Posterior Tibial Artery Perforator V-Y Advancement Flap for Small–Medium Size Lower Limb Defects

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INTRODUCTION

Restoring soft tissue loss in lower extremities is considered a challenging task for the reconstructive surgeon because of the suboptimal vascularity of the distal parts, weight bearing, limited skin availability, and tight skin envelope.

For many years, muscle flaps and free flaps were considered the gold standard for such defects. At last, the debates between the advantages of muscle versus fasciocutaneous flaps reported similar success rates with fasciocutaneous flaps.1–5 Moreover, fasciocutaneous flaps have advantages of simpler secondary procedures when compared with muscle flaps. Additionally, the significant improvement in perforator flaps make them a reliable option for the most challenging cases, with minimal donor site morbidity, sparing of nerves and muscles, and like-for-like coverage.

The posterior tibial artery perforator flap was described as a good option for small to moderate lower extremity defects with consistent anatomy and caliber.6 Different geometrical designs are found in the literature for posterior tibial artery perforator flaps and are mostly executed as propeller, peninsular, and island flaps. Upon literature review, V-Y advancement flaps were not commonly used, despite the clear design, persistent anatomy, and straight execution. Our aim was to report our case series to present the validity of such design and the success of reconstruction.

Method: Over 1 year, three cases were reconstructed successfully with posterior tibial artery perforator flaps with V-Y advancement design. Clinical evaluation was done for all patients as well as follow-up in the outpatient clinic until complete healing of the wounds was achieved. Multiple modifications were done intraoperatively to enhance flap reach and minimize the complications, including designing V-Y advancement flaps larger than the defect, careful perforator dissection, and finally, strict postoperative course.

Results: All three cases healed completely with no complications. The average follow-up time in the clinic was 3 months.

Conclusions: Posterior tibial artery perforator flap with V-Y advancement design is a viable option for reconstructing medium sized lower limb defects, but requires careful design and execution. The suggested steps will increase the survival of the flap and reconstruct the defect successfully. (Plast Reconstr Surg Glob Open 2022;10:e4139; doi: 10.1097/GOX.0000000000004139; Published online 18 February 2022.)

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complications, as partial or total flap necrosis, venous congestion, infection, and flap survival. All the patients were followed in the clinic to assess healing. The mean follow-up time was 12 months, with no late complications related to our V-Y flaps.

**Case 1**

The patient in Case 1 was a 74-year-old woman with hypertension, type two diabetes mellitus, and chronic kidney disease. She had a motor vehicle accident managed elsewhere and complicated with osteomyelitis and non-union of her left bimalleolar fracture with chronic open wound over left medial malleolus. Figure 1A and B show the initial skin defect dimensions requiring coverage.

After thorough irrigation, debridement and application of vacuum-assisted dressing (VAC), the decision was to take her for wound coverage with a posterior tibial artery perforator V-Y advancement flap.

Figure 1C presents the three perforators that were preserved and incorporated in the flap design. The great saphenous vein was identified but ligated eventually as it was limiting the axial advancement. Donor site was reconstructed with split thickness skin graft.

She had a smooth postoperative course without complications. Figure 1D shows the initial flap appearance after 10 days.

**Case 2**

The patient in Case 2 was a 35-year-old man, a heavy smoker with insulin-dependent diabetes mellitus. He was a victim of a motor vehicle accident and sustained right tibial plafond fracture, with chronic open wound, 3 × 2 cm over the right medial malleolus with exposed bare bone. CT angiography for his lower limb vasculature was reviewed, which showed patent vessels and adequate size perforators. He was taken to the operating theater for coverage via posterior tibial artery perforator V-Y advancement flap.

Intraoperatively, two good-size perforators were identified and preserved, as well as the great saphenous vein. The donor site was closed with a split thickness skin graft. Moreover, his postoperative course was uneventful. Figure 2 shows the immediate intraoperative flap inset.

**Case 3**

The patient in Case 3 was a 74-year-old man with type 2 diabetes mellitus, hypertension, and recent pulmonary embolism on heparin infusion. He had a history of falling down and was admitted as a case of left bimalleolar fracture with exposure of the left medial malleolus and tendinous structures (Fig. 3). After several trips to the operating theater for irrigation and debridement, obtaining negative cultures and preparing him for coverage with the hematologist, we proceeded with posterior tibial artery perforator V-Y advancement flap with split thickness skin graft for donor site (Fig. 4).

Initially, the saphenous vein was preserved to enhance drainage, but eventually it was compromised to enhance flap reach after ensuring good capillary refill (Fig. 4).

His postoperative course was uneventful, and complete healing was achieved (Fig. 4).

**SURGICAL TECHNIQUE**

With hand-held Doppler, two to three perforators were identified along the posterior tibial artery course. The best perforators were located at 6–8 cm and 10–12 cm proximal to medial malleolus (Fig. 1B). The defect dimensions were measured, and the flap was designed larger than the defects. However, it should be kept in mind not to exceed the tibial skin anteriorly and midline posteriorly. The key in all patients was thorough irrigation and debridement of the defect.

A tourniquet was inflated without exinguination for better visualization of veins. Then an exploratory incision through skin and subcutaneous tissue was committed first, and sub-fascial dissection was carried till the perforators were located. With hand-held Doppler, two to three perforators were identified along the posterior tibial artery course. The best perforators were located at 6–8 cm and 10–12 cm proximal to medial malleolus (Fig. 1B). The defect dimensions were measured, and the flap was designed larger than the defects. However, it should be kept in mind not to exceed the tibial skin anteriorly and midline posteriorly. The key in all patients was thorough irrigation and debridement of the defect.

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**Table 1. Patient Demographics**

| Patient | Age/Gender | Medical Conditions | Mechanism of Injury | Resulted Injury | Associated Infections | Exposed Structures | Previous Surgical Interventions |
|---------|------------|--------------------|---------------------|----------------|----------------------|---------------------|--------------------------------|
| 1       | 74 years Woman | Type 2 diabetes mellitus, Chronic kidney disease, Hypertension | Motor vehicle accident | Bimalleolar fracture | Yes | Medial malleolus | - Open reduction and internal fixation |
| 2       | 35 years Man | Type 1 diabetes mellitus | Motor vehicle accident | Plafond fracture | No | Medial malleolus | - Irrigation and debridement and VAC application Debridement and VAC application |
| 3       | 74 years Man | Type 2 diabetes mellitus, Chronic kidney disease | Fall | Bimalleolar fracture | No | Medial malleolus | - Open reduction and internal fixation. - Irrigation and debridement and VAC application |

**Takeaways**

**Question:** Can the posterior tibial artery perforator V-Y advancement flap be used for small to medium-sized defects in the lower limb?

**Findings:** This was a retrospective chart review, consecutive single-surgeon series of three patients with lower limb defects reconstructed via posterior tibial artery perforator V-Y advancement flaps. Patients were followed in the clinic with no observed complications and complete healing of the defects.

**Meaning:** The posterior tibial artery perforator V-Y advancement flap is a valid design, easy to execute with low risk of complications if carefully designed.
along the septum between the flexor hallucis longus and soleus were identified. The proximal end was the soleus muscular perforator, and we did not go beyond this point in any of our flaps. The great saphenous vein was preserved initially in all patients, but it was clamped eventually in two cases after ensuring good capillary refill to overcome tension.

After identifying the perforators, the tourniquet was deflated and Doppler signals were checked. The average size for the chosen perforators was within the range of 1.6–2.5 mm, with good pulsation. Once the validity of those perforators was observed, we committed to full flap design, and the flap was completely elevated subfascially. The perforators were dissected meticulously to source vessel to increase the mobility, and any extra small perforators that would contribute to tension upon advancement were ligated, keeping in mind not to jeopardize the flap viability and to preserve at least two large size perforators (Fig. 4).

Finally, the intermuscular septum was elevated off the tibia from distal to proximal direction, and the flap was advanced axially toward the medial melloulus. The flap was positioned with tension-free closure via non-absorbable sutures.

There was a low threshold to apply the skin graft to the donor site, especially if tension upon closure was a concern (Fig. 4C).

Noncomprisable dressing with a window was applied to allow flap monitoring. Postoperative edema was minimized with leg elevation, back slap, and bed rest for 1 week.

RESULTS

Two patients were above 60 years old. All of our patients were known cases of diabetes mellitus. One case had a chronic open wound complicated with osteomyelitis before closure. The flaps were successful in all of our patients, and complete healing was achieved. No wound dehiscence was encountered, nor venous congestion or partial versus complete flap necrosis.

DISCUSSION

Defects at the distal third of the lower limb harbor specific challenges, particularly in comorbid patients. Baker et al conducted a meta-analysis for perforator based lower limb reconstruction and identified three risk factors for pedicled-propeller flap failure: age above 60 years (relative risk, 1.61; \( P = 0.03 \)), diabetes (relative risk, 2.00; \( P = 0.02 \)), and peripheral occlusive arterial disease (relative risk, 3.12; \( P = 0.01 \)) and no significant impact related to smoking, arc of rotation, acute cause, and location of defect.\(^6\) Thus, those high-risk patients should be reconstructed judiciously, weighing benefits of reliable local perforator versus free flaps.

With the extended knowledge of lower limb vasculature, perforator flaps’ turn to have a significant impact in lower limb reconstruction obviated the need for micro-surgical transfer and minimized donor site morbidities, reduced the operative time, and allowed for relatively early mobilization. Moreover, recent systemic literature reviews

| Patient | Size of Defect | Location            |
|---------|----------------|---------------------|
| 1       | 4 × 7 cm       | Over left medial malleolus |
| 2       | 3 × 4 cm       | Over right medial malleolus |
| 3       | 7 × 4 cm       | Over left medial malleolus |

Table 2. Characteristics of Defects

![Fig. 1. Case 1. A, the preoperative image shows the defect site. B, Preoperative image shows defect dimensions. C, Intraoperative view of the preserved perforators. D, Ten days post flap inset.](image)
reported comparable complication rates between free flaps and propeller flaps, where the reported rate of total flap loss following free flaps used to reconstruct lower limb defects ranged from 4% to 22% compared with perforator flap total loss at 5% and partial flap loss at 11%.

The principle of the free style perforator flap was well introduced in 2004 by Wei and Mardini, and allowed for creative independency to tailor perforator flaps to suit the reconstructive needs of any defect. By combining this principle with the keystone flap concept introduced by Behan, we managed to harvest well-vascularized larger flaps by including multiple perforators in a single fasciocutaneous advancement flap to reconstruct challenging distal third lower limb defects via V-Y design.

Haddock et al conducted MRA for perforator identification to locate the best perforators along the posterior tibial artery as recipient to free flaps. The most proximal perforator, with a diameter of 1.8±0.7 mm, and was located 24.6±3.1 cm cephalic to the medial malleolus and the most distal perforators were 15.5±3.5 cm from the medial malleolus along the posterior intermuscular septum, which is consistent with our perforator locations. Moreover, he reported that the perforators were almost always accompanied by variable sizes of veins, with average being 2 mm, which explained the excellent venous drainage and the lack of venous congestion even after great saphenous vein ligation.

Considering the soleus muscle an easily approachable muscle, especially during lower limb reconstruction, and as it contains abundant superficial perforators, all these factors helped in the ease of locating the ideal perforator and designing the propeller flap in a V-Y fashion.

Poor cosmesis was reported as a limiting factor in posterior tibial artery propeller flaps. We managed to overcome this limitation by the unique V-Y design, which limited the donor site and allowed for a small skin graft. Lastly, V-Y design allows for incorporating more than one perforator with its veins, which improved arterial flow and decreased the chances of venous congestion.

Practical Points to Enhance Mobility and Flap Survival

1. Incision of the deep facia and sub-fascial dissection both allowed for more mobility of the flap toward the defect and provided extra blood supply to the flap by preserving the fascial plexuses.
2. Preservation of the great saphenous vein will enhance the venous drainage and prevent congestion, but if tension is a problem, it can be ligated once good capillary refill is secured.
3. Selection of the best perforator depends on many factors, but important intraoperative points for consideration include good size perforator, which many authors agreed is a minimum of 0.8mm; a pulsating perforator; and relative approximate location to defect. We always deflate the tourniquet after localizing the best perforators to assess the pulsation and to check the strength of Doppler signals.
4. By skeletonizing the perforators and ligating the small side branches, both will alleviate the risk to kink the perforators and will allow for more advancement.
5. Flap design should be larger than the defect, but we suggest not going beyond the solus muscular perforator proximally, tibial shin anteriorly, and midline posteriorly.
6. The flap should be positioned in tension-free style, and no effort should be taken to achieve watertight closure. In fact, any constricting band should be removed. The dressing should be applied by the surgeon in a tension-free fashion as well. And complete bed rest is advocated for the first week with elevation to eliminate edema.

The limitation of this report is the limited number of cases, and we suggest further research in this aspect to explore the validity of the posterior tibial artery V-Y advancement perforator flap and the possibility to apply it for a wide range of defects.

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Fig. 4. Case 3. A, The defect and the proposed flap. B, Intraoperative view of the dissected flap. C, Intraoperative illustration of the dissected perforators. D, Final flap inset and grafted donor site. E, The complete wound healing and graft take 20 days postoperative. F, The complete flap healing with complete graft take and no exposed vital structures.