The Journal of Foot & Ankle Surgery 49 (2010) 301–304

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Reconstruction of Massive Midfoot Bone and Soft Tissue Loss as a Result of Blast Injury

Rahul Banerjee, MD, FACS [1], Brian Waterman, MD [2], James Nelson, MD [2]

[1] *Assistant Professor, UT Southwestern Medical Center, Department of Orthopaedic Surgery, Dallas, TX*
[2] *Resident, Texas Tech University Health Sciences Center, William Beaumont Army Medical Center, El Paso, TX*

ARTICLE INFO

Keywords:
abductor hallucis
bone graft
explosive device
muscle flap
surgery
trauma

ABSTRACT

Lower extremity blast injuries represent a unique challenge to surgeons and often involve complex, limb-threatening wounds with extensive soft tissue and bone loss. Surgical treatment of these injuries can be difficult because of limited autogenous resources for reconstruction of the defect. In this article, we describe a technique for medial column reconstruction using iliac crest bone graft and soft tissue coverage with an abductor hallucis rotational flap combined with a split-thickness skin graft. This method addresses the extensive bone and soft tissue defects that frequently characterize blast injuries to the foot, and may be applicable in other situations where trauma or infection has caused extensive destruction of the medial column.

Options for the management of massive bone loss and large soft tissue defects in the midfoot are limited. When these injuries occur as the result of a blast mechanism, the treatment of combined bone and soft tissue defects is frequently complicated by compartment syndrome, ischemia, infection, difficult soft tissue coverage, the need for multiple secondary procedures, and long-term disability (1). Schwabegger and colleagues (2, 3) described the use of a distally based abductor hallucis muscle flap to cover defects of the medial column, and a number of other techniques for reconstruction of these challenging injuries have also been described, including the use of external fixation, cross-leg flaps, and temporary plating (4–7). In this article, we describe a method for medial column reconstruction with autologous tricortical iliac crest graft and staged soft tissue management using an abductor hallucis rotational flap combined with a split-thickness skin graft.

Surgical Technique

The indication for this technique is extensive bony defects of the medial column that are not amenable to anatomical reconstruction, with concomitant loss of the overlying soft tissues. Contraindications include acute infection, injury to the abductor hallucis muscle rendering it unable to be used for flap coverage, and absence of adequate bone stock in the first metatarsal and/or talar neck. For these reasons, inspection of the bony defect with standard radiographs and computerized tomography (CT) scans, and close clinical inspection of the vitality of the abductor hallucis are required.

Staged reconstruction of blast injuries usually entails serial debridements, as well as concomitant medical management to optimize the patient for definitive treatment. After inspection of radiographic and CT scans (Figure 1), and preparation of the patient for surgery, the patient is taken to the operating room for extensive wound debridement in preparation for subsequent definitive bone and soft tissue reconstruction. With the patient supine and under general anesthesia, the wound (Figure 2) is irrigated with 9 liters of normal saline using power-pulsed lavage or bulb syringe. Careful surgical debridement is then performed to remove contaminated and devitalized soft tissue and bone. A negative pressure wound dressing is then applied and empiric antibiotic therapy initiated, having procured suitable culture specimens from the involved tissues, after which the patient is returned to the surgical floor for ongoing local wound care and systemic medical management.

Definitive reconstruction entails return to the operating room, where the negative pressure dressing is removed and the extremity prepared under sterile technique. The ipsilateral iliac crest and contralateral extremity are also prepared and exposed. The foot is then manually realigned to restore medial column length, which is confirmed by means of C-arm fluoroscopic guidance and direct inspection, as well as comparison with the alignment of the

Financial Disclosure: None reported.
Conflict of Interest: None reported.
Address correspondence to: Rahul Banerjee, MD, FACS, Assistant Professor, UT Southwestern Medical Center, Department of Orthopaedic Surgery, 5323 Harry Hines Boulevard, Dallas, TX 75390–8870.
E-mail address: rahulbanerjee7@hotmail.com (R. Banerjee).

1067-2516/$ – see front matter
doi:10.1053/j.jfas.2010.02.011

Fig. 1. Anteroposterior (AP) radiograph of the right foot demonstrating extensive bone loss of the medial column.

contralateral foot. If necessary, a spanning external fixator can be applied to maintain midfoot length and alignment, with pins placed in the first metatarsal and the talus. The medial column is exposed by means of dissection through the traumatic wound, and an additional medial utility approach may be used if deemed necessary. Through a full-thickness surgical exposure, the cartilage at the base of the first metatarsal and talar head are denuded. Measurements are then obtained to determine the length of the osseous defect of the medial midfoot. The contralateral foot, if uninjured, may be used to determine the length of the patient's normal foot. Tricortical iliac crest autograft then is harvested to fit the determined length of the defect, and the graft is slightly oversized to allow for a tight, press fit between the talar head and the base of the first metatarsal. The tricortical wedge is impacted using a bone tamp under fluoroscopic guidance (Figure 3). To optimize healing, additional cancellous graft is harvested and packed at the proximal and distal aspects of the tricortical graft. A 3.5-mm reconstruction plate is then contoured and applied to span the grafted defect, and screws are placed proximally in the talar neck and distally in the first metatarsal base (Figure 4). The 3.5-mm reconstruction plate is useful as it may be contoured to fit the anatomy of the medial column (7). Additional stability can be obtained by extending the distal screws into the second and/or third metatarsal bases.

After stabilization of the bone graft, the abductor hallucis is exposed as described by Schwabeggar et al (Figure 5) (2, 3). Depending on the nature of the injury, the abductor hallucis flap may be based proximally or distally, but in our experience, we have used a proximally based flap. The elevated abductor hallucis is then rotated to fill the medial column defect and to cover the bone graft (Figure 6). The muscle flap is anchored using nonabsorbable sutures that are inserted into the distal aspect of the abductor hallucis. These sutures are brought out through the skin and anchored over a bolster to provide stability to the flap as it heals. A split-thickness skin graft, typically harvested from the ipsilateral thigh, is then applied to cover the muscle and to enable complete closure of the wound. Once again, a negative pressure wound dressing is applied over the skin graft, and maintained for 1 week set at a continuous 75 mm Hg of negative pressure. The patient's foot and ankle are immobilized in a removable posterior splint, if an external fixator is not being used and, after 1 week, the dressing is removed and the wound inspected. The patient is maintained non–weight bearing on the operated extremity for up to

Fig. 2. Intraoperative photograph of blast injury to right foot with extensive bone loss and soft tissue defect (5.5 × 4.0 cm).

Fig. 3. Intraoperative anteroposterior radiograph of right foot showing placement of tricortical bone graft.

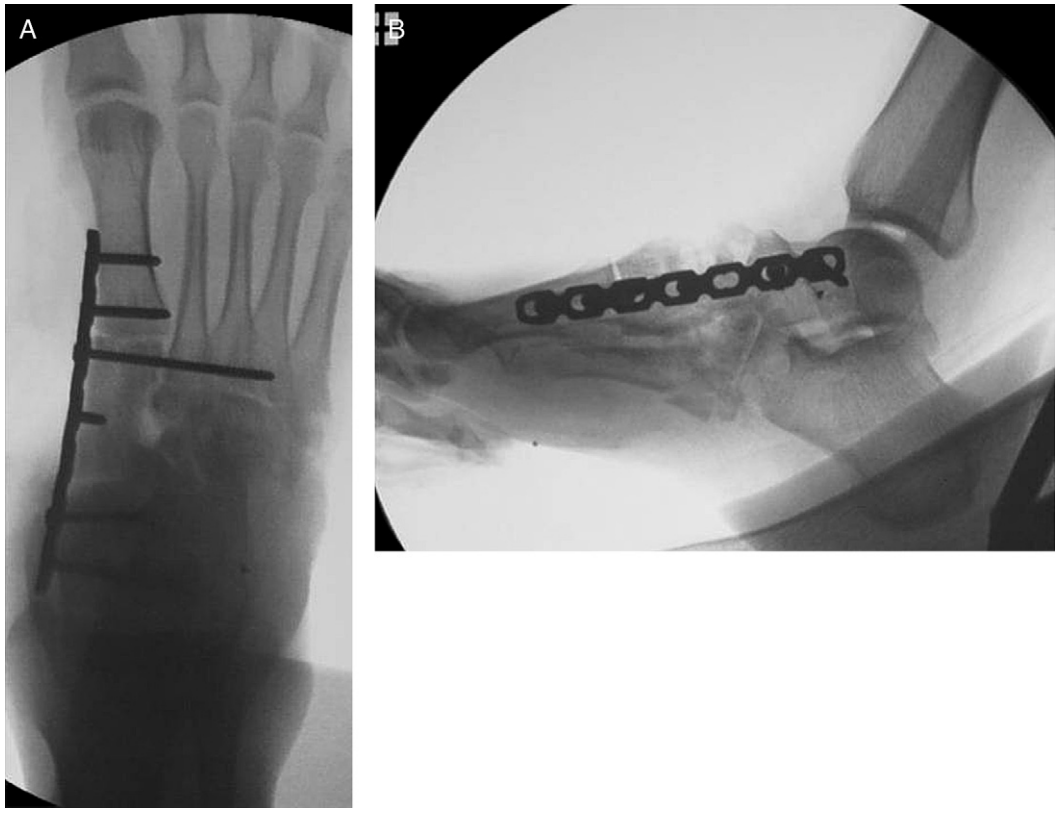

Fig. 4. Anteroposterior (*A*) and lateral (*B*) radiographs demonstrate the graft in position with the spanning medial column plate applied.

3 months. Gentle passive and active range of motion exercises are begun after the skin graft and flap demonstrate healing, and progressive weight bearing and strengthening are initiated at 3 months after surgery.

Discussion

We have used the technique described in this report twice for traumatic midfoot blast injury reconstruction. Both of the patients were transferred to the 332nd Medical Theater stationed in Balad, Iraq, for definitive treatment. The first patient was a 24-year-old Bangladeshi national male injured during an enemy mortar attack (Figures 1–6). He arrived after primary stabilization at the Forward Operating Base (FOB) and received serial debridement and staged midfoot reconstruction. At the 3-month follow-up visit, the soft tissue had healed without evidence of infection and the patient had begun progressive weight bearing with a cane, whereupon he returned to Bangladesh. The second patient was a 23-year-old Iraqi national with injuries secondary to an improvised explosive device (IED). Staged reconstruction and recovery proceeded in a fashion similar to that described previously, with long-term follow-up limited by transfer to an outlying Iraqi medical facility for further recovery.

Modern warfare tactics have resulted in high rates of blast-type injuries in the combat zone. With decreasing fatal battle-related injuries as a result of advances in body armor and forward medical care, the military focus has shifted from amputation to the reconstruction of extremity injuries and limb salvage. One report noted that up to 21% of crush injuries to the foot resulted in amputation (4). The

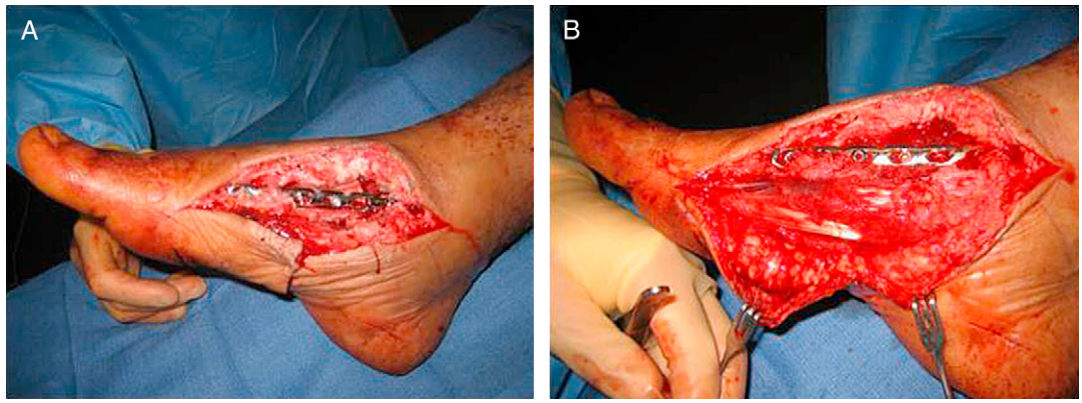

Fig. 5. Intraoperative photograph demonstrating extension of the traumatic wound for medial column reconstruction (*A*) and exposure of the abductor hallucis muscle (*B*).

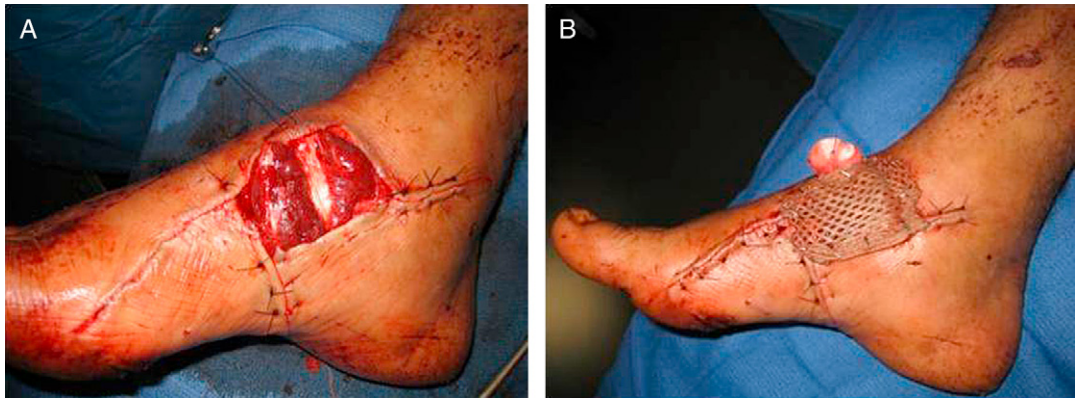

Fig. 6. Intraoperative photograph following rotation of proximally based abductor hallucis flap used to fill soft tissue defect; (*A*) the split thickness skin graft is applied over the flap (*B*).

technique that we describe in this report provides an option for salvage of the injured foot despite the presence of severe bone and soft tissue loss.

Advantages to this technique include maintenance of medial column length, prevention of gross pedal deformity, and effective soft tissue reconstruction without the need for a microvascular free flap. In open blast injuries, any salvage technique must also address bone loss. Iliac crest bone graft is readily available in most patients and results in predictable rates of union, with acceptable donor site morbidity. This is particularly important in the wartime setting, where many resources are scarce. Midfoot bone loss can result in severe deformity if not addressed. To prevent deformity and provide a stable midfoot, we used a modification of the temporary bridge-plating technique described by Schildhauer et al (7) for cases of extensive comminution of the midfoot. The abductor hallucis flap is locally based, hence technically easier, less morbid, and more likely to survive in comparison to a free flap. Schwabeggar et al (2, 3) observed that all of the patients in their study were fully mobile by 3 months, and displayed no gait deficit at the time of their long-term follow-up visit.

Disadvantages of the technique that we described include the risk of infection and loss of subtalar joint motion. Infection is a concern with all methods of operative fixation, especially with complex blast wounds. Other authors have proposed the use of a temporary cement spacer (4, 5) or an external fixation (4, 6) to address similar injuries. In cases of severe contamination, these techniques may be used initially to allow early soft tissue recovery before performing definitive reconstruction with a technique such as the one that we have described herein. This technique also requires fusion of the destroyed or absent talonavicular joint. Because the talonavicular joint accounts for approximately 80% of hindfoot motion and facilitates accommodative gait (8), subtalar motion is limited following the operation. By performing this technique and effectively fusing the talonavicular joint, midfoot motion is restricted. Tasks such as walking on uneven ground become difficult for the patient and may ultimately lead to increased stress on adjacent joints with development of secondary arthrosis. However, because this is a salvage operation, we believe that the risk of arthritis is acceptable. Moreover, the technique does not address injury to the lateral column, which may require additional reconstructive intervention.

It is also important to understand that the success of this procedure requires preservation of the medial plantar artery, which supplies the abductor hallucis muscle, and must be carefully dissected and mobilized in order to rotate the muscle over the bone graft. Damage to the blood supply of the abductor as a result of the injury or by surgical insult may result in flap failure. By the same token, this procedure requires acceptable surrounding bone stock (ie, the talus and first metatarsal), which may be severely damaged by blast injury.

In conclusion, the technique that we have described in this article provides a means for reconstruction of blast injuries to the medial column of the foot. Because of the nature of war, our follow-up for the patients in whom we used this technique is limited. However, the technique provides salvage for the severe injuries seen in modern warfare and may prevent deformity, provide an alternative to amputation, and ultimately allow the patient to have a stable, usable foot.

References

1. McGuigan FX, Forsberg JA, Andersen RC. Foot and ankle reconstruction after blast injuries. Foot Ankle Clin 11:165–182, 2006.
2. Schwabegger AH, Shafighi M, Harpf C, Gardetto A, Gurunluoglu R. Distally based abductor hallucis muscle flap: anatomic basis and clinical application. Ann Plast Surg 51:505–508, 2003.
3. Schwabegger AH, Shafighi M, Gurunluoglu R. Versatility of the abductor hallucis muscle as a conjoined or distally-based flap. J Trauma 59:1007–1011, 2005.
4. Chandran P, Puttaswamaiah R, Dhillon MS, Gill SS. Management of complex open fracture injuries of the midfoot with external fixation. J Foot Ankle Surg 45:308–315, 2006.
5. Largey A, Faline A, Hebrard W, Hamoui M, Canovas F. Management of massive traumatic compound defects of the foot. Orthop Trauma Surg Res 95:301–304, 2009.
6. Keeling JJ, Beer R, Forsberg JA, Andersen RC, Mazurek MT, Shawen SB. Open midfoot blast trauma treated with ring external fixation: case report. Foot Ankle Int 30(3):262–267, 2009.
7. Schildhauer TA, Nork SE, Sangeorzan BJ. Temporary bridge plating of the medial column in severe midfoot injuries. J Orthop Trauma 17:513–520, 2003.
8. Astion DJ, Deland JT, Otis JC, Kenneally S. Motion of the hindfoot after simulated arthrodesis. J Bone Joint Surg Am 79(2):241–246, 1997.