



Original Research

Reconstruction of Middle and Distal Third Crus Defects with Peroneal Artery Perforator Flap

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Abstract

Objectives: Reconstruction of lower extremity soft tissue defects, which may occur due to various reasons, is challenging. Although different methods have been described in lower extremity reconstruction, the peroneal artery perforator flap has unique advantages. This study aims to present the use of the peroneal artery perforator flap, which is gaining popularity day by day, to treat crus defects.

Methods: Twelve patients with middle or distal third crus defects who underwent reconstruction with peroneal artery perforator flaps were included in the study. The patients were evaluated according to age, gender, etiology, complications, defect area, and defect and flap size. The etiology included chronic wounds in one patient, trauma in six, and tumors in five. Among the patients diagnosed with tumors, two had squamous cell carcinoma, two had malignant melanoma, and one had dermatofibrosarcoma protuberans.

Results: The average age of the patients was 45.9 years. Four of the patients were female, and eight were male. Nine of the defects were located in the middle third of the crus, and three were distal. The flaps ranged in size from 78 to 210 cm². Venous insufficiency was observed in two flaps, and partial necrosis developed distally in one of them. All flaps survived.

Conclusion: The peroneal artery perforator flap is a versatile option that can be used in the middle and distal parts of the crus.

Keywords: Lower extremity, perforator, peroneal artery, propeller, reconstruction

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Lower extremity defects often occur because of trauma. Other causes include tumors and chronic wounds. Reconstruction of lower extremity defects is challenging, especially in patients with vascular insufficiency. There are many methods in lower extremity soft tissue reconstruction, and each has upsides and downsides. Early ambulation, restoration of function, infection prevention, and optimal aesthetic appearance are the main goals in lower extremity reconstruction.

Small defects in the lower extremity can be reconstructed with local flaps. Large defects, especially wounds with exposed bone, are often reconstructed with regional flaps or free flaps. On the other hand, appropriate free flap reconstruction requires a stable patient and a well-trained surgical team.^[1,2] According to classical knowledge, the crus soft tissue defect reconstruction algorithm is designed based on the defect location. Therefore, the leg is divided into three parts: while the gastrocnemius and soleus muscles

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have been considered for large defects of the proximal and middle thirds of the leg, respectively, insufficiency of the neighboring vascular pedicle lengths for regional flaps has favored free tissue transfers for the distal third.^[3]

Like the reconstruction ladder concept, this approach can be of benefit. However, the surgeon should evaluate each wound individually and choose the initial procedure with a high chance of success and low morbidity. In recent years, with the introduction of the advantages of perforator flaps, they have started to take their place among the options, particularly in the reconstruction of the middle and lower thirds of the lower leg.^[4] Perforator flap surgery, which gained momentum with the definition of the angiosome concept, offers advantages like lower donor site morbidity, no need for microsurgery, shorter operation time compared to free flaps, and lower perioperative morbidity.^[5,6]

This study aims to present the use of pedicled peroneal artery perforator flaps in crus defects and highlights the points that surgeons should consider when planning this versatile flap.

Methods

The collection of patient data for the study was conducted after obtaining institutional ethics committee approval (Sisli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee; date: 17.06.2025, no: 4915). This study includes a retrospective analysis of 12 patients who underwent lower extremity soft tissue reconstruction with a peroneal artery perforator flap between January 2018 and December 2019. Data were analyzed in regard to defect etiology and localization, flap size, age, gender, comorbidity, and postoperative complications. All patients were informed about the purpose of the study according to the principles of the Helsinki Declaration, and written/oral consent was obtained for their participation in the study.

In trauma patients, serial debridement and, if necessary, vacuum-assisted closure treatment were applied until a suitable wound bed was obtained. In tumor patients, simultaneous reconstruction was performed after excision with the recommended depth and margin following appropriate staging of the disease. Therefore, excision was performed with a 1–2 cm surgical margin (superficial to deep fascia) in patients with squamous cell carcinoma and malignant melanoma, respectively, and with a 4–5 cm surgical margin (including deep fascia) in dermatofibrosarcoma protuberans.

Surgical Technique

All patients were operated on under spinal anesthesia and in the supine position. Preoperatively, the most appropriate perforator vessel was marked with a hand-held Doppler probe. The flaps were elevated from posterior to an-

terior with the aid of 4.3X loupe magnification. Flaps were dissected in the suprafascial plane unless important anatomical structures, such as the major and lesser saphenous veins and the superficial peroneal nerve, were in the surgical margins of the tumor. If the vena saphenous parva or superficial peroneal nerve was injured in the initial trauma or resected with the tumor, the flaps were elevated completely in the subfascial plane. Dissections were performed until perforators were reached and isolated. The elevated flaps were able to be rotated freely as a propeller on their perforator axis before adapting to the defect (Fig. 1). In cases where the rotation angle increased, pedicle dissection was continued to the main artery and vein. Therefore, the pedicle was released from the surrounding tissues and septum, preventing twisting or tethering. Penrose drains were inserted under the flap. Flap donor regions were resurfaced with split-thickness skin grafts in all patients.

Postoperative Care

Postoperatively, all cases were administered intravenous 1000 mg 2x1 cefazoline and 500 mg 2x1 intravenous paracetamol. Penrose drains were removed on the second day after the operation, and the patients were mobilized. Anticoagulant treatment was not applied. All patients were discharged in the second postoperative week with oral antibiotics and followed up in the outpatient clinic.

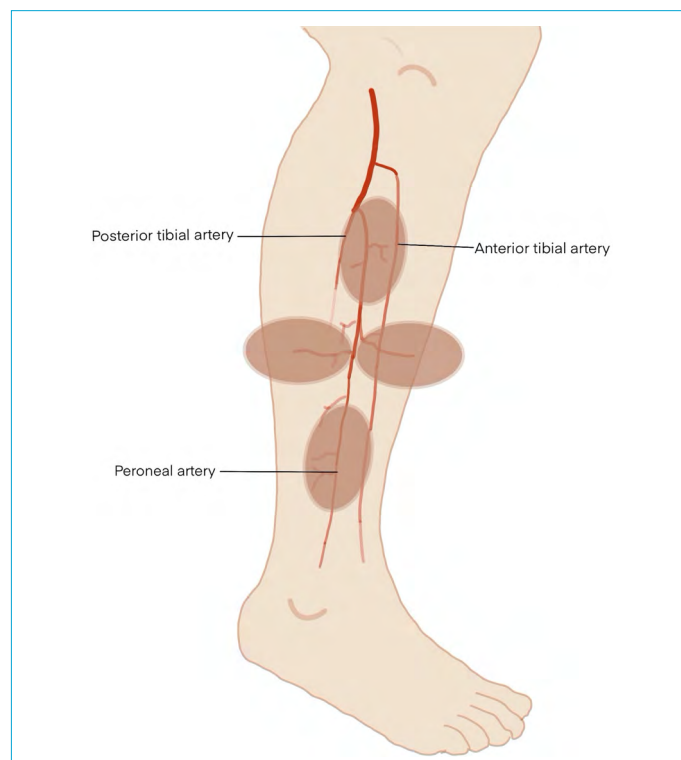


Figure 1. The illustration shows possible peroneal artery perforator flaps for proximal, middle, and distal crus defects.

Table 1. Patient demographic data and clinical characteristics

Case No.	Age	Sex	Etiology	Comorbidity	Defect location in crus	Defect size (cm ²)	Flap size (cm ²)	Complication
1	52	F	Trauma	HT	Middle 1/3	6x6	15x7	Nil
2	58	M	Tumor	DM	Middle 1/3	11x9	19x10	Nil
3	65	F	Trauma	AI	Lower 1/3	10x6	18x6	VI
4	45	M	Tumor	Nil	Middle 1/3	8x8	15x8	Nil
5	35	M	Trauma	Nil	Middle 1/3	8x7	13x6	Nil
6	28	F	Tumor	Nil	Middle 1/3	10x10	21x10	Nil
7	43	M	Trauma	Smoker	Lower 1/3	7x6	15x7	Nil
8	54	M	Tumor	Smoker	Middle 1/3	9x9	15x10	Nil
9	39	F	Trauma	Nil	Middle 1/3	8x6	14x8	Nil
10	61	M	Trauma	Smoker	Middle 1/3	10x8	14x9	Nil
11	41	F	Tumor	Nil	Middle 1/3	10x9	16x6	Nil
12	30	M	Chronic wound	Smoker, AI	Lower 1/3	7x6	13x7	VI, partial necrosis

*M: Male; F: Female; AI: Lower extremity arterial insufficiency; DM: Diabetes mellitus; HT: Hypertension; VI: Venous insufficiency.

Results

The age of the patients varied from 28 to 65 years, with an average age of 45.9 years (Table 1). Four of the patients were female, and eight were male. Four patients were smokers; one patient had diabetes mellitus (Case 2), one patient had hypertension (Case 1), and one patient had lower extremity arterial insufficiency (Case 12). The etiology included chronic wound in one patient (Case 12), trauma in six patients, and tumor in five. Tumor patients consisted of two squamous cell carcinomas, two malignant melanomas, and one dermatofibrosarcoma protuberans.

In the preoperative duplex ultrasound evaluation of the trauma patients, monophasic flow was detected in all three major arteries of the crus in two patients (Case 3 and Case 12), whereas total arterial occlusion was not detected in computed tomography angiography of these patients. Duplex ultrasound evaluation of the other patients was within normal limits.

The flaps ranged in size from 78 to 210 cm². The mean surgical time was 94.6 minutes. While nine of the defects were located in the middle third of the crus (Figs. 2–4), three were in the lower third of the crus (Fig. 5). Three flaps were elevated in the subfascial plane, and the remaining nine were elevated in the suprafascial plane. Clear and safe pathological margins were obtained in all tumor patients, and all remained recurrence-free for a minimum of 12 months.

Total flap loss was not seen in any patient. However, venous congestion and partial flap necrosis at the flap margins were observed in one chronic wound patient (Fig. 5, Case 12). During follow-up, the necrotic tissue was debrided, and wound healing was completed secondarily.



Figure 2. Defect in the middle third of the crus (a); peroneal artery perforator flap elevation (b) and adaptation (c); Postoperative second week (d), second month (e), and tenth month (f) images show healing with minimal deformity.

Additionally, in one patient with chronic wound etiology, self-limiting venous congestion of the flap was observed (Case 12). No complications were seen in the remaining ten patients.

Follow-ups ranged from 16 to 30 months.



Figure 3. Defect in the middle third of the crus (a); 13x6 cm² sized flap planning (b) and elevation (c); peroneal artery perforator flap and split-thickness skin graft adaptation (d, e); postoperative first-month image (f).

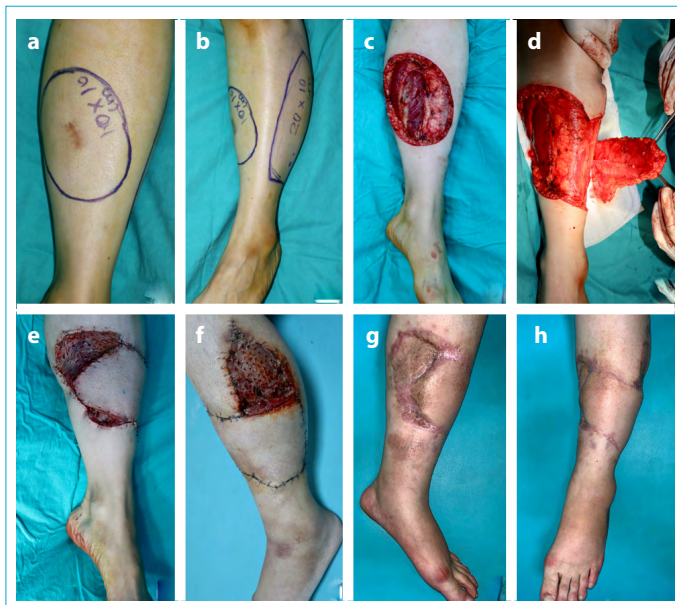


Figure 4. 10 cm diameter sized soft tissue excision planning (a); 20x10 cm² sized flap planning (b); soft tissue defect after excision (c); flap elevation (d); postoperative first month (e, f), sixth month (g, h) images show healing with minimal deformity.

Discussion

In lower extremity reconstruction, each step of the reconstructive ladder can be used in order. However, with progressive improvement of the reconstruction methods in recon-



Figure 5. 13x7 cm² sized flap planning (a); peroneal artery perforator flap elevation (b); adaptation (c); postoperative second week (d), postoperative sixth month (e), postoperative 30th month (f) images show healing with minimal deformity.

structive lift, free flaps can also precede the earlier steps.^[7] Reconstruction with perforator flaps may be a more favorable option in patients with comorbidities who are not suitable for demanding free flap surgery. Perforator flap surgery often does not require microsurgery and allows less dissection and morbidity because it does not jeopardize the major arteries. Furthermore, harvesting flap tissue from near the edge of the defect not only reduces operative complications and simplifies the procedure but also makes perforator flaps a reliable alternative in patients whose recipient vessels are depleted or in whom arterial anastomosis is likely to cause distal organ circulatory failure.^[8]

In 1975, Taylor et al.^[9] introduced the peroneal flap. It was initially used for grafting the vascularized fibula by a cutaneous flap that served only as skin. In 1984, Yoshimura et al.^[10] introduced the peroneal artery perforator flap. Since then, researchers have used a variety of flap types, including perforator, island, and free flaps. The lateral leg is one of

the most appropriate areas for harvesting perforator flaps.^[11] A study by Hansen et al.^[12] found that among the major vessels of the leg, the peroneal artery is the least likely to have atherosclerosis. This advantage makes the peroneal artery a more reliable option as a perforator or pedicled flap, particularly in elderly, diabetic, and smoker patients with chronic wounds.

Indeed, although half of the patients had comorbidities in this study, the reconstructions with the peroneal artery perforator flap were successfully completed. Two patients had monophasic flow in all major arteries of the crus (anterior tibial, posterior tibial, and peroneal arteries; Cases 3 and 12). Partial necrosis developed in the distal flap of one of these patients (Case 12, Fig. 5). While this event might be due in part to arterial and venous insufficiency, the latter was considered more likely because of a high angle of rotation. The debrided necrotic tissues healed secondarily with proper wound care. We consider local flap options as the first choice of surgery in such vascularly depleted patients. Even though we encountered partial necrosis postoperatively, we think that the peroneal artery perforator flap provides great convenience as it is a one-stage and short-time operation and can reasonably be preferred to at least reduce the defect or cover the underlying vital structures.

The peroneal artery travels downward along the postero-medial side of the fibula and generates several perforators to supply blood to the fibula, adjacent muscles, and the skin. It has an average of 6–8 perforators and supplies blood to the region ranging from the middle third to the lower third of the lateral side of the lower limb.^[13] While musculocutaneous perforators are usually distributed from the upper distal third to the middle third, septocutaneous perforators mostly settle from the middle to the lower third.^[10,14] According to anatomical studies, the pedicle length of these perforators ranges between 3.7 and 5.4 cm.^[15] Therefore, the distribution and pedicle length variations of the peroneal artery perforator flap offer a wide variety of coverage options for a large extent of the crus defects.^[13–15]

In our study, we successfully reconstructed 12 distinct defects of the middle and lower thirds of the leg, each with different dimensions and localizations. Four out of 12 perforators were septocutaneous. Shen et al.^[16] performed a successful reconstruction with a 34-cm-long peroneal artery perforator flap. However, it is often considered safe when harvested within the limits of 25×8 cm.^[15] Our largest flap was 21 cm in length and 10 cm in width.

When compared with the gastrocnemius muscle flap used in the coverage of middle third crus defects, the peroneal artery perforator flap requires less dissection and does not cause functional loss due to muscle division. It is not bulky

and provides excellent texture match by replacing “like with like.” Furthermore, the gastrocnemius muscle flap is used mostly in upper third crus defects and does not address the more distal crus defect needs. On the other hand, due to its high blood-supply capacity, muscle flaps are recommended for plate-screw exposed defects and osteomyelitis cases. However, in recent years, it has been shown that perforator flaps are as effective as muscle flaps in osteomyelitis cases, especially in lower extremity defects.^[17]

The peroneal artery perforator flap also offers advantages over other alternatives, such as the reverse-flow sural flap. Firstly, it does not cause sensory deficit compared to the reverse-flow sural flap used in lower third crus defects. In addition, the reverse-flow sural flap generally causes dog-ear deformity due to pedicle rotation, resulting in less cosmetically satisfactory outcomes and more revisional requirements. The peroneal artery perforator flap does not cause dog-ear deformity since rotation is based on the perforator vessels, and it is a single-stage procedure. Bulky appearances after free tissue transfers are common. Peroneal artery perforator flaps are very thin and flexible and require no additional surgery for thinning. Compared with workhorse flaps such as the anterolateral thigh flap, the peroneal artery perforator flap bleeds less, preserves muscle function, has a versatile flap design, and enhances the mobility of the flap.

The success of the peroneal artery perforator flap depends on the perforator size, flap length, and rotation angle. Even if all these conditions are met, venous insufficiency may still occur. In this study, venous insufficiency occurred in 2 out of 12 cases, and partial necrosis was seen in only one patient. The most important cause of venous insufficiency is the angle of rotation. Partial necrosis due to venous insufficiency was observed in a patient with a rotation angle of 180 degrees. In the other complicated patient, venous insufficiency regressed during follow-up. If the angle of rotation cannot be reduced to prevent venous insufficiency, one option is to release the pedicle by dissecting the perforator dissection until reaching the main artery and vein. However, if venous insufficiency is encountered in the postoperative period, leech therapy, bleeding, or flap massage from periphery to center can be performed.

This study has some limitations. First, the study includes a limited number of patients due to the relatively short selected time interval. However, the study's results indicate similar outcomes compared to larger patient series.^[10,15–16] Secondly, this manuscript does not address reconstruction of upper third crus defects. Including upper third defects of the crus might be beneficial to demonstrate a greater degree of versatility of peroneal perforators.

Conclusion

The peroneal artery perforator flap is a reliable and versatile procedure that can be utilized in middle and lower crus defects. Its most significant advantage is that it creates less surgical morbidity, consumes less operative time, and does not necessitate microsurgery compared with free flaps. The peroneal artery perforator flap is a method that should be kept in mind in lower extremity reconstruction due to its advantages.

Disclosures

Ethics Committee Approval: The study was approved by Sisli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee (No: 4915, Date: 17.06.2025).

Informed Consent: Informed consent forms were obtained from the participants.

Conflict of Interest: The authors declare that there is no conflict of interest.

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