comfort allows. The advantage of a hard-soled shoe is that free ROM of the ankle is preserved. Other treatment options include a supportive shoe with a longitudinal arch support to unload the metatarsal heads. Minimally displaced or non-displaced traumatic metatarsal fractures usually heal within 3 weeks and rarely result in functional deficit. Prolonged immobilization should be avoided to prevent joint stiffness.[14]

Some fractures of the proximal fifth metatarsal deserve special mention, since their high risk of nonunion makes them unique among metatarsal fractures. These so-called Jones fractures occur at the metaphyseal-diaphyseal junction of the fifth metatarsal, involving the fourth-fifth metatarsal articulation. Due to the poor blood supply in this region, these fractures have a high incidence of nonunion. These fractures are common in athletes involved in contact sports. Management entails strict non-weight-bearing in a short leg cast for 6 to 8 weeks. Due to the likelihood of delayed union or nonunion, Jones fractures often require surgical intervention, particularly in elite athletes. Early surgery minimizes the risk of non-union and expedites return to sports.[15]

Metatarsal Stress Fractures (Subacute and Chronic)

Stress fractures of the metatarsal shaft occur as a result of repetitive forefoot stresses, and are commonly seen in athletes; they can also occur after metatarsal-shortening forefoot procedures that alter the weight-bearing distribution among the metatarsal heads, such as a first metatarsal shortening osteotomy used for hallux valgus (bunion) correction. Stress fractures commonly occur in the second and third metatarsal necks and the fifth metatarsal shaft.[11] Patients with high-arched feet are predisposed to stress fractures of the fifth metatarsal since a disproportionate amount of weight is borne on the lateral aspect of the foot.

Patients with metatarsal stress fractures usually have localized pain and tenderness, sometimes without a history of trauma, but often with a recent change in the patient's activity level. The classic finding is tenderness over the affected bone, and hopping on one foot reproduces the pain. A thorough medical history may help to detect secondary causes of stress fractures, such as endocrinopathies, eating disorders, and malabsorption syndromes. A dietary history should address calcium, vitamin D, and protein intake, as well as alcohol and caffeine consumption.[15]

Standard three-view weight-bearing radiographs yield results that vary based on the acuity of injury. The earliest findings include subtle radiolucency or poor definition of the cortex; later findings include thickening and sclerosis of the endosteum along with periosteal new bone formation. These later findings may appear weeks to months after the onset of symptoms.[16,17]

Since radiographic findings tend to lag behind clinical symptoms by weeks, x-rays can be negative, particularly early in the course of disease. In this setting, technetium bone scans and/or MRI can be helpful. Occult stress fractures are generally visible on bone scans days to weeks earlier than on radiographs. While a bone scan has high sensitivity for detecting stress fractures, it is not very specific, and tracer uptake will be seen in the setting of any process that involves bone remodeling, including tumor, infection and stress reaction without fracture.[15] MRI is considered equally sensitive and more specific than a bone scan in diagnosing occult fractures. Diagnostic MRI findings include endosteal marrow edema and periosteal edema in the region of injury.[18]

Treatment

Treatment of metatarsal stress fractures involves several weeks of rest and immobilization in a CAM boot, with the duration dependent on tenderness and pain with weight-bearing. A gradual return to previous activity level should begin after the resolution of symptoms. Some institutions also recommend referral to a metabolic bone disease specialist if secondary causes of stress fracture are suspected.[15]

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