A Novel Technique to Close Large Defects in the Foot Secondary to Infection Using Widely Available and Inexpensive Tools

A Case Report

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One of the challenges after central ray resection is a large soft-tissue defect. Many authors have reported the use of external fixators as a means of narrowing the forefoot. Ours is the first article to report an interesting case using widely available and inexpensive tools such as Kirschner and cerclage wires as an external fixation means of narrowing the forefoot after a complete second-ray resection and extensive soft-tissue debridement for a severe diabetic foot ulcer. This simple yet inexpensive technique is easy to perform for any foot and ankle surgeon at any hospital or surgical center. (J Am Podiatr Med Assoc 112(2), 2022)

According to the Centers for Disease Control and Prevention, the prevalence and incidence of diabetes and prediabetes continue to grow. As reported in 2018, 34.2 million people, or 10.5% of US population, were reported to have diabetes, and 88 million people (34.5%) were diagnosed with prediabetes. In particular, of the patient population with diabetes, 26.9 million people were diagnosed, whereas 7.3 million people were undiagnosed.[1]

As the number of patients with diabetes increases, the risks and complications from the disease also increase. Diabetic foot ulceration is considered one of the most common major complications reported in the literature. Nearly 25% of the population with diabetes will likely develop a foot ulcer in their lifetime, and 50% of those ulcers would require a hospital admission and ultimately some type of amputation.[1,2] Unfortunately, roughly more than one-third of diabetic foot ulcers will become infected.[3] After the initial amputation, there is a 70% risk of having a proximal amputation on the ipsilateral limb within 5 years of the index procedure, and an increase in mortality rates up to 50%.[3–5] According to Klaphake et al,[6] after each primary amputation, which is defined as the initial surgery above the ankle joint before any vascular intervention, the mortality rates after 1 year, 3 years, and 5 years have been reported as 44%, 57%, and 84%, respectively.

One of the most common surgical procedures when treating both infected and noninfected diabetic foot ulcers is surgical debridement. Debridement is defined as a process that removes all nonviable soft tissue and bone that may impede the wound from healing and to remove niduses for infection. An aggressive surgical debridement is even more important in severe infections such as gas gangrene or necrotizing soft-tissue infections, which are both limb and life threatening. Early surgical debridement is ideal, and although one would be tempted to consider function during debridement, it is important to remove all nonviable tissue, as reconstruction is to be considered after source control of infection is obtained. Our article is the first to report an interesting limb salvage case that used aggressive surgical debridement and second ray amputation for infection control; and used inexpensive yet widely available tools such as Kirschner and cerclage wires to narrow the soft-tissue defect that resulted after the central ray amputation.

Case Report

A 58-year-old man newly diagnosed with type 2 diabetes with a medical history of hypertension was presented to our team for a severe left forefoot diabetic foot infection after developing a wound secondary to trauma caused by one of his horses. He

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was initially seen and treated to manage the emergent infection through bedside incision and drainage at another facility but then referred to our limb preservation service for a higher level of care for limb salvage.

When initially seen at our facility, the patient's pedal pulses were palpable. The left lower extremity was noted with significant edema, erythema extending to the ankle, an entirely necrotic second digit, and three incisions with significant purulent drainage extruding out. Two linear incisions were noted on the dorsal left foot at the first and second interspaces, in addition to a long incision in the plantar first interspace with purulence and tissue necrosis. There was a deep probe to the diaphysis of the second metatarsal and surrounding fluctuance.

Because of the placement of the incisions from the initial treatment from the outside hospital and the severity of tissue necrosis, a challenge arose for our operative planning (Figs. 1 and 2). The patient required



Figure 1. Dorsal aspect of the left foot following the previous incision and drainage from an outside hospital.



Figure 2. Plantar aspect of the left foot from the previous incision and drainage.

a total second-ray resection with debridement of all nonviable soft tissue and bone of the first interspace, in addition to excision of the skin over the second metatarsal skin because of the placement of parallel dorsal incisions, which would likely have resulted in skin bridge necrosis if left intact. This extensive debridement resulted in significant tissue loss and gapping between metatarsals 1 and 3 (Figs. 3 and 4). After completion of the procedure, the patient was returned to the ward, and vigilant wound care was undertaken in addition to administration of intravenous antibiotics to keep the open wound viable and to abate the infection.

Four days later, after source control of infection was obtained, the patient was returned to the operating room. The patient underwent irrigation and debridement until healthy bleeding tissue was noted. We



Figure 3. Dorsal left foot after the complete second-ray amputation at our institution.

did apply a patch of silver-impregnated bioengineered dermal repair scaffold over the lateral capsule of the first metatarsophalangeal joint, because of the lack of soft-tissue coverage in this area after our debridement. Next, the patient underwent the narrowing procedure using 1.6-mm Kirschner wires and 18-gauge cerclage wire. Retentions sutures were place dorsally to reapproximate skin edges and accelerate wound closure. As shown in Figures 5 and 6, plantarly, the gap was closed; however, skin was not able to be reapproximated with continued depth. Although negative-pressure wound therapy (NPWT) would have accelerated healing, he was not a candidate for outpatient therapy because of insurance restrictions. He was discharged with simple wet-to-dry dressings to his plantar wound along with nonweightbearing precautions to the right foot.

The patient continued care on an outpatient basis. His dorsal incision was healing quite well and had nearly completely epithelialized by postoperative week 1. Because of his inability to receive NPWT, he decided to accept our next proposal, which can accelerate wound healing to the plantar surface by using a bilayered wound healing matrix in the operating room. Roughly 4 weeks after his narrowing procedure, we removed the silicone from his wound healing matrix, removed the Kirschner wires, and removed the dorsal sutures.

The patient continued follow-up with us on an outpatient basis, with healing of his dorsal incision and significant decrease in wound size plantarly with robust granulation tissue. We did offer the patient the option for a split-thickness skin graft to apply plantarly to expedite healing, because this was now a nonweightbearing surface following total second-ray resection. He decided to continue with healing by secondary intention using wet-to-dry dressings because of familial issues. The patient continued to follow-up with us at 6-week intervals for wound checks, and there was noted wound improvement at each visit. Five months after his index procedure, the patient's wounds had completely epithelialized (Figs. 7 and 8). He was placed in diabetic shoes with total contact accommodative inserts, and has been ambulating without issues. He remains healed, and has been able to return to his normal activity and to work.

Surgical Technique

The patient is placed supine on the operating room table with the limb in neutral rotation with the use



Figure 4. Plantar left foot after the complete second-ray amputation.



Figure 5. Dorsal left foot after an application of two 1.6-mm Kirschner wires and an 18-gauge cerclage wire for close reduction of the gap.

of an ipsilateral hip bump. Regional anesthesia usually suffices; however, spinal anesthesia or general anesthesia can be used as needed. A tourniquet is typically not used because perfusion of the limb is required to assess tissue viability with punctate bleeding.

In the setting of infection, all nonviable and necrotic tissue is excised completely both dorsally and plantarly. Debridement must be complete, especially in the interspace, as these tissues will no longer be visible at the conclusion of the procedure because of the narrowing technique. The metatarsal needs to be resected proximally to at least the level of the metaphysis to allow narrowing, and to ensure adequate soft-tissue bone coverage. After completion of the debridement and osseous resection, the wound is irrigated with 3 to 9 liters of crystalloid solution using pulse lavage. Hemostasis is then carefully achieved.

Next, the ability to reduce the defect is demonstrated by manual reduction with hand or with the use of bone clamps. Once confirmed, Kirschner wires are placed in the adjacent metatarsals at the level of the diaphysis, and placed bicortically. The minimum size of Kirschner wires should be 1.6 mm. It is essential to place the wires parallel to each other. An 18-gauge cerclage wire is then placed around the two wires, roughly two fingerbreadths above the dorsal skin. The Kirschner wires are then bent at 90°, the medial metatarsal wire medially and the lateral metatarsal wire laterally. This is to prevent the cerclage from sliding up during tightening and losing reduction. The cerclage wire is then tightened using pliers, and the reduction of the gap can be seen grossly during this portion of the procedure. Once adequate reduction has been performed, the skin can be reassessed. If clinical presentation permits, skin closure can be undertaken, or retention sutures can be placed. Appropriate surgical dressings are placed. The patient is then immobilized and placed nonweightbearing until appropriate healing has occurred.

Discussion

Forefoot narrowing using external fixators has been discussed by many authors. Strauss et al[7] reported an interesting technique using a bulky miniature external fixator and large pins to allow direct access to the wound. Using a similar concept, Oznur and Tokgozoglu[8] reported their success using two Ilizarov half rings and narrowing the forefoot by tensioning from medial to lateral using olive wires. Later, Bevilacqua et al[9] described an advanced approach for narrowing cleft wound after central ray amputation using a small miniature external fixator. The forefoot was compressed manually until the plantar skin edges apposed, and the fixator was closed down to hold the position. It also helps prevent the significant



Figure 6. Plantar left foot after the application of two 1.6-mm Kirschner wires and an 18-gauge cerclage wire for close reduction of the gap.



Figure 7. The soft-tissue defect was completely healed on the plantar foot.

transverse deformity of the remaining digits. However, we were able to achieve the same results and narrow the soft-tissue defect using two Kirschner wires and a cerclage wire, which were extremely inexpensive and widely available at any hospital or surgical center. Our surgical approach was also the first reported in the literature thus far.

Cosmetically, the method we have used was much less bulky than using the Ilizarov frames or MiniRail (Stryker Corp, Kalamazoo, Michigan). We believe our method to be quite economical for its ability to achieve similar results. At our institution, the cost of the supplies included 1.6-mm Kirschner wires costing $3.85 each, and the cerclage wire costing in the range of $13 to $14. In contrast, the average cost per external fixation frame was $5900.[10] Our simple technique can be performed easily at any hospital or surgical center for fractions of the cost of external frame fixation.

Because of insurance issues, the patient was not qualified for NPWT on an outpatient basis. We believed that this significantly delayed his healing and recovery progress. According to Bickels et al,[11] 25% reduction of soft-tissue defects were seen on average of 20 patients with the aid of vacuum-assisted closure during the first 4 weeks. Furthermore, hospital stay was much shorter for the group of patients that received NPWT and bioengineered graft (4–30 days) compared to the control group (15–72 days).

Even though we reported an interesting case of reducing large soft-tissue loss using inexpensive tools and equipment such as Kirschner and cerclage wires, careful patient selection using this technique is a must. The patient has to be compliant with being nonweightbearing and be willing to follow-up in the office frequently for close monitoring.

Conclusions

Although using an external fixator to narrow the large soft-tissue defect after a central ray amputation was reported, our article is the first to report such simple and extremely inexpensive tools to accomplish the same goal as the concept of the external fixator. This surgical approach can be performed at any hospital or surgical center any time. This technique is also



Figure 8. The dorsal left foot was completely healed.

easy to perform for surgeons without the use of specialized equipment. We hope this technique will aid in limb salvage, expedite healing, reduce hospital stays, and decrease the financial burden associated with these significant musculoskeletal injuries.

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