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Traumatic Forefoot Reconstructions With Free Perforator Flaps

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ABSTRACT

The forefoot is critical to normal walking; thus, any reconstruction of forefoot defects, including the soft tissues, must be carefully done. The free perforator flap, with its physiologic circulation, lower donor site morbidity, and minimal thickness is the most popular technique in plastic and microsurgery, and is theoretically the most suitable for such forefoot reconstruction. However, these flaps are generally recognized as more difficult and time-consuming to create than other flaps. In 41 patients with traumatic forefoot defects, we reconstructed the forefoot integument using 5 types of free perforator flaps. The overall functional and cosmetic outcomes were excellent. Three flaps required repeat exploration; one survived. The most common complications were insufficient perfusion and the need for second debulking. The key to our success was thoroughly debriding devitalized bone and soft tissue before attaching the flap. Forefoot reconstruction with a free perforator flap provides better function, better cosmesis, better weightbearing, and better gait than the other flaps we have used.

The forefoot is critically important for normal walking. The loss of the base of the proximal phalanx of the great toe disrupts the plantar aponeurosis and the windlass mechanism and destabilizes the medial longitudinal arch. This destabilization decreases weightbearing on the first metatarsal head and transfers it to the lesser metatarsal heads (1). If the base of the proximal phalanx of one of the lesser toes is removed, similar instability will occur, but to a much lesser degree, particularly moving laterally across the foot (2). The shortened ray also causes increased stress and callus formation beneath the adjacent metatarsal head, which is subjected to increased weightbearing (3). Any reconstruction of the soft tissue defects of the forefoot, therefore, is worthwhile.

Modern flap surgery has made the preservation of the distal forefoot possible. The free perforator flap is more suitable than local flaps for forefoot coverage because the antegrade arterial blood flow and retrograde venous return provide better circulation. Any distally pedicled flap for forefoot coverage will have nonphysiologic blood circulation because the arterial blood flows retrogradely and the venous blood flows from proximally to distally. However, the free perforator flap is generally more difficult and time-consuming to use than classic free transfers. When appropriately chosen and managed, the flap can greatly improve functional outcomes of the foot results in less donor site morbidity. It is thick enough to allow the reconstructed foot to be accommodated to reasonable footwear without a second debulking.

During the past 20 years, we have tried nearly all the flap techniques for foot coverage. In the present study, we report our experience with free perforator flaps in treating patients with partial amputation of the forefoot.

Patients and Methods

We reviewed our experience of consecutive patients presenting to the Department of Orthopaedic Surgery at Kunming General Hospital from January 2007 to December 2012 with traumatic injuries and soft tissue defects over the forefoot, including metatarsal or phalanx fractures, defects, and dislocations. We did not include patients who had undergone emergency amputation of their foot.

Before the definite flap operation, any dead bone or tissue was debrided. If the wound had much effusion liquid or pus, the debridement operation would be repeated until fresh granulation tissue was grown. We used vacuum-assisted closure to help in preparation of the wound. If the patient had a fever or a low hemoglobin level, we would treat those conditions first.

To begin the flap surgery, a Doppler probe was routinely used to decide on the optional perforators for the flaps. Each flap was designed to meet the needs of each wound, although all flaps were 1 cm larger than the length and width of the wound. We used 2 surgical teams, 1 team (the first 3 of us [Y.-L.Z., X.Q.H., Y.W.]) to harvest the flaps and perform microsurgical anastomosis and 1 team (Q.L., X.-Y.F., Y.Q.X.) to expose the recipient site and close the donor site.

We began by incising only 1 edge of the skin flap so the skin paddle can be altered according to the feeding vessel selected. The dissection proceeded at the subfascial level. At this level, the perforators could be easily located. Blood-free, clean dissection was achieved by separating the tissue with a knife and direct ligation of the vessel branches. Once a clear view of the main perforator had been

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Table
Perioperative complications and treatment of forefoot deformities reconstructed with free perforator flaps

Complications	Patients (n)	Treatment	Results
Insufficient circulation of flap margins	5	Continuous massage for 72 hr	Healed
Too bulky; difficulty with shoe wear	5	Second debulking	Normal shoe wear
Vein or artery thrombosis	3	Re-exploration	1 saved; 2 lost
Partial flap necrosis	2	Dress change	Secondary healing
Chronic subflap infections	2	Daily wound caring	Healed
Deformity union of bones	2	None	Normal foot walking
Mild varus deformity	1	None	Normal gait
Equinus deformity	1	Ilizarov techniques	Deformity corrected
Delayed healing of donor site	1	None	Healed

established, we follow the vessel through its intramuscular course. Usually we would leave a cuff of fascia around the vessel. At the point at which the perforator entered the muscle, the muscle fibers were split in both directions using blunt dissection. Every side branch was ligated until a sufficient pedicle length was obtained. We did not use coagulation or clipping. For certain flaps, such as a free anterolateral thigh perforator flap, which had a long pedicle, we would dissect the pedicle in reverse direction (i.e., we started the pedicle dissection where it descended from the source artery). From proximally to distally, we ligated all the side branches until the perforators had entered into the deep fascia. When the pedicle had been dissected and carefully preserved, the other edge of the skin flap was dissected quickly, and the whole flap was taken down. It was then inset into the recipient bed using skin suturing. The flap pedicle was anastomosed to the recipient vessels under a microscope.

In some cases, we used a fillet flap to help cover the distal forefoot and decrease the size of the simultaneous free perforator flap. The sensory nerves were not coapted. The dorsal pedal vessels were most often used for microvascular anastomosis. Fractures or dislocations were also reduced and fixed with Kirschner wire fixation during flap transfer.

Postoperatively, the patients were monitored in hospital for 3 to 5 days and then transferred to a rehabilitation unit. The dressings were changed with special care during this period, because it is the key time for survival of the transferred flap. Problems with venous perfusion, which usually occurred in the distal flap if they developed, were treated with 72 hours of continuous massage on the flap. This massage was done by the finger pressing and releasing repeatedly on the distal flap and was usually successful. It could also be performed by the patient's nurse or relatives.

Results

We treated 41 patients (mean age, 30 years; range, 13 to 56 years; 33 males and 8 females). Of the 41 defects, 22 (53.7%) were in the dorsal forefoot, 4 (9.8%) in the plantar forefoot, and 12 (29.3%) in the distal forefoot; 3 (7.3%) were mega-size defects that included the midfoot or hindfoot. The injuries had been caused by traffic accidents in 11 (25.6%), crushing forces in 19 (46.3%), mechanical accidents in 8 (19.5%), and an electrical accident in 1 (2.4%). Only 4 patients (9.8%) had intact bones and joints of the foot. All other patients had metatarsal or phalanx fractures, defects, dislocations, or amputations. The size of the soft tissue defects ranged from 3×2 cm to 28×6 cm.

We used 32 free anterolateral thigh perforator flaps (78.0%), 2 free fibular flaps (4.9%), 5 free lateral arm perforator flaps (12.2%), 1 free medial arm perforator flap (2.4%), and 1 free thoracodorsal artery perforator flap (2.4%).

After discharge, the patients were followed up on an outpatient basis. The follow-up period started from the day the patient was discharged. It lasted $\geq$18 months. In the present series, the follow-up period was 26.7 ± 9.3 (range 18 to 45) months. Partial weightbearing was begun at 3 weeks, and gait recovery was usually acceptable by 3 months. Full weightbearing began after full union of the flap and fractures.

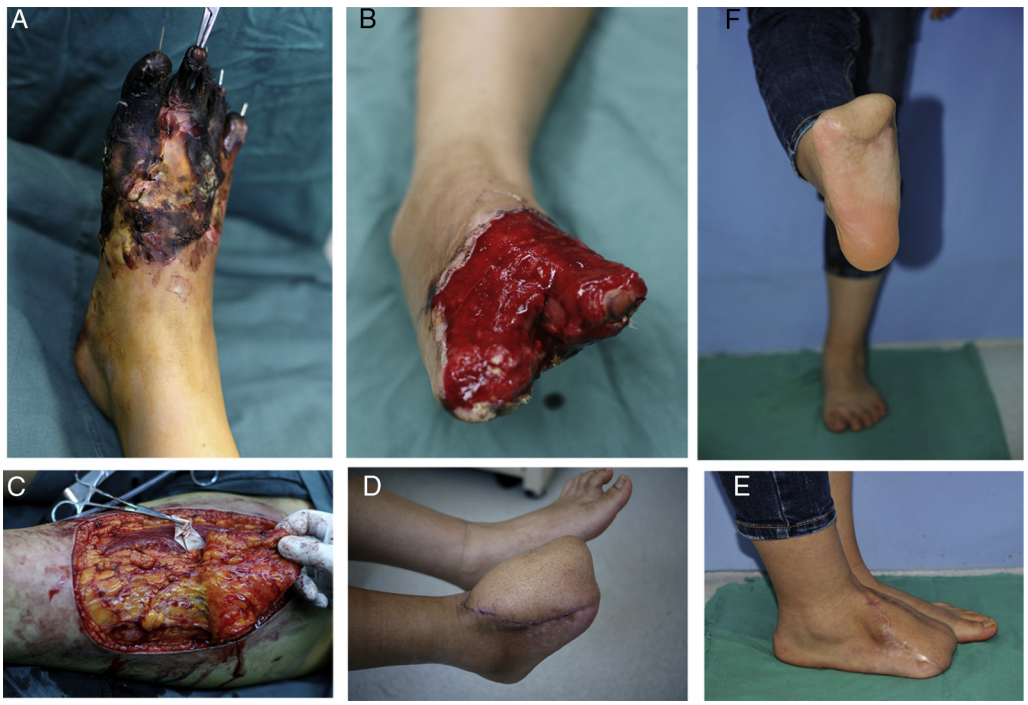

Fig. 1. (*A*) The right foot of a 19-year-old female became partially necrotic 1 week after primary debridement. (*B*) After the second debridement and 2 weeks of daily wound nursing, the wound was clean. (*C*) When harvesting a free anterolateral thigh perforator flap, one half of the subcutaneous fat was left in situ (1-stage debulking). The flap thickness was already considerably decreased. (*D*) After 3 months, the flap had healed well but was too bulky. The patient had trouble wearing shoes, especially when the ankle was dorsiflexed. (*E*) The flap was thinned a second time, and the dorsal contours of the feet were now the same. She had no more trouble wearing shoes. (*F*) The plantar aspect of the foot showed a satisfactory flap form.