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Reconstruction of Traumatic Composite Tissue Defect of Medial Longitudinal Arch With Free Osteocutaneous Fibular Graft

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A R T I C L E I N F O

Level of Clinical Evidence: 4

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A B S T R A C T

A 34-year-old male sustained a crush injury resulting in bone and soft tissue loss along the medial longitudinal arch of his left foot. Specifically, the injury resulted in loss of first metatarsal without injury to the medial cuneiform or proximal phalanx, fracture of the third metatarsal, and a 5-cm × 9-cm soft tissue defect overlying the dorsomedial aspect of the right foot. After debridement and daily wound care, the defect was subsequently reconstructed using a free osteocutaneous fibular graft. Approximately 6 months after reconstructive surgery, the patient returned to his job without pain, and his pedogram showed almost equal weightbearing distribution on both feet.

The medial longitudinal arch is composed of the calcaneus, talus, navicular, 3 cuneiforms, and the first 3 metatarsals. It supports most of the weight of the erect body. Among the anatomic structures of the medial arch, the first metatarsal and first cuneiform constitute most of the first ray, which is important because it bears approximately one third, or more, of the weight of the body during the late stance and push-off stages of walking (1). Therefore, after tumor resection, the treatment of osteomyelitis, and the repair of traumatic injuries, reconstruction of the structural integrity of the first ray is particularly important for optimal function of the foot. In the present report, we describe the successful treatment of an adult male who had sustained an open, crush injury with substantial loss of the first metatarsal and underwent reconstruction with a free osteocutaneous fibular graft.

Case Report

A 34-year-old male laborer who had sustained a crush injury resulting in bone and soft tissue loss from his left foot presented to our emergency service. The physical examination and radiographs revealed focal loss of the first metatarsal without injury to the medial cuneiform or proximal phalanx and a minimally displaced fracture of third metatarsal. The wound was complicated by a 5-cm × 9-cm skin defect overlying the first metatarsal. The dorsalis pedis artery had been severed with segmental loss, although the deep peroneal nerve was intact. The arterial supply and venous circulation were grossly adequate throughout the foot, including to the hallux. Initially, using general anesthesia, the patient underwent debridement of the necrotic soft tissues and remnants of the first metatarsal. A Kirschner wire was interposed between the medial cuneiform and the proximal phalanx in an effort to preserve the length of the first ray during the period that wound care and supportive measures would be used to prepare the patient for a secondary procedure, at which time definitive reconstruction would be undertaken (Fig. 1). The patient was hospitalized and monitored, with daily irrigation and wound dressing changes. Gentamicin (2 × 80 mg intravenously) and cefazolin (3 × 1 g intravenously) were used for prophylaxis, and the definitive reconstruction procedure was performed on 10 days after the initial injury.

At the second surgery, an osteocutaneous free fibular graft was harvested from the ipsilateral extremity, procuring 10 cm of the fibula and an accompanying 10-cm × 6-cm skin paddle (Fig. 2). The graft did not contain soleus muscle. The cartilaginous joint surfaces of both the medial cuneiform and the proximal phalanx were resected, and receptacle tunnels of the appropriate diameter were created to incorporate the corresponding ends of the fibular bone graft. The fibular bone graft was interposed and secured to the medial cuneiform and proximal phalanx, respectively, using a one third semitubular plate with 2 locking screws (Fig. 3).

After securing the bone, an arterial microanastomosis was performed between the peroneal and tibialis anterior arteries. Venous

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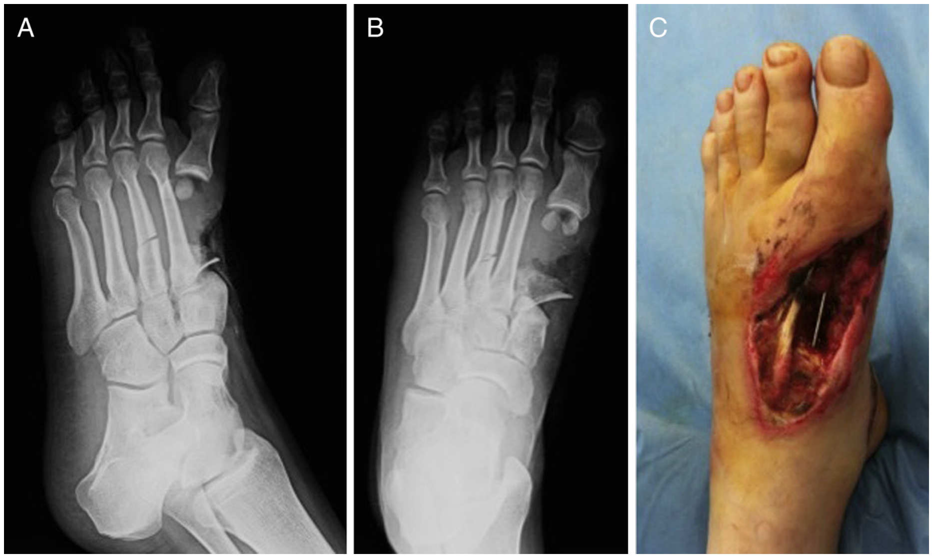

Fig. 1. Preoperative (*A*) oblique and (*B*) anteroposterior radiographs and (*C*) dorsal clinical view of the injured left foot after initial debridement and Kirschner wire fixation.

anastomosis was performed between satellite peroneal and saphenous veins. Because of the relatively large skin paddle and the edematous extremity due to the trauma, we covered the donor site with a split-thickness skin graft harvested from the anterolateral aspect of the ipsilateral thigh. The left foot recipient graft site also required some additional coverage, which was achieved with an additional split-thickness skin graft from the ipsilateral anterolateral thigh. The patient was discharged from the hospital on the tenth postoperative day, having recuperated and undergone dressing changes.

At no time during the postoperative period did we ever encounter any problem related to venous congestion, arterial occlusion, or skin paddle necrosis. The skin grafts of the donor and recipient sites healed uneventfully. Bony union at both ends of the fibular graft was detected at 8 weeks after surgery, after which, gradually increasing weightbearing was allowed. The patient returned to his job 6 months after reconstructive surgery. Pedobarographic analyses were performed at 6 and 13 months postoperatively. The first test showed little weightbearing through the first metatarsal head and excessive weightbearing throughout the lateral arch, indicative of antalgic guarding of the medial column. By the second pedobarographic analysis, the weightbearing distribution had improved such that the distribution of the left foot appeared similar to that of the right (uninjured) foot (Fig. 4). During the follow-up period, the reconstruction remained uncomplicated, and the patient was satisfied with the results of the surgery (Figs. 5 and 6). After a 13-month follow-up period, the patient's overall satisfaction was scored as 95.2 points using the foot and ankle disability index (2).

Discussion

The arrangement of the bones of the foot form the medial, lateral, and transverse pedal arches, which share the weight of the body

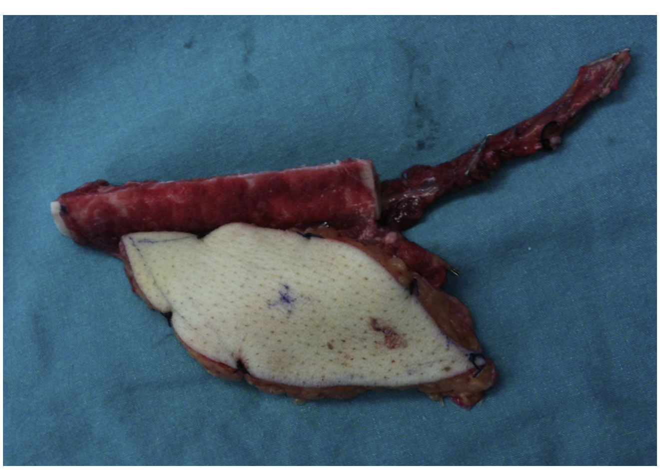

Fig. 2. The osteocutaneous flap after harvest and before transplantation.

Fig. 3. The appearance of the foot after graft transplantation and internal fixation.

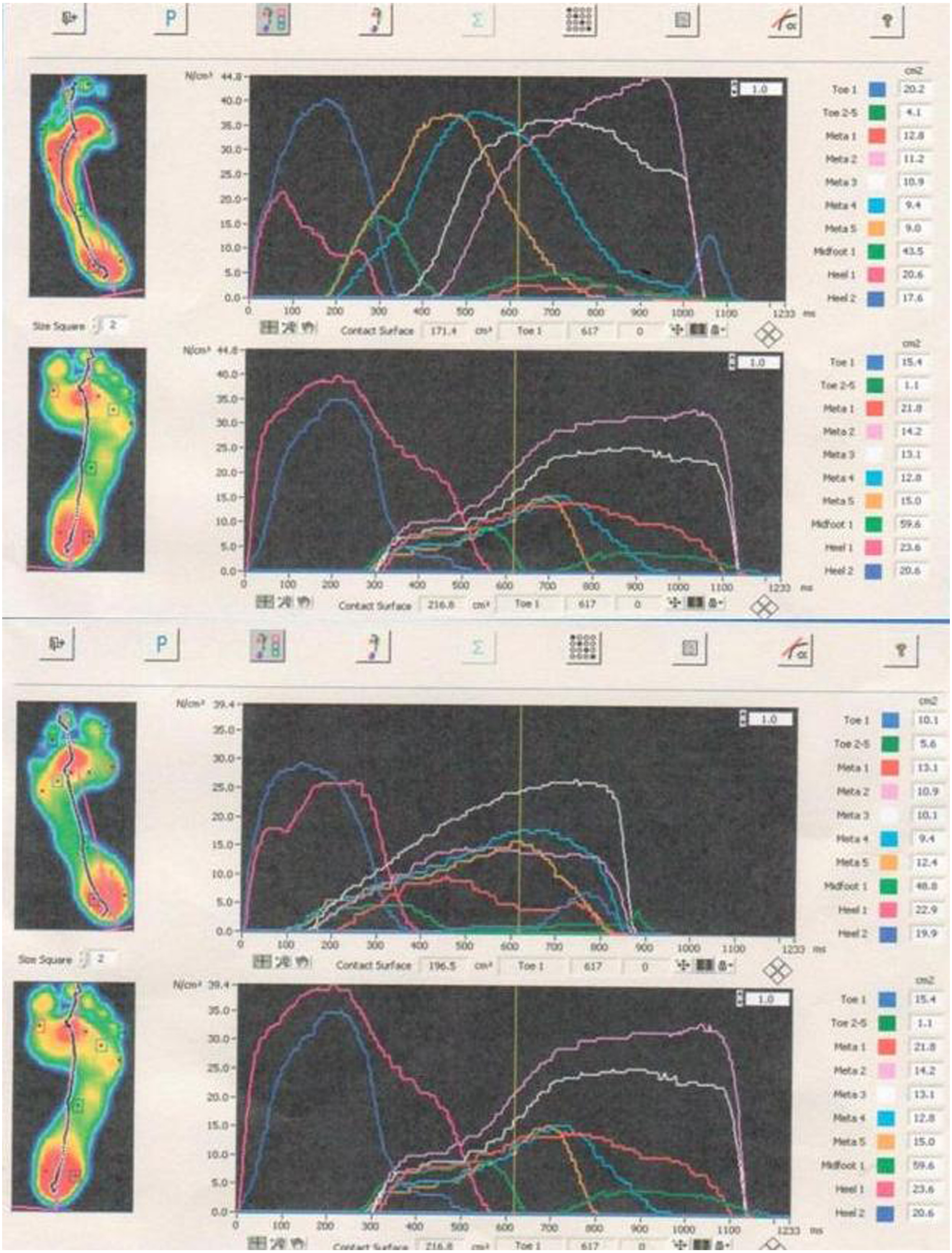

Fig. 4. Comparison of the 6-month *(top)* and 13-month *(bottom)* postoperative left (reconstructed) and right (uninjured) pedobarograms.

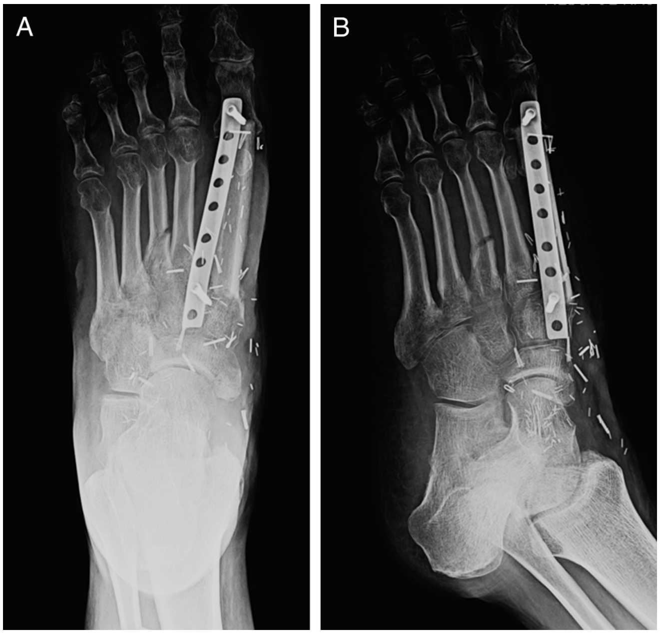

Fig. 5. (*A*) Anteroposterior and (*B*) oblique left foot radiographs at 13 months postoperatively.

during stance and gait. Among these, the medial longitudinal arch is the main load-bearing structure in the foot. During the stance phase of gait, the first ray (primarily the first metatarsal and medial cuneiform), along with the navicular, talus, and calcaneus, forms a solid truss, which is connected to the plantar aponeurosis at its base (3). This triangular arrangement is important in controlling the structural integrity of the foot. The first metatarsal has a greater diameter than that of the lesser metatarsals, and, on the plantar surface, the skin and subcutaneous fat are particularly thicker than that of the lateral aspect of the foot to bear most of the weight of the body. For these reasons, reconstruction of the soft tissue and bone loss involving the medial column can be very challenging and require complex reconstructive interventions that combine skin, muscle, and bone.

The vascularized fibular flap is a proven method for reconstruction of bone defects >6 cm in length. Vascularized grafts are significantly stronger structurally and more resistant to infection than conventional nonvascularized grafts, because they heal by primary bone healing rather than creeping substitution. Thus, incorporation of the graft is rapid and complete, and the incidence of stress fracture is less than that observed with conventional, nonvascularized bone grafts (4). Still further, without operative restoration of the blood flow to and from the bone graft, it would be exceedingly unlikely that a bone graft with a length >3 to 4 cm would ever entirely incorporate in a timely fashion in the foot. Few reports have been published of free, vascularized bone grafts used to replace metatarsal defects (5–8). The use of an accompanying soft tissue transplant consisting of the soleus muscle and/or a skin paddle as a composite tissue transfer has also been previously described (9). The similar cortical thickness and shape of the fibula enables it to serve as a substitute for the first metatarsal, and the reverse flow pedicled fibular flap is an option for bone defects of the lower leg (10,11). However, it is important to consider the location of the skin perforator artery if the bone is to be transferred with the skin island. In the present case, the skin perforator artery was detected using hand-held Doppler ultrasonography. It was situated at the junction of the middle and distal thirds of the fibula. Because the pedicle of a reverse flow osteocutaneous fibular flap would be too short to reach the medial pedal defect, we performed flap reconstruction using a free flap method. K-wires were used for temporary fixation in the first operation. An external fixator would be an alternative for fixation. Kadow et al reported that external fixators were effective to protect the length and alignment during staged treatment of midfoot fracture/dislocations (12). But we anticipated that the second stage would be closer and K-wire fixation would be enough for temporary fixation.

Various fixation methods, including Kirschner wires, small plates at both ends of the fibula, and external fixators, have been used for osteosynthesis of a fibular flap. In our patient, we used a one third semitubular plate with single locked screws at the cuneiform and proximal phalanx for rigid fixation of the bone component of the flap, without compromising the intraosseous blood circulation of in the transplanted fibula.

During the follow-up period, the patient's pedograms were recorded at the 6th and 13th postoperative months. The patient also returned to his work at 6 months after surgery. Although the patient had no pain at the 6-month postoperative point, when he resumed his work duties, the first pedogram showed increased weightbearing along the lateral aspect of his left foot. This was probably the result of hesitation in weightbearing along the reconstructed medial arch of the foot. However, the pedogram at 13 months showed an almost equal weightbearing distribution in both feet, when the reconstructed left foot was compared with the uninjured right foot. In the published data, complications such as valgus deformity, muscle weakness, ankle instability, and persistent pain have been reported as a result of harvesting a large segment of the fibula for use as a structural bone graft (13,14). Kalra et al (13) claimed that muscle weakness at the donor site could be relieved with physical therapy and progressive weightbearing. Pacelli et al (14) reported that retention of only 10% of the fibular length distally would be enough to prevent iatrogenic ankle instability because of retention of the tibiofibular syndesmotic ligaments. In our patient, the graft was harvested above the level of the syndesmosis, which, we believe, is one of the reasons that our patient's ankle remained stable and the pedobarographic measurements were

Fig. 6. Clinical appearance of the foot in stance at 13 months postoperatively.

essentially the same. Preservation of the tibiofibular syndesmosis, combined with restoration of a solid medial column, repair of the large soft tissue defect, and avoidance of infection, enabled our patient to recover to the degree that he could resume his work duties, which required long hours standing on his feet wearing work boots. From our understanding of the existing data, and our experience with the present patient, we believe that the vascularized osteocutaneous fibular flap can be used to provide rapid union of bones, restoring the extensive pedal bony architecture, with functional and cosmetically acceptable soft tissue coverage of the foot, preserving ankle stability and function.

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