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Lisfranc Injuries and the Management of Primarily Ligamentous Injuries: Literature Review

by Tad Borland, DPM [1]

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Abstract: Lisfranc fractures and dislocations are uncommon injuries accounting for only 0.2% of all fractures. The joint complex acquires stability through its osseous arrangement and numerous ligamentous attachments. The strong interosseous Lisfranc ligament that attaches between the medial cuneiform and base of the 2nd metatarsal is the strongest stabilizer of the joint. Disruption of this ligament leads to instability and deformity. Purely ligamentous Lisfranc injuries pose a big challenge as conventional open reduction and internal fixation yield less than ideal results. Though primary arthrodesis of these injuries may result in better long term results, there is still no consensus on the recommended treatment for these types of injuries.

Key words: Lisfranc, tarsometatarsal joint, ORIF, arthrodesis

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Lisfranc injuries refer to a variety of injuries involving the tarsometatarsal joint complex. They can include closed or open fractures, dislocations, and sprains[1]. Fracture-dislocations of the Lisfranc joint are uncommon, accounting for only 0.2% of all fractures and it is estimated that between 20-30% are missed at time of initial presentation[1,2].

Even with accurate diagnosis and early treatment, Lisfranc injuries can result in chronic disability[3]. Open reduction and internal fixation has been the treatment of choice for Lisfranc fracture dislocation, however, it has been observed that ORIF of purely ligamentous Lisfranc dislocations without fracture are associated with a poorer outcome eventually requiring conversion to an arthrodesis[3,4]. Given the poor response to ORIF, studies have looked at whether primary arthrodesis of purely ligamentous Lisfranc injuries is a better alternative with fewer complications and higher patient satisfaction.

Address correspondence to: tborland@kent.edu.
[1]Podiatry Resident, Mercy Health Foot and Ankle Residency, Cleveland Ohio

Anatomy

The Lisfranc joint complex is comprised of the five metatarsals and their articulations with the three cuneiforms and the cuboid. The bony anatomy is often described as three longitudinal columns. The medial column is the articulation of the medial cuneiform and the 1st metatarsal. The middle column consists of the middle and lateral cuneiforms and the 2nd and 3rd metatarsals. Lastly, the lateral column consists of the cuboid and the 4th and 5th metatarsals.

Motion at the Lisfranc joint complex varies between the three columns. Normally, there is 5-10 degrees of sagittal plane motion at the 1st TMT joint, very little range of motion at the 2nd and 3rd TMT joints, and 10-20 degrees at the 4th and 5th TMT joints. The greater amount of motion in the lateral column is important for accommodating for uneven ground[5]. The first through third TMT joints have been referred to as

"non-essential" joints given their relatively immobility[6].

The stability across the Lisfranc joint complex can be explained by the osseous arrangement and the ligamentous attachments. The three columns described before are incorporated in the transvers arch of the foot. This arch is comparable to a Roman arch which is an inherently stable structure[7]. The 2nd metatarsal sits at the apex of the arch and is referred to as the "keystone". Also, the base of the 2nd metatarsal sits recessed between the medial and lateral cuneiforms contributing to additional stability.

A complex array of dorsal, interosseous, and plantar tarsometatarsal ligaments supplement the osseous stability to the Lisfranc joint complex. There are seven dorsal and five plantar tarsometatarsal ligaments that enhance the stability across the joints. The strong interosseous ligament known as the Lisfranc ligament is a vital structure to the complex and has attachments to the medial cuneiform and 2nd metatarsal base. Regarding the strengths of the ligaments, claims of dorsal ligaments being weaker than their plantar counterparts have been based on anatomical observations regarding the relative size of the ligaments rather than on quantitative measurements[8].

A 2001 study done by Solan et al[9] looked to test the hypothesis that the Lisfranc and plantar ligament complex was stronger and stiffer than the dorsal ligament and that the Lisfranc ligament was stronger and stiffer than the plantar ligament. Twenty pairs of cadaveric feet were obtained and the 2nd and 3rd metatarsal along with the first cuneiform were dissected. Using a servo-hydraulic testing apparatus which applied a load along the longitudinal axis of the ligament fibers, the tensile strength for each ligament was tested. The ligaments' strengths were defined as the peak load on the force-versus-deformation plot. They found that the mean strength of the dorsal ligaments was 170 +/- 93 N, the Lisfranc ligament at 449 +/- 58 N and the plantar ligaments were 305 +/- 38 N. Their findings coincide with prior statements that the dorsal TMT ligaments are indeed weaker than the plantar TMT ligaments and that the interosseous Lisfranc ligament was the strongest of the three.

Mechanisms of Injury

Lisfranc injuries can result from either a direct or indirect mechanism. The injury may be purely ligamentous, bony or more commonly a combination of both[8]. Direct injuries commonly involve a force applied to the dorsum of the foot. The resulting pattern of dislocation is dependent upon the point of application of the force[10]. The intensity and angle of force in this type of injury will determine if the injury is osseous and/or ligamentous[5].

Indirect trauma, the more common mechanism of injury, involves a rotational force applied to the forefoot with a fixed hindfoot or axial loading on a plantar flexed fixed foot[2]. As previously discussed, the dorsal tarsometatarsal ligaments are weaker than the plantar ligaments and therefore provide the lowest resistance to dislocation. This would explain the common pattern of dorsal metatarsal dislocation seen in these injuries. With higher energy patterns, the strong plantar ligaments are also torn, making the tarsometatarsal complex very unstable[5].

Classifications

Given the complexity of Lisfranc injuries, a few classifications schemes have been devised to describe these injuries. In 1909, Quenu and Kuss[11] classified Lisfranc injuries into three subtypes based on the thre-column concept: homolateral, isolated and divergent. This classification scheme was further modified by Hardcastle et al[12] and again by Myerson et al[10] in 1986. Lisfranc classification schemes may be helpful in providing standard terminology, but they have not been found to correlate with outcome[7].

A more recent classification system by Nunley and Vertullo[13] is useful in describing subtle Lisfranc injuries. The classification in based on the findings on clinical exam, comparative weight-bearing radiographs, and bone scans. Stage I injuries involve restrictive midfoot pain and patient is incapable of participating in sporting activities. Weight-bearing radiographs show less than 2 mm of diastasis between the 1st and 2nd rays with no collapse of the medial arch. Stage II injuries have similar clinical findings, but radiographs show a diastasis of 2-5 mm with no collapse of the arch on lateral view. Stage III has

greater than 5 mm of diastasis and loss of midfoot arch height as measured by reduced distance between the 5th metatarsal and medial cuneiform on lateral radiograph. The authors state that their classification system offers a methodical investigational plan and evidence-based management.

Treatment Options

Various treatment options exist for the management of Lisfranc injuries and include closed reduction and immobilization, closed reduction with percutaneous pinning, open reduction and internal fixation (ORIF), and primary arthrodesis. A consensus exists that closed reduction followed by casting is unsuccessful in the majority of Lisfranc fracture-dislocations and that initial reduction is often lost when soft tissue swelling subsides[14,6]. In literature, the two main options for treatment of Lisfranc fracture-dislocations is either ORIF or primary arthrodesis.

Mulier et al retrospectively compared ORIF to primary arthrodesis for treatment of severe Lisfranc dislocations[15]. They found no significant difference in outcome scoring between the ORIF and partial arthrodesis group. They did note, however, that patients who underwent arthrodesis of TMTJs 1-5 yielded poorer results in comparison to those who did not have the lateral column fused.

A level I study by Henning et al also looked to compare the outcomes of patients treated with primary arthrodesis and versus those treated with ORIF[6]. There were no statistical differences between primary arthrodesis and ORIF in terms of physical functioning and satisfaction rates at an average post-op follow up of 53 months. They did find, however, that the ORIF group had a greater rate of planned and unplanned secondary surgeries, 78.6% versus 16.7%.

Treatment of Primarily Ligamentous Injuries

There is much controversy over the optimal treatment of patient with Lisfranc injuries, particularly in those with purely ligamentous injuries[16]. Open reduction and internal fixation is currently the recommended and accepted procedure for Lisfranc fracture-dislocation, however, it has been observed that pure dislocations without fracture may be associated with a poorer outcome despite undergoing ORIF[6,15,4]. It's been stated that despite appropriate initial treatment, up to 94% of these patients develop posttraumatic arthritis and require arthrodesis of the tarsometatarsal joints as a salvage procedure[17].

Kuo et al[4] performed a retrospective study to analyze the results of ORIF of injuries to the Lisfranc complex and was particularly interested in those consisting of purely ligamentous disruption without fracture. A total of 42 patients were included in the study, 29 had combined ligamentous and osseous injuries and 13 had ligamentous only injuries. All patients underwent ORIF with screw fixation with or without temporary fixation of 4th and 5th metatarsals with K-wire. Compared to the combined midfoot arthrosis rate of 25%, the purely ligamentous group demonstrated a 40% arthrosis rate.

Ly and Coetzee's level I study[3] looked to compare short and medium-term functional outcomes of primarily ligamentous Lisfranc joint injuries repaired by ORIF vs primary arthrodesis. 41 patients with primarily ligamentous Lisfranc injuries were enrolled in the study and were randomized into either an arthrodesis group (n=21) or ORIF group (n=20). At 42 months post-op, the AOFAS midfoot scores were greater in the arthrodesis group than in the ORIF group, 86.9 compared to 57.2 respectively. They also found that the arthrodesis group was able to return to a higher percentage of preinjury level of functional participation, 92% versus 65% at 24 months post op. The ORIF group required more prominent/painful hardware removal and had greater incidence of loss of correction, increased deformity and arthrosis, 5 of which required conversion to arthrodesis. The authors postulated that healing of the ligaments and capsules provided insufficient strength to maintain the initial reduction and recommended that patients with a primarily ligamentous Lisfranc injury should be treated with primary arthrodesis. They later retracted this statement in a later article[18] and stated that primary arthrodesis should not be used too liberally for all Lisfranc injuries. "If there is not multidirectional instability with manipulation, a fusion

should not be done". He gives the example of a hyper-plantarflexion injury where partial or complete disruption of the dorsal structures occurs and the plantar ligaments are spared. In this less severe injury, patients will do reasonably well with conventional ORIF.

Discussion

There is no general consensus in the literature as to the ideal treatment option for Lisfranc injuries and it is safe to assume that there may never be a single correct way in treating all of these injuries. As with other traumatic injuries, not all Lisfranc injuries are created equal and each one requires thorough evaluation and operative planning. As a whole, Lisfranc injuries respond almost equally well to ORIF and primary arthrodesis. One major difference is the higher incidence of secondary procedures in the ORIF group, whether it be planned or unplanned hardware removal or conversion to arthrodesis for symptomatic arthrosis.

Despite anatomic ORIF, patients with primarily ligamentous injuries tend to have a poorer outcome with greater incidence of arthrosis, decreased satisfaction, and greater incidence of secondary procedure. In this group of patients, primary arthrodesis should be taken into serious consideration as it has shown to give patients better functional outcome in comparison to ORIF.

In current literature, arthrodesis has been reserved as a salvage procedure after failed ORIF, for a delayed or missed diagnosis, and for severely comminuted intra-articular fractures[3]. Aside from fusing the lateral column, tarsometatarsal joint fusion should not be viewed as a drastic procedure. As mentioned before, there is minimal ROM of the 1st through 3rd TMT joints and they can be viewed as being "nonessential" joints. Mulier et al's study[15] showed that patients tolerated fusion of these joints well in comparison to those who underwent arthrodesis of the lateral column.

There is a sparsity in research comparing ORIF and primary arthrodesis in the treatment of Lisfranc injuries. There are even fewer studies that look at the long-term surgical outcomes of patients who sustained purely ligamentous injuries. Though this type of injury is less common than other fractures and dislocations, more research is needed as this injury can result in prolonged disability.

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