MODIFIED RETROGRADE-FLOW MEDIAL PLANTAR ISLAND FLAP FOR RECONSTRUCTION OF DISTAL DORSAL FOREFOOT DEFECTS—TWO CASE REPORTS

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Soft tissue reconstruction of the distal forefoot and toes poses a difficult problem. Skin grafts are not suitable when deep structures are exposed. Local flaps are not available, particularly for defects of the toes. Free flaps are spared for larger defects. Medial plantar flap has been widely used for plantar defects, especially weight-bearing surface of the heel. Distally based retrograde-flow design of this flap allows the transfer of the pedicled flap distally and provides coverage of soft tissue over the metatarsal heads. In this report, we further modified the retrograde-flow medial plantar island flap to extend its use for distal dorsal forefoot defects. The technique and outcomes of two patients are presented. © 2010 Wiley-Liss, Inc. Microsurgery 30:146–150, 2010.

Defects of the forefoot with exposed tendons, bones, and nerves are challenging and are common problems facing the plastic surgeon. Diabetes mellitus, peripheral vasculopathy, or trauma can further complicate the clinical situation. For the dorsal forefoot soft tissue defects, common reconstructive options include skin grafts, local flaps, and free tissue transfer. The retrograde-flow medial plantar island flap (RFMPIF) provides fascia and plantar skin from the instep region and has been used mainly for plantar forefoot reconstruction.[1–5]

The posterior tibial artery bifurcates into medial and lateral plantar arteries. The medial plantar artery travels between abductor hallucis and flexor digitorum brevis muscles, and perforating vessels provide cutaneous blood supply to the instep region. At the base of the first metatarsal bone, it passes along the medial border of the first toe anastomosing with the first dorsal metatarsal artery. At the bases of the first and second metatarsal bones, lateral plantar artery unites with the deep plantar branch of the dorsalis pedis artery, thus completing the plantar arch. When the proximal medial plantar artery is ligated, flow is reversed, and the flap is supplied in a retrograde fashion by the communication with deep plantar arch.[1,2] These communications determine the vascular pivot point and allow the anterior transposition of the flap. To the best of our knowledge, this report is the first to describe the use of RFMPIF for dorsal forefoot soft tissue defects. Herein, we present the technical modifications to further extend the flap and long-term clinical outcomes of two cases.

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SURGICAL TECHNIQUE

Before the surgery, pulsations of dorsalis pedis and posterior tibial arteries were checked. After the patency was verified, a template of the defect was made from a green operation towel. The shape and dimensions of the flap were planned accordingly. For maximally anterior and dorsal transposition, the proposed skin paddle was placed in posterior and dorsal direction rather than centered over the most concave plantar area as in the traditional medial plantar artery flap (Fig. 1). The flap was elevated with the fascia of abductor hallucis and flexor digitorum brevis muscles, and the soft tissue around the pedicle was preserved. The medial plantar nerve was protected and left at the donor site (Fig. 2). To confirm the retrograde circulation, a temporary vascular clamp was applied to the pedicle proximal to the flap. The proximal pedicle was ligated after adequate perfusion was seen. Then the flap was transposed to the defect based on the distal pedicle. The skin between the distal pedicle and the defect was incised, and the skin edges were undermined extensively to facilitate the wound closure and avoid compression over the pedicle. Subcutaneous tunneling was not performed. Once the pedicle was thought to have the possibility of being compressed in the sutured wound, skin graft was used to resurface the pedicle. The flap donor site was covered by split thickness skin graft (STSG).

CASE PRESENTATION

Case 1

A 20-year-old healthy male patient sustained left foot crush injury due to a motorbike accident. A 5 × 4 cm of deep skin defect over the left first dorsal metatarsal joint

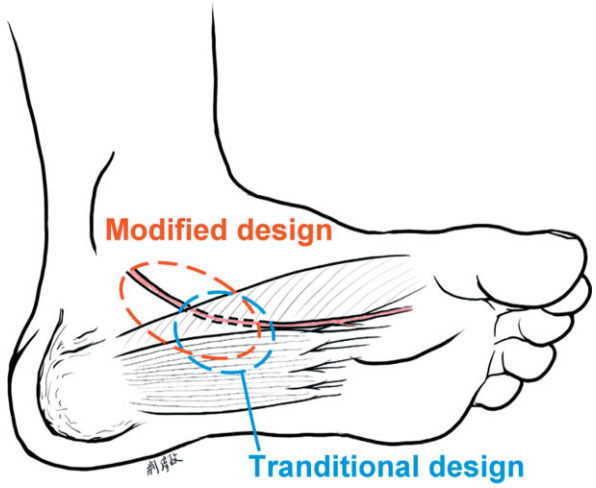

Figure 1. For maximal anterior and dorsal transposition, the modified design of the skin paddle was placed in posterior and dorsal direction rather than centered over the most concave plantar area as in the traditional medial plantar artery flap. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Figure 3. A 5 × 4 cm of deep skin defect located at the left first dorsal metatarsalphalangeal joint area with a partial disruption of extensor hallucis longus tendon and exposure of the first metatarsal joint. A 9 × 4 cm skin defect continued superficially over the medial dorsal foot toward the medial malleolar area. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

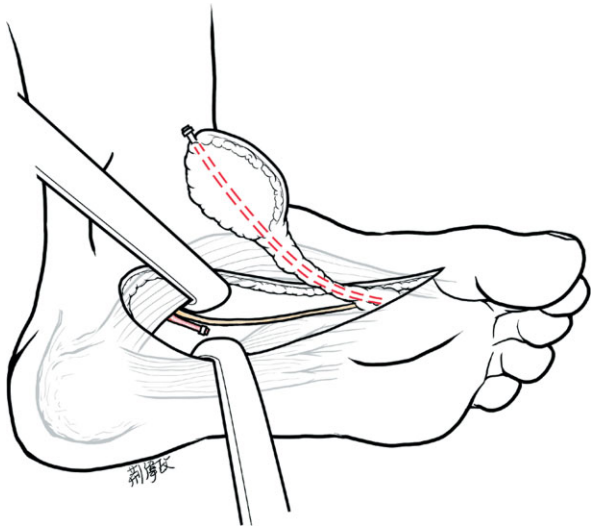

Figure 2. The flap was elevated based on the retrograde flow of medial plantar artery. The medial plantar nerve was protected and left at the donor site. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

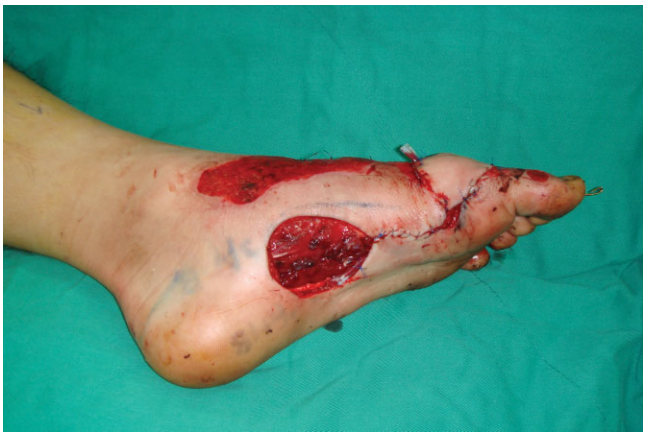

Figure 4. Left RFMPIF was harvested and the flap was transposed to reconstruct the defect over the first metatarsal joint. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

area was observed along with a partial disruption of extensor hallucis longus tendon and exposure of first metatarsal joint. A 9 × 4 cm skin defect continued superficially over the medial dorsal foot toward the medial malleolar area (Fig. 3). Following admission, wound debridement and temporary arthrodesis to first metatarsal joint were performed to stabilize the joint. The wound was covered with saline wet gauze dressing for the following 5 days. Subsequently, according to the technique mentioned earlier, left RFMPIF was harvested and the flap was transposed to reconstruct the defect over the first metatarsal joint (Fig. 4). The superficial skin defect and the flap donor site were covered by STSG. The flap was well perfused and no venous congestion was seen. The patient was discharged on postoperative day 7 and following the removal of the stitches, he underwent physical therapy to overcome the joint stiffness following arthrodesis. In addition, massage over the flap area and maintained joint motion seemed to keep the flap soft and sup-

Figure 5. The figure showed adequate wound coverage of left first dorsal metatarsal joint area by RFMPIF. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

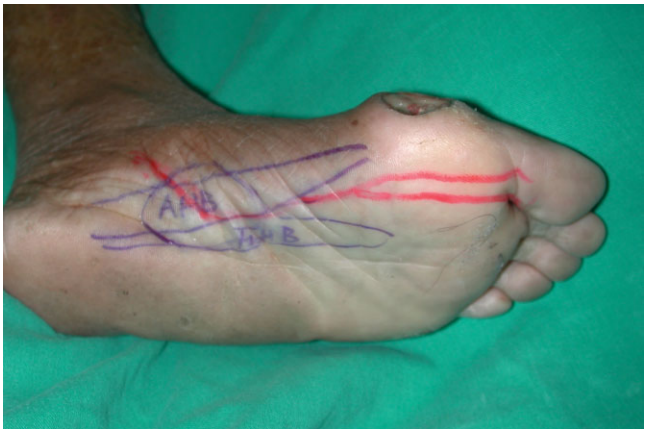

Figure 7. A 3 × 3 cm fasciocutaneous defect was noted over the medial dorsal aspect of first metatarsal joint. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Figure 6. The figure demonstrated no limitation of plantar flexion of the first toe after more than 1 year follow-up. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Figure 8. A 3.5 × 3.5 cm RFMPIF was harvested and transposed to reconstruct the defect. A split thickness skin graft (STSG) from the ipsilateral thigh was used to cover the pedicle for preventing the pedicle from compression when closing the wound. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

ple. The case was followed for 1 year and the postoperative course was uneventful. The plantar flexion of the first toe recovered well (Figs. 5 and 6).

Case 2

A 58-year-old diabetic female patient suffered from bullae formation, which progressed to open wound over the left dorsal foot. After debridement and sequestrectomy for the necrotic bone and surrounding soft tissues several times, a 3 × 3 cm fasciocutaneous defect was developed over the medial dorsal aspect of first metatarsal joint (Fig. 7). Strong and palpable pulsations of dorsalis pedis and tibialis posterior arteries were discerned before the surgery. A 3.5 × 3.5 cm RFMPIF was harvested according to the technique mentioned previously and transposed to cover the defect (Fig. 8). To prevent the pedicle from compression when closing the wound, a STSG from the ipsilateral thigh was used to cover the pedicle and the flap donor site. Tie-over dressing was applied. On postoperative day 10, the patient was discharged. All the stitches were removed on postoperative day 10. The patient received regular physical therapy, and full recovery ensued with no limitation of

dorsiflexion and flexion of the first toe after 6 month follow-up.

DISCUSSION

Soft tissue defects over the first dorsal metatarsal and great toe area may commonly result from trauma and vascular outcomes of diabetes mellitus. Local care, antibiotic therapy, or minor debridement are usually inadequate to handle the problem, especially in diabetic patients.[2] Conventional methods for reconstruction include skin grafts, local flaps, and free flaps.[6] Free flaps are lengthy procedures and spared for larger defects because they require microvascular expertise and sophisticated equipments. Skin graft would not take over the first dorsal metatarsal head area with bare bone or tendon exposure. Vacuum-assisted wound closure (VAC) is traditionally used to treat large soft tissue loss and induces granulation tissue growth before skin graft application.[7] However, in relatively smaller defects as in our cases, the duration of the VAC treatment and the intrusive noise of the machine and restricted mobility can be of concern. Further, secondary contraction of skin graft over the joint area may lead to contracture deformity.

For small defects over the dorsal foot with bare tendon exposure, the use of local flaps is cost-effective, and the widely used alternatives include reversed dorsalis pedis flap, RFMPIF, and toe fillet flap. The donor site morbidity of free or reversed dorsalis pedis flap can occur at the immediate postoperative period and can persist or recur over a decade after the flap was harvested.[8] The problems include delayed donor site wound healing, osteomyelitis, breakdown of skin graft, and ischemic gangrene.[3] Besides, if the first plantar metatarsal artery is dominant, extensive pedicle dissection deep into the intrinsic muscle between the first and second metatarsal bone can further increase the soft tissue damage and secondary donor site morbidities.[9,10] In our first patient, the use of dorsalis pedis flap was precluded because of arterial crush injury.

Toe fillet flap may be another alternative method for the defects over dorsal metatarsal head.[11] However, metatarsalphalangeal joint of great toe plays an important role in "toe-off" phase of gait. Most of the body weight is transferred to the ground during the "toe-off" phase and thus faster pace running requires greater range of motion at this joint.[12] Therefore, especially in young and active patients, amputation of the great toe may not be worthy and problems such as gait disturbance and running disability may ensue.

Oberlin et al.[13] described a method to extend the instep flap by ligation of the posterior tibial vessels just proximal to its bifurcation into medial and lateral plantar vessels to allow the flap to be perfused from the plantar arch, retrograde through the lateral plantar artery. Using this maneuver, the pedicle length can be almost doubled and make it possible to cover the dorsal defect. However, such a procedure may be inadvisable when patients have vascular insufficiency, anatomic anomalies, or previous trauma histories, which involve interruption of blood flow through the dorsalis pedis or peroneal arteries. Therefore, application of such a method would be risky in our two patients because the dorsalis pedis artery was of doubtful quality in the first trauma case and for the second case, sacrifice of the tibialis posterior artery might have posed a further ischemia risk in an already vascularly compromised diabetic foot.

Instead, RFMPIF possesses numerous advantages. It provides durable plantar skin from a nonweight-bearing donor site and avoids exposing the donor site to weight-bearing stresses. It also provides consistently well-vascularized tissue to the defect of the distal foot, and the dissection is similar to that of medial plantar artery flap. After the flap was harvested, the raw surface can be easily resurfaced by a skin graft.[14] Only a single-stage procedure is required, and there is no need to sacrifice a major vessel (e.g., posterior tibial artery). Some soft tissue around the pedicle was retained to protect the pedicle veins and to reduce arterial spasm as suggested by Granick et al.[15] Widely undermining the incision edges of plantar skin in which the pedicle is placed may help to prevent the pedicle compression.

Several modifications are reported to enhance the utility of the flap. Butler and Chevray maximized the anterior reach of the flap by using a posterior skin paddle design and complete dissection of the pedicle to the pivot point.[1] Coruh described a new distally based fasciocutaneous medial plantar flap where the blood supply came mainly from the perforators of the medial plantar artery.[3] The major advantage was not to sacrifice the medial plantar vessels. However, the short length of perforators limited the anterior reach of the flap. Miyoshi et al. reported a retrograde medial plantar flap based on the common plantar digital artery to the second toe.[4] It might enhance the anterior extent of the flap. However, this new design was not suitable for all cases due to the frequent variation of this vascular system.[4] Uygur et al. used the flap to reconstruct the distal forefoot burn defect.[5] Modifications such as including skin over the pedicle and augmenting venous drainage by anastomosing concomitant plantar vein of the flap to the first plantar digital vein were advised to increase the success rates of the flap. Although most of these modifications were designed to extend the anterior reach of the flap to reconstruct the distal plantar defect, no reports were addressed to use this flap to resurface dorsal defect of distal foot.

To reach the dorsal metatarsal head area, increasing the length of the flap is required. Placing the skin paddle

only in posterior direction will achieve the goal, but it also sacrifices the weight-bearing tissue over the heel. Therefore, we modified the flap design by placing the skin paddle not only in posterior but also in dorsal direction. It not only increases the length of flap but also preserves the intactness of weight-bearing heel.

Caution should be emphasized with the use of this flap in high-risk patients, such as those with potential vascular insufficiency (DM or previous trauma). One easy way to determine the vascular status is to check the pulsation of dorsalis pedis artery and posterior tibial artery preoperatively. For a more detailed study of the vascular condition, an ankle brachial index study or noninvasive study such as color Doppler and CT angiography may be helpful to define the vessel condition.

SUMMARY

By the modified design of skin paddle, RFMPIF can be used not only in the plantar forefoot reconstruction but also in the reconstruction of first dorsal metatarsal head wound defects. This option is useful and practical for small- to medium-sized dorsal foot defects at the first dorsal metatarsal area when the dorsalis pedis artery is of doubtful quality.

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