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Surgical Treatment of Lisfranc Injury With Plantar Plate Approach

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ABSTRACT

Midfoot injuries are the second most common athletic foot injury documented in the published data. High-energy Lisfranc dislocations are commonly seen secondary to traumatic etiologies and disrupt the strong midfoot ligaments supporting the arch. These injuries require immediate surgical intervention to prevent serious complications such as compartment syndrome and amputation. The present case series reports a new Lapidus plate system used in 3 patients who underwent arthrodesis procedures for Lisfranc joint dislocation. Three patients in their fourth to fifth decade of life presented with a traumatic injury at the Lisfranc joint and subsequently underwent open reduction and internal fixation using the plantar Lapidus Plate System (LPS; Arthrex, Naples, FL). The LPS was placed in a predetermined safe zone, with measures taken to avoid the insertional points of the tibialis anterior and peroneus longus tendons. Radiographs were obtained for ≤6 months postoperatively and revealed consolidation across the fusion site, intact hardware, and satisfactory alignment. On examination, the corrections were well maintained and free of signs of infection. Clinical evaluation showed no indication of motion within the tarsometatarsal joint and no tenderness to palpation surrounding the fusion sites. All 3 patients successfully returned to their activities of daily living without discomfort or pain. Modern surgical treatment of Lisfranc injuries most commonly includes open reduction and internal fixation, accompanied by arthrodesis. The present case series has demonstrated that the LPS provides relief, stability, and compression of the joint in our small cohort of patients who experienced a traumatic injury to the Lisfranc joint.

Midfoot injuries are the second most common athletic foot injury documented in the published data (1). Of these, the high-energy Lisfranc dislocation is commonly seen in males secondary to a traumatic incident, such as a motor vehicle accident or fall (1,2). Lisfranc injuries, which disrupt the strong midfoot ligaments supporting the arch, require immediate surgical intervention to prevent complications such as compartment syndrome and amputation (3). On clinical examination, patients can present with edema, point tenderness, and decreased function (2,4). The dorsal drawer test of the medial column will elicit a "clunk" compared with the contralateral side, and the passive midfoot pronation abduction test will yield positive results (1). On radiographic evaluation, Lisfranc injuries commonly show an increased asymmetric joint space at the naviculocuneiform joint and first and second metatarsal bases. The notch sign, in which a small notch appears in the lateral aspect of the medial cuneiform, might also be seen (1).

Conservative treatment includes midfoot stabilization and movement restriction. For Lisfranc injuries without displacement on weightbearing radiographs, the use of cast immobilization for 6 to 12 weeks is common (5). Modern surgical treatments include closed reduction and immobilization, closed reduction and percutaneous pinning, and open reduction with percutaneous pinning or screw fixation (6).

Open reduction and internal fixation (ORIF) has become the most commonly performed surgical treatment of a Lisfranc joint injury with or without arthrodesis. Studies have shown that primary arthrodesis is a better treatment method for patients with Lisfranc injuries than ORIF (6). Of the various ORIF techniques, screw fixation offers an earlier return to weightbearing activities and a lower rate of displacement compared with the Kirschner wire technique (7). Alternatively, surgeons have used dorsal plating, with screw placement over tarsometatarsal joints, which is ideal for posttraumatic

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arthrodesis (7). Dorsal plating provides stability without joint compromise (8). In recent years, the use of plates has become more prominent. Medial locking plates and H-plates have been used; however, H-plates have proved to be unsuccessful in providing the necessary stability. The plantar plate construct with compression screw might be superior to dorsomedial screw for Lapidus fusion and is more in line with the AO principles biomechanically, because the plate is placed on the side of the tension (9–11). Plantar plates have demonstrated a better bone contour of the plate, decreased soft tissue irritation, and better soft tissue coverage. Plantar plating compared with dorsomedial plating showed significantly less range of motion (ROM) in the fused joint space and increased stiffness (11). Of concern with plantar plating is the tibialis anterior (TA) tendon and peroneus longus (PL) tendon at their insertion sites on the medial cuneiform and first metatarsal (10).

Scranton et al (12) demonstrated a newer model of plantar plating, using their plantar Lapidus Plate System (LPS; Arthrex, Naples, FL), which provided compression and increased stability, while protecting the PL and TA tendons. Plaass et al (10) determined a "safe zone" that could prevent irritation or tendonitis by placing the plantar lapidus plate between and away from the insertions of the TA and PL tendons. Our study further analyzed the results of the plantar LPS in 3 patients who underwent arthrodesis for Lisfranc injury secondary to trauma.

Case Report

Patient 1

A 41-year-old male patient presented to our clinic in March 2016 with a chief complaint of pain in the dorsal midfoot from an injury 1 day previously. A right foot Lisfranc ligament disruption secondary to trauma was diagnosed. The lower extremity physical examination showed exquisite tenderness to palpation around the dorsal second metatarsal base and marked pain with ROM of the tarsometatarsal articulations. The radiographs (Figs. 1–3) showed homolateral dislocation at the tarsometatarsal joints and comminuted fractures of the bases and cuneiforms. The patient provided consent for right foot Lisfranc fracture treatment with ORIF.

Fig. 2. Non-weightbearing medial oblique view of patient 1 at the initial visit.

Fig. 1. Non-weightbearing anteroposterior view of patient 1 at the initial visit.

Patient 2

A 58-year-old female presented in September 2016 with acute right foot pain after a traumatic fall from a ladder. She had significant history

Fig. 3. Non-weightbearing lateral view of patient 1 at the initial visit.

Fig. 4. Weightbearing anteroposterior view of patient 2 at the initial visit.

of polyarthralgia and chronic synovitis. On physical examination, she experienced instability of the midfoot and Lisfranc complex, with tenderness to palpation surrounding the midfoot and painful ROM of the first and second tarsometatarsal joints. The radiographs (Figs. 4–6) revealed a disrupted Lisfranc complex with displacement at the first metatarsocuneiform, diastasis of the first and second metatarsal base interval, misalignment of the second metatarsal, and a base fracture

Fig. 5. Weightbearing medial oblique view of patient 2 at the initial visit.

Fig. 6. Weightbearing lateral view of patient 2 at the initial visit.

of the second metatarsal. She elected to undergo surgical correction with midfoot arthrodesis.

Patient 3

A 43-year-old male patient was seen in our clinic at the end of March 2016 with acute right foot and ankle pain that had started after the patient had fallen off a skateboard 3 days previously. He presented with tenderness to palpation at the dorsal second metatarsal base and pain with ROM of the tarsometatarsal articulations. Radiographs (Figs. 7–9) from the day of injury showed displacement of the third metatarsal fracture and misalignment of the second tarsometatarsal joint, with diastases of the second metatarsal and first metatarsal base interval. Computed tomography showed positive second tarsometatarsal joint avulsion at the Lisfranc ligament attachment and a small avulsion fracture at the first tarsometatarsal joint. Given the instability of the patient's fracture, he underwent open

Fig. 7. Weightbearing anteroposterior view of patient 3 at the initial visit.

Fig. 8. Weightbearing medial oblique view of patient 3 at the initial visit.

reduction of the right foot Lisfranc fracture, with primary fusion of the tarsometatarsal joints the following week.

Surgical Treatment

Three patients in the fourth to fifth decade of life presented to our clinic after a traumatic Lisfranc dislocation injury, as described. As the standard of care, our surgeons considered and discussed nonoperative treatment, ORIF with screw fixation, and the possibility of tightrope fixation. Nonoperative treatment would have entailed the use of a short leg walking cast, with a slow transition to a controlled ankle motion boot. However, anatomic alignment would have been compromised. Studies have shown that anatomic alignment yields greater rates of good to excellent results than nonanatomic alignment (2). Our patient cohort presented with unstable and displaced fracture dislocation injuries. Thus, prompt anatomic fixation was deemed critical for optimal results and the prevention of significant long-term morbidity (13). Given that the published data have shown that arthrodesis for a Lisfranc injury results in better outcomes than ORIF (6), we discussed the options with the patients, who consented to undergo primary arthrodesis using the plantar LPS. The risks, benefits, and possible complications were discussed in detail. The Palo Alto Medical Foundation surgical centers were used for all surgeries.

Fig. 9. Weightbearing lateral view of patient 3 at the initial visit.

In the operating room, the patients were given antibiotic prophylaxis, general anesthesia, and a local nerve block using bupivacaine (Marcaine). A medial incision over the first tarsometatarsal joint was carried to the level of the subcutaneous tissue. Blunt soft tissue dissection was performed with careful treatment of the TA and PL tendons. After exposure and distraction of the articular surface of the first tarsometatarsal joint, subchondral drilling and fish scaling were performed to prepare the joint for arthrodesis. An ArthroCell allograft (Arthrex) was applied to the site. A Lapidus plantar plate (Arthrex) was affixed using a 4.0-mm headless compression screw. Fluoroscopy was used intermittently throughout placement to ensure adequate intermetatarsal angles.

Subsequently, a linear incision was carried to the level of subcutaneous tissue across the dorsal aspect of the second and third metatarsal bases. With careful distraction of the dorsalis pedis neurovascular bundle, further dissection allowed for capsulotomy of the tarsometatarsal joints. The joint was prepared for arthrodesis with fish scaling of the second and third tarsometatarsal joints. An ArthroCell allograft (Arthrex) was applied to the fusion sites, followed by a T-plate (Arthrex) and BB-taks (Arthrex) over both joints. To further fixate and stabilize the third tarsometatarsal joint, a T-plate was applied. The free-floating second metatarsal fragment was fixated with a 0.062-in. Kirschner wire. The surgical site was irrigated with copious amounts of normal saline solution, and the incision site was closed in a normal layered fashion. Intraoperative fluoroscopy was used to ensure adequate reduction of the second metatarsal. The patient's leg was dressed and then placed in a well-padded posterior sugar-tong splint.

Results

All 3 patients tolerated the procedure and anesthesia well. Surgery was performed on an outpatient basis, and the patients were discharged with postoperative instructions to be non-weightbearing in a postoperative shoe until the first follow-up appointment at 10 days. The patients were advised to take hydrocodone-acetaminophen 10/325 mg orally, 1 to 2 tablets, every 4 to 6 hours, as needed for pain. The 10-day follow-up radiographs revealed intact fixation and satisfactory alignment for all 3 patients.

On examination, the corrections were found to well maintained and free of signs of infection. The sutures were removed at the 3-week follow-up visit, and the patients were placed in a short-leg non-weightbearing fiberglass cast. At the 6-week follow-up examination, the patients were recommended to return to normal shoe great with over-the-counter orthoses. Radiographic follow-up examinations were performed for all patients for a minimum of 4 months, with visits at 10 days, 1 month, and 4 months postoperatively. At the 4-month follow-up appointment, all 3 patients had primary fusion, with radiographs showing intact fixation and satisfactory alignment. Physical examination showed no pain with ROM, joint ROM approaching normal, and an ability to tolerate normal shoes and activities. All 3 patients had 5 of 5 muscle strength for the TA and PL tendons.

Fig. 10. Weightbearing anteroposterior view of patient 1 at 3 months postoperatively.

Fig. 12. Weightbearing lateral view of patient 1 at 3 months postoperatively.

Initially, patient 2 had experienced a longer duration of pain and technical difficulty compared with the other 2 patients, which was exacerbated by the severity of her condition and her obesity. These symptoms had resolved at the 4-month appointment, and the physical examination revealed no pain with ROM, the same as with the other 2 patients. At their discharge appointment at 6 months, the patients were recommended to return to clinic if they experienced any complications, pain, or discomfort (Figs. 10 to 18). At 1 year postoperatively, all patients were tolerating the LPS well and had not returned to clinic with any complaints related to their surgery.

Fig. 11. Weightbearing medial oblique view of patient 1 at 3 months postoperatively.

Fig. 13. Weightbearing anteroposterior view of patient 2 at 6 months postoperatively.

Fig. 14. Weightbearing medial oblique view of patient 2 at 6 months postoperatively.

Fig. 16. Weightbearing anteroposterior view of patient 3 at 5 months postoperatively.

Discussion

In recent studies, ORIF and arthrodesis have been used as the keystone surgical treatment methods for Lisfranc injuries. Screw fixation or dorsal plating has been commonly used in the reported data. Hsu et al (14) found that dorsal plate fixation maintains some midfoot motion and protects the cartilage but might not be a useful tool for complex injuries. Their study was limited to 1 patient's success with dorsal plating, and they recommended the use of other forms of arthrodesis for complex injuries (14). Our study addressed more complicated Lisfranc injuries in 3 patients, using the plantar LPS with favorable outcomes at 1 year postoperatively.

Fig. 15. Weightbearing lateral view of patient 2 at 6 months postoperatively.

All 3 patients had experienced a traumatic injury and dislocation at the Lisfranc joint. In contrast to dorsomedial plating, the plantar LPS design provides better bone contour, decreased soft tissue irritation, and increase soft tissue coverage (11). Additionally, the construct provides locking and compression for increased stability, not seen with other plating systems (12). Our study showed that all 3 patients were able to return to normal ROM and activity within 4 months postoperatively. A study using dorsal plating showed that the patient was kept non-weightbearing for 3 months, and our patients were able to return to full activity within 4 months. Hardware removal was recommended for the patient with dorsal plating. However, our study showed that at 1 year postoperatively, none of the 3 patients had experienced hardware complications (14). Radiographs indicated fusion across the joint sites without signs of nonunion or delayed union. Despite patient 2's comorbidities and obesity, her radiographs at 4 months postoperatively showed intact fixation and satisfactory alignment.

The plantar LPS approach also provides better fusion against the bending forces to which the fusion site is subjected (11). A cadaveric study using plantar LPS showed that the load to failure was higher (12), and this was supported in our study. Klos et al (11) showed that mean stiffness in the dorsomedial plate was 7.0 N/mm, that of the plantar plate was 24.8 N/mm, and the mean maximum load to failure was 192.6 N in the plantar group and 110.0 N in the dorsomedial group. These findings suggest that plantar plating results in greater rates of fusion and greater resistance against breakage (11). These findings were

Fig. 17. Weightbearing medial oblique view of patient 3 at 5 months postoperatively.

supposed by our study, given that all patients were able to perform early weightbearing.

One of the primary strengths of the LPS is that it creates a safe zone for the TA and PL tendons. This "safe zone" protects the tendons. Plaass et al (10) found that all 29 cadaveric feet had placement of the LPS on the plantar first tarsometatarsal joint without touching the central parts of the tendon insertions, even if the plates did not show perfect alignment. The application in our patients did not show any signs of tendonitis at their postoperative visits, supporting the results of the previous study of protecting the TA and PL tendons.

Fig. 18. Weightbearing lateral view of patient 3 at 5 months postoperatively.

Our study had certain limitations, such as the small sample size. A larger study is needed to compare screw fixation and the use of dorsomedial and plantar plates. A randomized control study comparing screw fixation and LPS fixation would provide more information on whether the plantar plate approach might be the future of Lapidus fixation. Although our patients were followed up for 1 year, long-term follow-up data are needed to determine how the plantar plate approach and its relationship to arthritides of the proximal and distal joints.

In conclusion, the plantar LPS showed satisfactory patient outcomes with no pain with ROM, no tenderness with palpation, increased bone contouring, and primary fusion within the 4-month follow-up period. Our study did not show any loss of muscle function to the TA and PL tendons at their insertion site. The plantar construct is able to protect these tendons and maintain their muscle strength postoperatively. In contrast to dorsal plating, the load to failure was greater, and the patients were able to return to full activity within <4 months. With the dependence on ORIF technology for traumatic Lisfranc injuries, this new LPS provides a more viable alternative that can help patients return to their activities more quickly and without injury to the supporting tendons at the tarsometatarsal joints. More research comparing this new plating system with the current constructs is necessary. The long-term monitoring of patients will also help to identify the arthritic changes that can occur secondary to the traumatic event and plate fixation.

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