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Review article

Evaluation of the Typology of Lisfranc Foot Disorders

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Abstract

Background : Although Lisfranc fractures and dislocations can occur at the TMT joint or in conjunction with other midfoot, Chopart, and ankle joint injuries, they are usually classified as midfoot injuries. Our hypothesis is that Lisfranc injuries have more complex patterns than previously known, involving the midfoot and hindfoot as well. So far, no prior studies have provided a comprehensive picture of the complexity of Lisfranc injuries, and the best way to manage Lisfranc injuries remains unknown. Using a combination of initial injury radiographs, preoperative computed tomographic (CT) scans or magnetic resonance images (MRI), and intra-operative image intensifier (II) screening, this paper attempts to obtain a typology of Lisfranc injuries combined with other foot bones and joints involvement. We also investigated treatments given for each type. **Methods :** Between 2013 and 2015, a total of 54 patients (56 feet) with Lisfranc injuries were identified and treated at our centre. We looked at the typology of Lisfranc injuries by reviewing the patients' pre-operative original injury, stress view radiographs, MRI or CT, or intra-operative II screening. **Results :** We discovered three types of Lisfranc injuries: type 1 ligament injury, type 2 associated metatarsal base fracture or dislocation, and type 3 Lisfranc injury coupled with either Chopart joint fracture or ankle fracture. **Conclusion :** Lisfranc injuries appear to be extremely variable and complex, with associated fractures and dislocations. We discovered several kinds of Lisfranc injuries that had not previously been classified. There were numerous Lisfranc fractures or dislocations linked with injuries to the midfoot, Chopart, and ankle joints. Except for Type Ia, all instances were treated with operative fixation. Lisfranc injuries can range from minor ligament issues to high-energy complex fractures. This research will shed some light on the wide range of Lisfranc injuries.

Keywords : *Midfoot Fracture; Lisfranc Injury; Chopart Joint; Outcome; And Internal Fixation*

Introduction

Minimal dissociations between the bases of the five metatarsals (MTs) and their articulations with the four distal tarsal bones have been widely identified as Lisfranc injuries. Lisfranc injuries are typically caused by a rupture of the Lisfranc ligament, an interosseous ligament situated between the medial cuneiform and the second MT.

It is critical to completely recognise, classify, and treat the various severity levels of Lisfranc injuries. It is estimated that up to 20% of subtle Lisfranc injuries are overlooked or misdiagnosed, resulting in incorrect treatment. This could become a permanent cause of foot pain and function loss[1]. The primary cause of misdiagnosis is that early radiographs for 20% to 50% of Lisfranc injuries are negative[2].Misdiagnosis should be reduced if CT and MRI images are performed, and subtler Lisfranc injuries should be identified. Furthermore, Lisfranc injuries have been linked to other tarsal fractures or dislocations[3]. The purpose of this research is to examine the typology of Lisfranc injuries using a combination of initial injury radiographs and CT or/and MRI images, and compare it to Myerson's widely used Lisfranc classification, which is based on various kinds of fractures diagnosed by plain radiographs. The goal of this research is to look at how fracture/dislocation patterns differ between Lisfranc injuries and other types of injuries.

Materials and Method

Ethical approval for this study was obtained from research review boards. We retrospectively analyzed images and the operative notes of 54 patients (56 feet) with a. Lisfranc injuries in isolation, b. midfoot injuries, and c. Lisfranc injuries combined with Chopart and ankle injuries. Data was takenfrom two orthopedic centers, between Jan 2010 and Jan 2015. They were a tertiary level major trauma centre and a level II multi-specialty hospital.All images we included were plain radiographs, prior to operation and post reduction of fracture, intra-operative image intensifier (II) screening, CT scans or MRI scans. These were analyzed for fracture patterns and for evidence of subtle Lisfranc injuries. The initial injuryradiographs of AP, lateral, and oblique views were used to analyze the location of the fractures and direction of the dislocation or subluxation.

This work received ethical approval from research review boards. We examined images and operative notes from 54 patients (56 feet) who had a. Lisfranc injuries alone, b. midfoot injuries, or c. Lisfranc injuries coupled with Chopart and ankle injuries. Data was collected from two orthopaedic clinics between January 2010 and January 2015. They were a level II multi-specialty hospital and a tertiary level significant trauma centre. Plain radiography, both before and after fracture reduction surgery, intra-operative image intensifier (II) screening, CT scans, or MRI scans were all included. These were examined for fracture patterns and signs of Lisfranc injuries. The initial injuryradiographs of AP, lateral, and oblique views were used to evaluate the fracture location and severity.

We found: 1) dislocation or subluxation of the Lisfranc joint in the coronal and/or sagittal planes; 2) evidence of midfoot joint dislocation/fractures in AP, lateral, and oblique views; 3) presence of more than 2 mm diastasis between the medial cuneiform and the base of the second MT when compared to the contralateral foot; and 4) fractures of the MTs and tarsals. 5) Lisfranc injuries due to Chopart joint dislocations; 6) Lisfranc injuries due to ankle fractures. MRI was also used to evaluate Lisfranc ligament injuries, which were suggested by the rupture of the ligament signals. CT scans were used to look for injuries in the tarsal bones, Chopart joints, and ankle joints, as well as to identify a widening between the medial cuneiform and the base of the second MT.The severity of the injury, midfoot stability, and intra-operative II screening images were all gathered. Treatment techniques, such as surgery or non-surgery, fixation methods, and patient operative notes, were also examined.

We then classified Lisfranc injuries using the following typology: Ligament damage, type 1. By MRI or physical examination under anaesthesia, this can be seen as a ligament sprain (partial tear) or full rupture, demonstrating laxity, and can be further subdivided as follows: 1a: Lisfranc ligament tear alone, 1b: Lisfranc ligament tear in conjunction with TMT ligament rupture, and 1c: Lisfranc ligament tear in conjunction with tarsal bone ligament rupture.

Lisfranc ligament damage with MT or tarsal bone fracture: Type 2: 2a: Lisfranc ligament injury in conjunction with a second MT base fracture, 2b: Lisfranc ligament injury in conjunction with an MT base fracture or dislocation, and 2c: Lisfranc ligament injury in conjunction with a tarsal bone fracture or dislocation (such as cuneiform fracture or dislocation)Fractures associated with type 3: 3a: Lisfranc ligament injury with Chopart joint displacement or fracture; 3b: Lisfranc ligament injury with ankle fracture

To identify journal articles referring to Lisfranc dislocations and fractures, an extensive literature search was conducted using the MEDLINE (1996 to present), PubMed, and Cochrane databases. Midfoot fractures, Lisfranc injury, Chopart joint, and internal fixation were the terms used. The search results were restricted to humans and articles written in English. All patients in this research were followed up on at least one year after surgery by the American Orthopedic Foot and Ankle Society (AOFAS).

Results

There were 41 men and 13 women among the 54 cases. They were classified into categories as a result of our classification (Table 1).

The average age was 38.7 years old (range, 16 to 68). 52 patients had CT scans, 3 had MRI scans, and 3 had conservative treatment (casting and non-weight bearing for six weeks); 51 patients (53 feet) had surgical repairs; 4 cases were only fixed with trans-articular screws, while other cases were fixed with a combination of trans-articular screws and bridging plates (Table 2).

The surgical approach was chosen based on the fracture pattern and the surgeons' opinions.We discovered and classified various kinds of Lisfranc injuries (Table 3-10). Based on the AOFAS foot ankle score method, all patients were followed up on one year after surgery. In this study, the average score was 81.3 points, and the result was evaluated by type. The average (Type Ia-Ic) result was 90.5 points. The average result for (Type IIa-IIc) was 80.3, with (Type IIa) receiving 86.4 points, (Type IIb) receiving 83.4 points, and (Type IIc) receiving 76.9 points. The average result of (Type IIIa-IIIb) was 73.0 points, with (Type IIIa) scoring 79.7 points and (Type IIIb) scoring 68.2 points.

Discussion

Jacques Lisfranc de St. Martin, a field surgeon in Napoleon's army who fought on the Russian front, was the first to notice the unique characteristics of midfoot anatomy and biomechanics[4]. This midfoot area became known as the Lisfranc joint, and the associated ligament was subsequently named the Lisfranc ligament. It is the link between the second metatarsal root and the medial cuneiform. It's called an oblique tendon. The bones of the Lisfranc joints have a Romanesque arch form in the coronal plane, with the apex at the second metatarsal. Although the base of this metatarsal is recessed into cuneiforms, which contributes to its overall stability, no inter-metatarsal ligament connects the first and second inter-metatarsals. Plantar, interosseous, and dorsal tendons make up the midfoot ligaments[5].The greatest stabilisers of this construct are the interosseous and plantar inter-metatarsal ligaments, while the weakest are the dorsal ligaments[6]. Because of this biomechanical construct, the midfoot is vulnerable to injury from forefoot torsion and axial stress.

Injuries to the tarso-metatarsal (TMT) joint are classified as either indirect or direct. Indirect injuries can be high energy, such as those sustained in car crashes or falls from great heights, or low energy, such as those sustained during athletic activity[7]. In most cases, secondary injuries are caused by a longitudinal force applied to the forefoot, which is then rotated and compressed, resulting in Lisfranc ligament rupture[8]. The most frequent causes of MT dislocations or fractures are excessive plantar flexion and abduction[9].

Nunley and Vertullo published a study in which they classified athletic Lisfranc ligament injuries into three groups based on clinical findings, weight-bearing radiographs, and bone scan[16]. Their stage I injury is characterised by discomfort but no radiographic findings, with the Lisfranc complex showing only increased uptake in a bone scan. Stage II injuries had diastasis between the first and second MTs that was 1 to 5 mm larger than the contralateral side, but there was no loss of foot arch height. Diastasis of more than 5 mm and the loss of arch height indicated stage III injury.Non-surgical treatment of stage I patients and surgical treatment of stage II and III patients led to a good outcome in 93% of cases. Nunley and Vertullo argued in their report that conventional classification systems place too much stress on the simple diastasis seen in low-energy athletic injuries. In our typology assessment, we agree with Chiodo and Myerson's traditional classification scheme, which excludes low-energy injuries.

In our research, three simple Lisfranc ligament injuries, Type 1a, out of 14 cases of type I, received conservative treatment. Type I has an average value of 90.5 points. Except for one non-surgical case, which had a partial tear on the Lisfranc ligamentous injury and a slight antalgic gait due to second TMT joint arthritis, all of these were good outcomes. This case highlights the importance of diagnosing ligamentous injury and determining whether non-surgical management of Lisfranc ligamentous injuries is suitable.Our typology study also revealed numerous combinations of Lisfranc injuries, such as Types 2 and 3, with other fractures and dislocations of the midfoot, hindfoot, and ankle joints. Traditional classification systems do not only exclude low-energy injuries, but also a wide variety of multiple trauma and high energy injury patterns.

Although the Lisfranc joint is the most frequent site of midfoot injury, Lisfranc injuries have been reported to co-occur with tarsal fractures or dislocations[3]. In this study, we found a disproportionate number of Lisfranc injuries associated with other Type 2c and Type 3b injuries, as well as tarsal bone and ankle fractures and dislocations. Because the outcomes of these associated injuries correspond with the degree of anatomical incongruency of the Lisfranc joints, we believe it is critical to examine foot injuries in terms of Lisfranc injury typologies. Our typology study also revealed numerous combinations of Lisfranc injuries, such as Types 2 and 3, with other fractures and dislocations of the midfoot, hindfoot, and ankle joints. Traditional classification systems do not only exclude low-energy injuries, but also a wide variety of multiple trauma and high energy injury patterns.

This is also supported by Richter et al's 2001 retrospective review of 155 patients with midfoot injuries. In this research, functional outcomes, as assessed by the AOFAS clinical rating scale, were significantly worse for patients with combined Chopart and midfoot injuries, than for those with either injury by itself[19]. Through altered joint kinematics and altered loading, these combined injuries, which are frequently linked with high-energy motor vehicle accidents, can contribute to significant arthrosis of the TMT joints. However, when they are linked with additional trauma, they are frequently missed in diagnosis[20]. Our analysis of Lisfranc injury typologies should help to explain highly variable midfoot injuries and reduce future misdiagnosis using our typology.

Management

The midfoot complex plays a dynamic mechanical function in transferring weight to the forefoot during walking. Each midfoot joint's motion is variable and complex. The Chopart joint is rigid at toe off, but it becomes a flexible structure during heel impact, increasing the Achilles complex's lever arm[21].

Lisfranc injuries, if not treated, can result in post-traumatic arthritis, which has been documented in nearly 50% of cases[22]. These bones' fractures and fracture-dislocations can cause significant functional impairment and arthrosis. As a result, early surgical intervention is advised to realign the articulations, which has been shown to enhance function[23]. Patients with displaced or insecure injuries require anatomical reduction surgery[24].

According to Eleftheriou, post-traumatic arthritis is more prevalent at the base of the second MT, implying that incongruity may be tolerated better at the medial and lateral columns[25]. The lateral column is the least likely to be implicated in post-traumatic arthritis because it has the most plane motion. The middle and medial columns are stabilised with screw fixation or dorsal plating because they are comparatively rigid. For the more flexible lateral column, K-wire fixation is used[26].

According to our experience treating advanced adult acquired flat-foot, structural abnormalities such as calcaneus valgus, forefoot abduction, and loss of the longitudinal arch contribute to midfoot arthritis [27,28].The key to restoring post-traumatic foot function is to pay attention to hindfoot and forefoot alignment during operation, as well as to restoring the midfoot arch. Furthermore, pathologic midfoot conditions (e.g., inflammatory arthropathy with synovitis and joint destruction) are frequently documented to cause pain and instability. Loss of midfoot stability can cause abnormal foot posture and the collapse of the longitudinal arch, resulting in greater tensile stress on the plantar ligaments and foot pain[29].

Except for Type 1a, which can be managed non-surgically, we believe that all subtypes require surgical treatment, either internal fixation or primary arthrodesis. Following the prior outcomes of this treatment modality, we believe stable and non-displaced injuries like Type 1a can be managed non-surgically with a non-weight-bearing cast for six weeks, with the majority of patients returning to their pre-injury sporting activities[30]. A longer period of immobilisation, spanning three to four months, may be needed for complete ligamentous rupture. We have surgically handled all of our Types 1b and 1c cases.

Nonetheless, there is still debate about how to manage patients with extensive articular damage (multiple joint fragments) as well as those with complete ligamentous rupture[31]. Both of these kinds of injuries are currently treated with open reduction internal fixation (ORIF), though it has been suggested that primary arthrodesis may be more appropriate[32]. To ready the joint, the cartilage is removed and the screws are compressed[33]. This is frequently regarded as an alternative because it has been demonstrated that purely ligamentous injuries to the Lisfranc joint do not always heal after ORIF, resulting in an increase in joint degeneration[34]. Furthermore, up to 94% of patients acquire arthritis later in life, necessitating secondary arthrodesis of the TMT joints[35].

Bridge plates or trans-articular screws are presently being discussed as surgical options. The preponderance of Lisfranc fracture and dislocation operations now involve open reduction and trans-articular screw fixation. Bridge plates were used more frequently in our research. This is because we use a joint-spanning technique to stabilise fracture dislocations with minimum articular damage. Bridge plating for Lisfranc injuries has demonstrated at least comparable functional results to trans-articular fixation[36].

In a cadaver study of 20 specimens comparing dorsal plates and trans-articular screws, it was discovered that screw placement caused 2% to 6% more damage to the articular surface, but there was no difference in displacement distances after loading, leading to the conclusion that both methods demonstrate similar stability[37]. Screw fixation, according to Kuo et al, provides better temporary stability and has the potential for early recovery[38].

Radiographic Imaging

Lisfranc problems are difficult to diagnose. Around 20% of accidents go unreported[39]. This is most likely due to the difficulties associated with conventional radiographic imaging. Anterior-posterior (AP), lateral, and oblique views of the foot, obtained parallel to the midfoot joints, should be included in the initial imaging of a suspected Lisfranc injury. A weight-bearing film with both feet on a single X-ray cassette should be acquired to assist in the diagnosis of more subtle injuries. This final image is a stress view of the foot.

Although incongruity of the third and fourth joints is better visualised at a 30 degree oblique angle, AP radiographs are used to show mal-alignment of the first and second TMT joints[40]. The dorsal and plantar aspects of the MTs should correlate to the cuneiform and cuboid in the lateral view. The first MT base should be intersected by a tangential line traced through the medial aspect of the medial cuneiform and navicular[41]. Lateral weight-bearing radiography can be used to detect longitudinal arch flattening as well as dorsal displacement at the second TMT joint. These are frequently sufficient to detect more obvious Lisfranc fracture dislocations, but they miss a substantial number of less obvious injuries[42]. Non-weight-bearing radiographs were found to be normal in up to 50% of cases, missing the diastasis between the first and second metatarsals. As a result, it has been proposed that weight-bearing radiographs be used to detect mild Lisfranc injuries. Because a weight-bearing radiograph can be excruciatingly painful, some argue that it should be done under local anaesthetic with an ankle block[43]. The fleck sign, a small chip of bone found between the first and second metatarsal bases, suggests Lisfranc ligament avulsion[44, 45]. This finding should be explored using AP and oblique radiographs.

The most challenging Lisfranc injuries to diagnose and treat are the subtle ones. Inter-cuneiform extension is common in these injuries, with the damage exiting through the medial naviculo-cuneiform facet. Most surgeons think that pure ligamentous injuries heal much more slowly than bony counterparts [53]. A novel strategy to these difficult cases may result in a faster return to sports.According to one study, MR imaging has a 94% sensitivity and predictive value for Lisfranc joint instability, making it highly useful for diagnosing subtle Lisfranc injuries[54].

Summary

Lisfranc injuries appear to be extremely variable and complex, with associated fractures and dislocations. We found several types of Lisfranc injuries and classified them accordingly. Many Lisfranc fractures or dislocations occurred as a result of other midfoot, Chopart, and ankle joint issues. Lisfranc injuries can be complicated, and we should be mindful of the different types of midfoot. According to our data, correct decision making is needed prior to starting on operative fixation, and further analysis of the patterns of injuries is required to choose the method of surgical management based on our Lisfranc injury typology.

Conflict of Interest : The authors declare no conflicts of interest associated with this manuscript.

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