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Technical Note

Flexible fixation for ligamentous lisfranc injuries

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ABSTRACT

Lisfranc injuries require anatomic reduction and stabilization of the tarsometatarsal joints. We describe a novel technique that provides flexible fixation that is simple, cost-effective and that may offer certain advantages over more traditional techniques.

Introduction

The tarsometatarsal (TMT) and intercuneiform (IC) joints, broadly known as the Lisfranc complex, are the key anatomic components of the midfoot. The stability of this complex is contingent upon osseous and ligamentous structures with disruption leading to varying levels of instability. The presentation of Lisfranc injuries can be highly variable, representing a wide spectrum of severity which makes these injuries challenging to treat – particularly when attempting to compare the effectiveness of different methods for surgical stabilization. While various treatment options exist ranging from non-operative treatment to closed reduction percutaneous pinning, percutaneous reduction/fixation, formal open reduction internal fixation (ORIF) and arthrodesis, the heterogeneous nature of these injuries often make several options reasonable in properly selected patients.

Most existing literature examining the anatomy of the Lisfranc complex focuses on the integrity of the plantar interosseous ligament which traverses the articulation between the second metatarsal base and the medial cuneiform. [1–3] As the largest and most critical structure of the TMT joint complex, the Lisfranc ligament is essential for stabilizing the 2nd metatarsal base between the medial and middle cuneiforms axially, and in the keystone of the midfoot arch in the coronal plane. Injury to this structure results in loss of osseous stability of the transverse arch, diastasis between the medial and middle columns of the foot, and ultimately midfoot collapse, pain and arthrosis. [4] Additionally, most Lisfranc injuries consist of significant concomitant osseous and other ligamentous injury which require stabilization. While rigid internal fixation is warranted for gross instability or joint dislocation, alternative methods to stabilize more subtle instability may be warranted.

Multiple studies have examined various fixation techniques for the treatment of Lisfranc injuries. [5–7] While effective, limitations of commonly used metal implants include iatrogenic articular cartilage damage, implant breakage and need for implant removal [5]. Alternatively, the use of suture buttons has been described, but implant cost and technical considerations make their use uncommon. [8] A consideration regarding fixation of Lisfranc injuries is that, once the 2nd metatarsal base is stabilized, relative stability is imparted to the other TMT joints. However, non-physiologic motion is often still present although additional rigid internal fixation with metal implants in the form of either ORIF or arthrodesis may be unnecessary. For these reasons and for this clinical indication a fixation method that (1) maintains stable anatomic reduction in a joint-sparing fashion, (2) allows some degree of mobility and (3) eliminates the need for implant removal, is pertinent and promising. We describe a novel low-cost and simple technique for flexible fixation of ligamentous Lisfranc injuries.

Surgical technique

The patient is placed in the supine position with a bump placed under the ipsilateral hip to encourage internal rotation of the lower extremity and ease access to the dorsal foot. Depending on the injury pattern, one or two dorsal, longitudinal incisions are made.

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Fig. 1. Abduction stress test under fluoroscopy demonstrating TMT joint instability.

The first and second TMT joints are approached by a dorsal incision centered between the medial and middle cuneiforms with care to avoid the neurovascular bundle. If fixation of the lateral three TMT joints is required, a second incision can be made dorsolaterally. The instability pattern is then assessed both clinically and fluoroscopically. It is the senior author's preference to debride the articulation between the second metatarsal and the medial cuneiform to impart limited arthrodesis in cases of open reduction internal fixation (ORIF) and to formally debride and prepare the 2nd TMT joint when formal arthrodesis is to be performed. Utilizing a pointed reduction clamp, anatomic reduction of the Lisfranc articulation and the second TMT is achieved and rigidly fixed. If intercuneiform instability is demonstrated on stress examination, a screw is then placed across the cuneiforms.

At this point, stability of the other TMT joints is assessed by performing an abduction stress test under fluoroscopy. (Fig. 1) If instability is demonstrated by medial joint gapping, flexible fixation is performed for each TMT joint. The TMT joint is anatomically reduced under direct visualization and stabilized with k-wires. Two 2.7 or 3.5 screws with washers are placed from dorsal to plantar in the base of the metatarsal and in the respective tarsal bone to serve as posts. A non-absorbable #2 FiberWire (Arthrex, Naples, Florida) is looped 3–5 times in a Figure-of-8 fashion around the screws beneath the washers, tensioned, knotted and secured by tightening the screws. (Fig. 2) Repeat fluoroscopic stress views are performed to ensure stability of the TMT joint. (Fig. 3) Fluoroscopic images are obtained to demonstrate anatomic alignment of the Lisfranc joint complex. Wounds are closed in a layered fashion and a sterile dressing applied. Post-operative protocol includes 6 weeks of non-weight bearing, followed by 4 weeks of protected weight bearing in a removal fracture boot with initiation of range of motion exercises. Full weight-bearing with transition into a regular shoe is allowed 10 weeks post-surgery.

Fig. 4A–D.

Fig. 5A–E.

Fig. 6A–C.

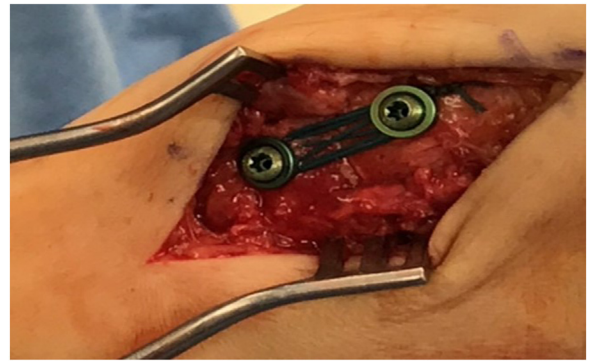

Fig. 2. Non-absorbable suture looped 3–5 times around the screws beneath the washers, tensioned, knotted and secured by tightening the screws.

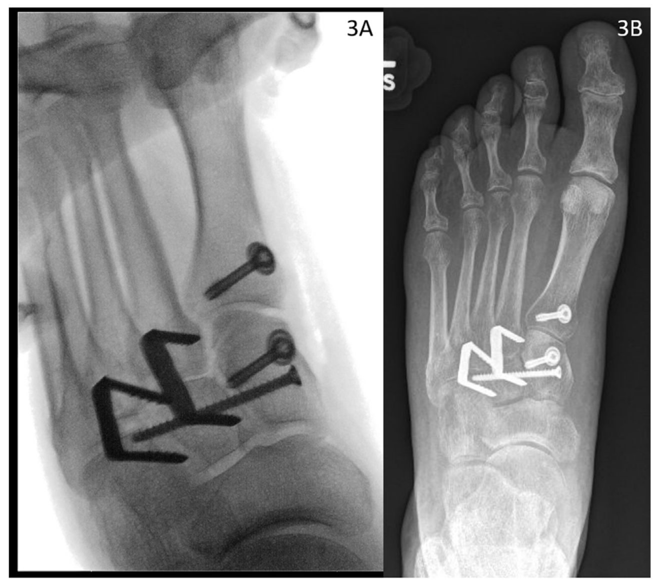

Fig. 3. A) Repeated fluoroscopic stress view to ensure stability of the TMT joint. B) Postoperative x ray showing anatomic alignment of the Lisfranc joint complex.

Discussion

Despite advances in surgical techniques for Lisfranc injuries, treatment remains challenging due to the relatively high incidence of post-traumatic arthrosis and chronic pain, even in operatively-treated patients. [9] Since the quality of anatomic reduction has been shown to directly correlate with outcomes, the most important goal of treatment is to achieve anatomic joint alignment [10–12]. Although several surgical options are available, the surgeon must choose the best treatment option to restore alignment and stability of the foot according to the severity of the injury and functional demands of the patient.

Open reduction and internal fixation has traditionally been the treatment of choice for most Lisfranc injuries. However, in the last decade, several studies have reported equivalent or superior results in patients treated with primary arthrodesis. [5,13,14] Despite this literature, ORIF remains a valid treatment option for many patients, especially for low-energy sports injuries and subtle instabilities. [3,7,9,15] This is particularly germane given difficulties that can be encountered when performing TMT arthrodesis such as ray shortening, malreduction and associated metatarsalgia, nonunion and need for hardware removal [5]. The TMT joints play a complex role in force transfer, and their individual rigidity or

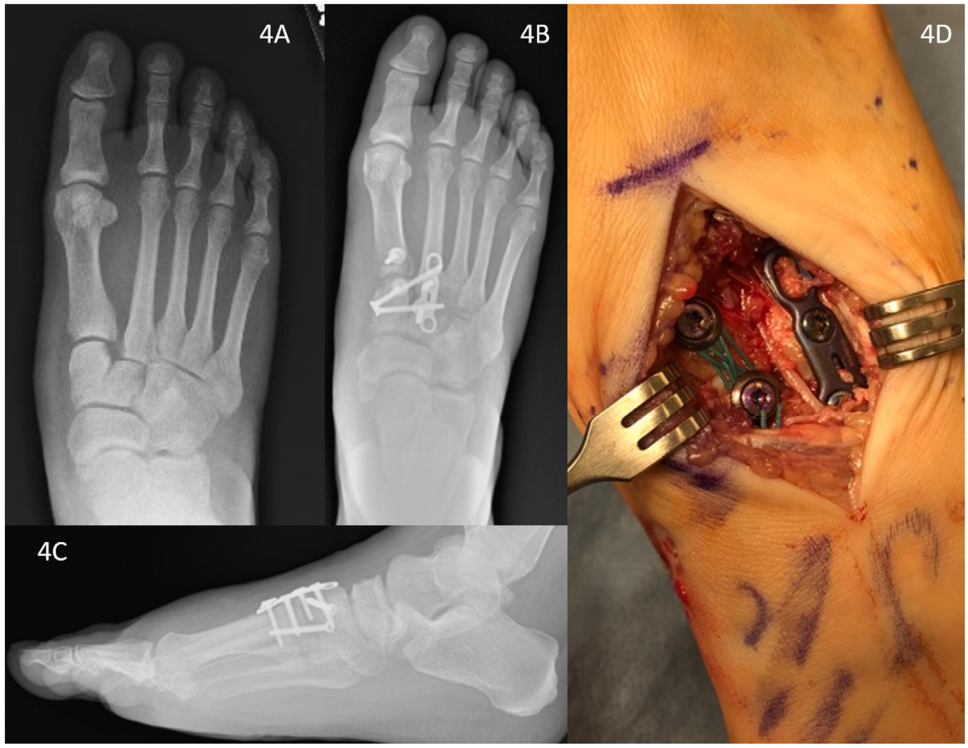

Fig. 4. A) Preoperative x-ray showing an unstable Lisfranc injury. After fixation of 2nd TMT joint, 1st TMT instability was demonstrated and flexible fixation was performed. B and C) Postoperative AP and lateral x-rays. D) Intraoperative picture of the TMT fixation.

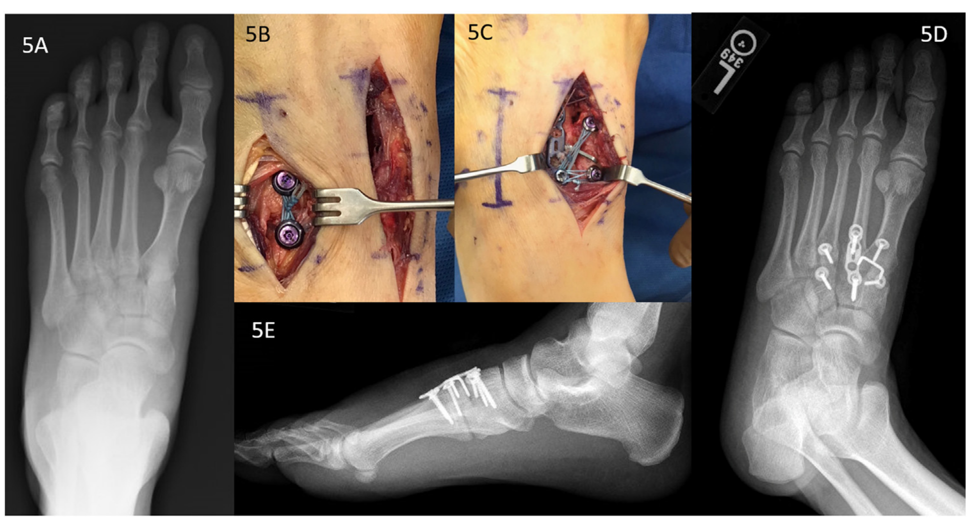

Fig. 5. Another case of unstable Lisfranc injury. A) Preoperative x-ray. B and C) Intraoperative picture of fixation of 1st and 3rd TMT joint. D and E) Postoperative x-rays demonstrating anatomic reduction of TMT joints.

flexibility is thought to be intricately linked to their ability to distribute forces effectively during load bearing and gait [16]. Additionally, the loss of mobility, particularly of the first TMT joint, is a relevant concern. Mulier et al. in their investigation comparing ORIF with arthrodesis demonstrated more complaints of stiffness and higher complication rates in the group treated with primary arthrodesis [17]. Like any joint that loses mobility, a theoretic risk of compensatory hypermobility and arthrosis of adjacent joints exists, and a 12% rate of adjacent joint arthritis after primary fusion was indeed reported by Reinhardt et al in a cohort of 25 patients with mid-term follow-up of 42 months [18].

In attempts to obviate complications associated with primary arthrodesis and ORIF, several authors have explored the idea of flexible internal fixation of the Lisfranc joint. In 2008, Cottom et al reported a series of 3 patients with Lisfranc injuries treated with suture-button fixation of the Lisfranc joint using an adaptation of the TightRope system (Arthrex, Naples, Florida). [19] In 2015, Charlton et al performed similar suture-button fixation in 7 high-level athletes with use of the Mini TightRope (Arthrex, Naples, Florida) [20]. At final followup, all patients returned to full activity without restrictions by 6 months post-operatively, and by 1 year reported a mean AOFAS hindfoot score of 97. Comparison of

Fig. 6. 56-year-old male at 1 year follow up after flexible fixation of Lisfranc injury. A, B, and C) Weightbearing x-rays at 1 year follow up demonstrating anatomic alignment maintained with flexible fixation. He reported no pain at clinical visit.

transarticular screw fixation with suture buttons of the Lisfranc joint in cadaveric models has shown comparable stability under load conditions, suggesting that flexible fixation may be a viable alternative to transarticular screws for open reduction internal fixation. [21,22] While promising, the current literature is limited by few reports which have only described a single implant and issues such as implant cost, technical considerations and unknown utility in stabilizing other midfoot joints exist.

In the current investigation we present a novel treatment option for ligamentous Lisfranc injuries that may demonstrate several advantages to traditionally utilized implants. Additionally, we have expanded the indication for flexible fixation from that of the Lisfranc ligament itself to include other joints within the Lisfranc joint complex, including the 1st, 2nd and 3rd TMTs as well as the intermetatarsal and intercuneiform joints. Use of flexible fixation allows for maintenance of anatomic reduction during healing, but seems to allow for more physiologic joint mobility upon resumption of activity without the need for implant removal. It offers the same advantage of bridge plating technique by eliminating iatrogenic cartilage damage caused when transarticular screws are used. Tightening of the suture around the screws increases tension in the construct thus allowing for increased resistance to dorso-plantar motion. Furthermore, this technique is technically straightforward, cost-effective and may result in decreased need for hardware removal. As of the date of submission, 2 of 12 patients with 14-month follow-up have required removal of hardware. One patient underwent removal secondary to soft-tissue irritation from shoe wear. The other patient lost reduction at the 2nd TMT joint (treated with traditional internal fixation) and was converted to arthrodesis. However, the rate of removal may have been similar or increased with traditional constructs and we cannot conclude this was a result of the utilization of flexible fixation as described above.

There are some limitations to this technique. While minor avulsions and minimally displaced fractures of the metatarsal bases or cuneiforms does not preclude use of this technique, severe fracture-dislocations should be addressed by other means. Additionally, while this technique appears sufficiently rigid as internal fixation for subtle instability, it should not be utilized when TMT arthrodesis is performed. While screw prominence and tendon irritation may be of concern, typically flexible fixation is placed in similarly anatomic areas that normal plate and screw constructs would be utilized. However, extensor tendon irritation is a potential complication of any surgical treatment. Finally, traditional rigid internal fixation may be more appropriate in patients likely to be noncompliant with weight-bearing restrictions or in the setting of neuropathy given the likely higher failure rate of flexible fixation in this population.

Additionally, cost should be considered. While a thorough cost analysis is beyond the scope of this paper, one should consider not only implant list prices but more importantly total cost of care if secondary surgeries such as implant removal is necessitated. While the cost of flexible fixation is variable depending on size (length and diameter) and type (cannulated versus solid) of screws utilized as well as suture type, variability of construct costs is similarly high when metal plate and screw constructs are utilized.

In conclusion, we describe a novel technique that utilizes flexible fixation for the treatment of acute ligamentous Lisfranc injuries. Future directions being undertaken include (1) a biomechanical study assessing the rigidity of flexible suture fixation as compared to other implants used for the treatment of Lisfranc injuries, (2) assessment of suture caliber and different suture configurations on construct stability and (3) report of a larger case series of patients treated utilizing this technique as compared to other fixation techniques.

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