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Multiple-Pedicle Peroneal Artery Perforator Propeller Flap for Distal Lower Extremity Reconstruction: Technical Considerations and Preliminary Clinical Outcomes

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Abstract

Background and Objectives: Peroneal artery perforator-based propeller flaps are widely used for reconstruction of distal lower extremity defects. However, venous congestion remains a frequent complication of single pedicle propeller flaps, with reported rates of approximately 15% to over 30%. The clustered perforator anatomy of the peroneal artery may allow incorporation of multiple pedicles within a single propeller flap. This study evaluated the feasibility of multiple pedicle peroneal artery perforator propeller flaps for ankle and distal foot reconstruction. *Materials and Methods*: This retrospective case series included five patients who underwent reconstruction using multiple pedicle peroneal artery perforator propeller flaps between January 2017 and December 2021. Defect characteristics, number of incorporated perforators, interpedicle distance, rotation angle, and clinical outcomes were reviewed. *Results*: The cohort consisted of four males and one female (mean age, 47.4 years). Defects involved the lateral ankle ($n = 3$), anterolateral ankle ($n = 1$), and posterior foot ($n = 1$), with sizes ranging from 16 to 30 cm^2 (mean, 23.6 cm^2). Four flaps incorporated two perforators, and one incorporated three perforators. Interpedicle distances ranged from 32 to 37 mm. Flap rotation ranged from 120° to 180°. None of the cases demonstrated venous congestion, arterial insufficiency, partial necrosis, or total flap loss. All wounds healed within 3–4 weeks (mean, 3.6 weeks). *Conclusions*: Multiple pedicle peroneal artery perforator propeller flaps were technically feasible in this small case series, with complete flap survival and no vascular complications observed among the five patients. Given the small sample size and retrospective design, these findings should be interpreted as preliminary clinical observations rather than evidence of generalized safety or superiority over conventional single-perforator propeller flaps.

Keywords: perforator flap; propeller flap; peroneal artery; multiple pedicle; ankle reconstruction; foot reconstruction

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1. Introduction

Perforator-based propeller flaps have become an established reconstructive option for distal lower extremity defects, allowing local tissue transfer while preserving the major

vascular axes [1–4] (Figure 1). Recent comparative evidence has further supported their role as an alternative to free tissue transfer in selected lower leg and foot defects [4]. Among available source vessels, the peroneal artery system has been widely utilized for distal leg and ankle reconstruction due to its relatively consistent perforator distribution along the posterior fibular border [5–8].

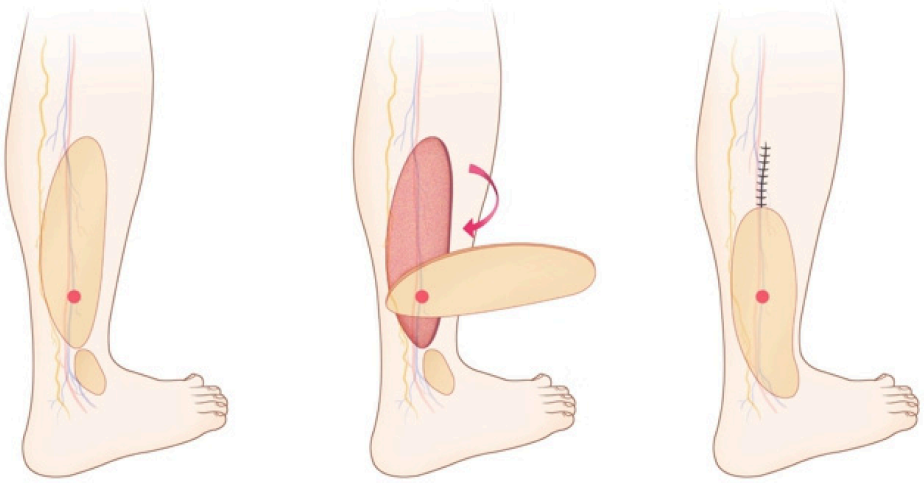


Figure 1. Schematic illustration of a perforator-based propeller flap. The flap is designed around a single perforator pedicle, which serves as the pivot point for rotation of up to 180°. This design preserves the underlying major vascular trunk while allowing coverage of distal defects.

Despite these advantages, venous congestion remains an important complication of perforator-based propeller flaps, particularly after substantial pedicle rotation [9–12]. Recent studies have continued to identify venous congestion as a major cause of flap compromise in lower-extremity propeller reconstruction and have explored adjunctive strategies such as additional venous drainage or venous supercharging [13,14]. This complication is particularly relevant in distal leg reconstruction, where high rotation angles are often required.

Anatomical studies demonstrate that the peroneal artery typically provides multiple perforators within the distal third of the leg [5–8]. The presence of clustered perforators in this region raises the possibility of incorporating more than one pedicle into a single propeller flap design. Although multiple-perforator and double-pedicle flap concepts have been described previously, deliberate preservation of multiple closely spaced perforators arising from the same source artery within a propeller flap has received limited attention.

In this case series, we describe our experience with this single-source, multiple-perforator configuration, with particular emphasis on its technical considerations, including interpedicle geometry and rotational mechanics, and preliminary clinical outcomes in ankle and distal foot reconstruction.

2. Materials and Methods

2.1. Study Design and Patient Selection

This retrospective case series was conducted after approval from the Institutional Review Board of our institution. Medical records of five patients who underwent reconstruction of ankle or distal lower-extremity soft tissue defects using multiple pedicle peroneal artery perforator propeller flaps between January 2017 and December 2021 were reviewed. Patients were included in this series if two or more adequate peroneal artery perforators were preserved in the final flap. This approach was considered for defects suitable for

local perforator flap coverage, whereas peripheral vascular disease or inadequate perforator anatomy precluded selection of the multiple pedicle configuration.

The reconstructive strategy was determined through preoperative vascular assessment and intraoperative evaluation of perforator anatomy. Although preoperative Doppler ultrasonography and computed tomography angiography (CTA) were used to identify potential perforators, the final decision was based on direct intraoperative findings. During flap elevation, the actual perforator locations, interpedicle distance, pedicle mobility, and feasibility of flap rotation were assessed. Multiple perforators were preserved only when they could be incorporated without compromising flap perfusion or tension-free rotation. When the perforators were too widely spaced, or when preservation of multiple pedicles resulted in unfavorable rotational mechanics or compromised perfusion, a conventional flap based on a single reliable perforator was preferred. Thus, the multiple pedicle configuration was selected according to intraoperative anatomical and technical feasibility rather than as a separate reconstructive indication.

2.2. Preoperative Planning

All patients underwent preoperative handheld Doppler ultrasonography and computed tomography angiography (CTA) to assess the peroneal artery, identify suitable perforators, and confirm vascular patency before flap planning.

2.3. Surgical Technique

All procedures were performed under general anesthesia and the patient was placed in the supine position with a sandbag under the ipsilateral hip to facilitate lateral access to the distal lower leg. A pneumatic tourniquet was applied to the proximal thigh. Before tourniquet inflation, perforators of the peroneal artery were identified using a handheld Doppler device and marked on the skin surface. After thorough debridement of the defect and confirmation of healthy wound margins, the flap was designed according to the size of the defect and the distance to the selected perforators (Figure 2a). A skin incision was made along one margin of the designed flap. Septocutaneous and/or myocutaneous perforators arising from the peroneal artery were carefully identified (Figure 2b). The sural nerve and small saphenous vein were identified and carefully preserved throughout the procedure. When multiple perforators were incorporated, each pedicle was meticulously dissected in a skeletonized fashion to achieve sufficient mobility for rotation. Care was taken to avoid excessive traction or compression of the pedicles, and only a minimal cuff of surrounding tissue was preserved when possible to protect the pedicles without unnecessarily restricting their mobility (Figure 2c). Once adequate pedicle length and mobility were obtained, the tourniquet was released to assess flap perfusion. Capillary refill, bleeding from the flap edges, and Doppler signals over the perforators were evaluated before rotation. The flap was then rotated as a propeller around the incorporated perforator pedicles by up to 180° and inset without tension (Figure 2d). After rotation and flap inset, all preserved pedicles were inspected to ensure that the surrounding tissue did not cause pedicle crowding, compression, torsion, or kinking. The donor site was closed primarily and a silastic drain was placed as needed (Figure 2e). Postoperatively, the limb was elevated, and the flap was serially monitored for color, capillary refill, and handheld Doppler signals. Clinical evidence of progressive venous congestion or arterial insufficiency, or loss of a previously detectable Doppler signal, would prompt urgent reassessment for possible re-exploration. Postoperative pharmacologic management consisted of a single oral dose of aspirin 100 mg after resumption of oral intake and a single intravenous administration of alprostadil 10 μg diluted in 100 mL of normal saline.



Figure 2. Representative case demonstrating the surgical procedure and postoperative course of a multiple pedicle peroneal artery perforator propeller flap. (**a**) Preoperative marking showing the flap design centered over the identified peroneal artery perforators along the lateral leg, with the distal defect outlined at the ankle. (**b**) Intraoperative identification of multiple peroneal artery perforators following initial flap elevation, prior to skeletonized pedicle dissection. (**c**) Close-up view of the dissected perforator pedicles, confirming adequate interpedicle distance and vascular integrity prior to rotation. (**d**) Fully elevated flap following completion of skeletonized perforator dissection, demonstrating adequate pedicle mobility prior to propeller rotation. (**e**) Immediate postoperative appearance after 150° propeller rotation and flap inset, with primary closure of the donor site. (**f**) Postoperative day 1, demonstrating flap viability without signs of venous congestion or marginal necrosis. (**g**) Postoperative day 4, showing continued flap perfusion and no distal congestion. (**h**) Postoperative week 2, demonstrating progressive wound healing with intact flap survival. (**i**) Postoperative month 1, showing satisfactory flap integration and suture removal. (**j**) 2 months postoperatively, demonstrating stable flap contour and donor site healing.

2.4. Outcome Assessment

Recorded variables included patient demographics, defect size, designed flap dimensions, flap length-to-width ratio, number of perforators incorporated, interpedicle distance, and rotation angle. Venous congestion was defined as dusky discoloration with brisk capillary refill. Arterial insufficiency was defined as pallor with delayed refill. Partial necrosis was defined as any flap loss not requiring total flap removal. Patients were monitored during the immediate postoperative period and followed clinically until complete wound healing.

3. Results

Five patients underwent reconstruction using multiple pedicle peroneal artery perforator propeller flaps. The cohort consisted of four males and one female, with a mean age of 47.4 years (range, 42–54 years). Defect etiology included infection in three patients and trauma in two patients. Defects involved the lateral ankle ($n = 3$), anterolateral ankle ($n = 1$), and posterior foot ($n = 1$). Defect sizes ranged from 16 to 30 cm^2 (mean, 23.6 cm^2). All defects involved exposed bone, with additional tendon exposure in one case (Case 3). All patients underwent debridement followed by temporary negative-pressure wound therapy before definitive flap coverage, and no exposed hardware was present in any case. Relevant

comorbidities included diabetes mellitus in two patients and dyslipidemia in one patient; one patient was a current smoker. Designed flap dimensions are presented in Table 2, with length-to-width ratios ranging from 3.67:1 to 6.00:1. Four flaps incorporated two perforators, and one flap incorporated three perforators. Interpedicle distances ranged from 32 to 37 mm (mean, 34.8 mm). The degree of rotation ranged from 120° to 180° (mean, 144°). None of the cases demonstrated venous congestion, arterial insufficiency, partial necrosis, or total flap loss, and no additional surgical procedures were required. Time to complete wound healing ranged from 3 to 4 weeks (mean, 3.6 weeks). The mean follow-up duration was 43.8 weeks (range, 36–48 weeks). All patients commenced ambulation within 4 to 6 weeks postoperatively and returned to preoperative occupational activities within 3 months. No late flap-related complications were observed during follow-up. No clinically apparent donor site complications, including scar contracture or sensory disturbance, were identified. Patient and wound characteristics, flap characteristics, and postoperative outcomes are summarized in Tables 1–3, respectively.

Table 1. Patient and wound characteristics.

Case	Sex	Age	Etiology	Location	Defect Size (cm^2)	Exposed Structure	Comorbidity	Smoking
1	M	45	Infection	Lateral ankle	24	Bone	None	Smoker
2	M	53	Infection	Lateral ankle	20	Bone	Diabetes mellitus	Non-smoker
3	M	42	Trauma	Posterior foot	16	Bone, Tendon	Dyslipidemia	Non-smoker
4	F	54	Infection	Lateral ankle	28	Bone	Diabetes mellitus	Non-smoker
5	M	43	Trauma	Anterolateral ankle	30	Bone	None	Non-smoker

Table 2. Flap characteristics.

Case	Flap Dimensions (L × W, cm)	L:W Ratio	Pedicles (*n*)	Rotation (°)	Interpedicle Distance (mm)
1	22 × 6	3.67:1	2	120	34
2	20 × 5	4.00:1	2	150	32
3	24 × 4	6.00:1	3	180	36
4	25 × 5	5.00:1	2	120	37
5	23 × 6	3.83:1	2	150	35

Table 3. Postoperative complications, healing time, and follow-up.

Case	Venous Congestion	Partial Necrosis	Total Loss	Additional Procedure	Healing Time (weeks)	FU (weeks)
1	None	None	None	None	3	47
2	None	None	None	None	4	42
3	None	None	None	None	4	48
4	None	None	None	None	4	46
5	None	None	None	None	3	36

4. Discussion

In this retrospective case series, multiple pedicle peroneal artery perforator propeller flaps were used for reconstruction of ankle and distal foot defects. Flaps incorporating two or three perforators achieved complete survival without venous congestion, partial necrosis, or need for secondary procedures. Notably, rotation up to 180° and coverage extending to the posterior foot were accomplished without vascular compromise (Figure 3). These findings support the technical feasibility of preserving multiple perforators from a single source vessel in selected cases with favorable perforator anatomy; however, the small number of patients does not allow conclusions regarding generalized safety, vascular reliability, or reproducibility.

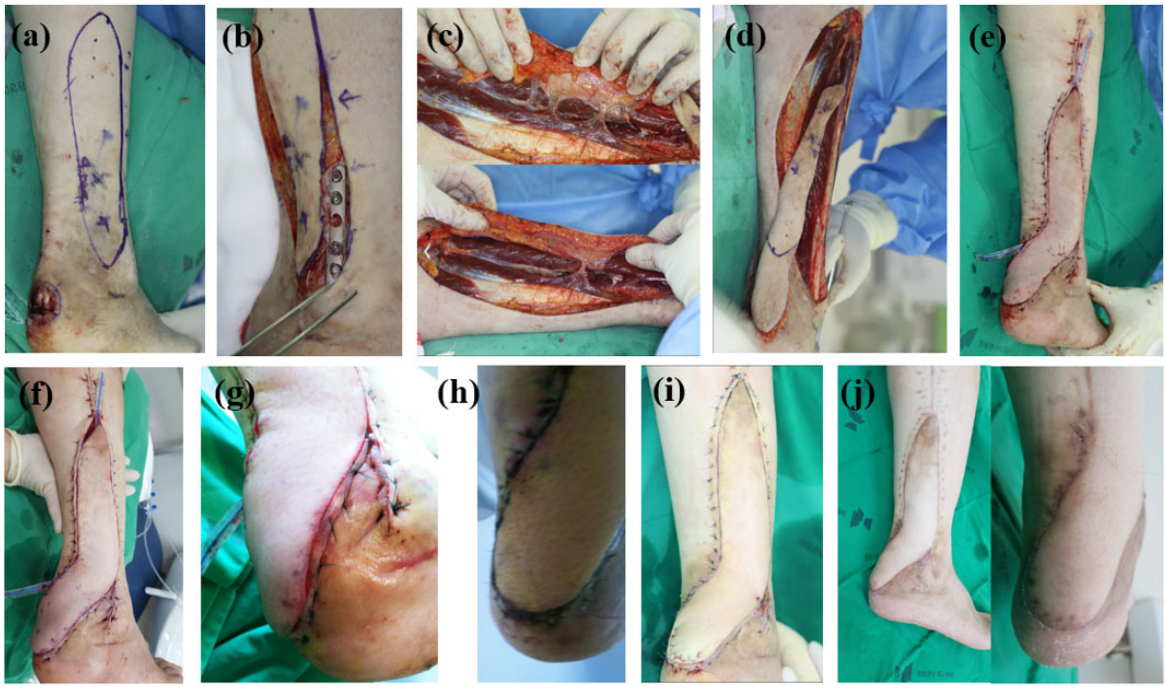


Figure 3. Three-pedicle peroneal artery perforator propeller flap combining septocutaneous and myocutaneous pedicles for reconstruction of a foot defect. (**a**) Preoperative marking showing the flap design along the lateral leg with the soft tissue defect at the foot. (**b**) Intraoperative exposure with perforator locations marked along the peroneal axis. (**c**) Close-up views of the elevated flap demonstrating multiple peroneal artery perforators with adequate interpedicle distance. (**d**) Fully elevated flap incorporating both septocutaneous and myocutaneous peroneal artery perforator pedicles, demonstrating adequate pedicle mobility prior to propeller rotation. (**e**) Immediate postoperative appearance following flap rotation and inset with primary donor site closure. (**f**) Postoperative day 1, demonstrating flap viability without signs of venous congestion, with drain in situ. (**g**) Postoperative day 2, showing continued flap perfusion of the distal flap and heel region. (**h**) Postoperative week 2, demonstrating progressive wound healing with intact flap survival. (**i**) Postoperative month 1, showing satisfactory flap integration and donor site healing. (**j**) 3 months postoperatively, demonstrating stable flap contour and donor site healing.

Venous congestion remains an important cause of flap compromise in lower-extremity propeller flap reconstruction [9–14]. Recent reports have continued to investigate strategies for improving venous outflow, including preservation or addition of a separate venous drainage pathway and venous supercharging [13,14]. Mishra et al. described a perforator-based propeller flap with an additional venous pedicle, whereas other recent clinical data have highlighted the relationship between greater rotation and venous congestion [13,14]. Zheng et al. described a double-pedicle propeller flap incorporating both the peroneal artery perforator and the sural neurovascular bundle, thereby combining two distinct vascular

systems [15]. Their technique differs from the present configuration in that it incorporates the sural neurovascular axis in addition to a peroneal artery perforator. Thus, preservation of more than one vascular pedicle in flap reconstruction is not itself a new concept. The specific technical feature examined in the present series is the deliberate preservation of multiple closely spaced perforators arising from the same peroneal artery within a propeller flap, with particular attention to interpedicle geometry and rotational mechanics.

In our practice, the multiple pedicle configuration was considered when two or more suitable peroneal artery perforators were identified in close proximity within the planned flap and could be preserved without compromising pedicle mobility or flap rotation. This was an intraoperative technical decision based on the observed perforator anatomy rather than a distinct indication for multiple pedicle reconstruction. A conventional single-perforator propeller flap may also have been feasible for the defects in the present series, and our findings do not establish that preservation of multiple perforators was necessary for adequate reconstruction. Rather than combining separate vascular territories, we preserved the sural nerve and relied exclusively on perforators originating from the peroneal artery. The peroneal artery territory appears particularly suitable for multiple pedicle designs. Anatomical studies have consistently demonstrated clustered perforators in the distal third of the leg [5–8], enabling incorporation of adjacent vessels within a single flap. In our series, interpedicle distances ranged from 32 to 37 mm, allowing preservation of multiple perforators while maintaining adequate arc of rotation. In the setting of multiple pedicle propeller flap design, the interpedicle distance may represent an important but insufficiently investigated technical factor. Several studies suggest that adjacent perforators arising from the same source vessel may share perfusion through linking vessels [16,17]. These findings provide theoretical support for inclusion of multiple perforators within a single angiosome territory. However, preservation of multiple perforators also introduces a potential trade-off in rotational mobility. Unlike a conventional propeller flap rotating around a single pivot point, a multiple pedicle flap is constrained by the spatial relationship between the preserved pedicles. When the interpedicle distance is excessively long, simultaneous tension-free rotation of multiple pedicles may become technically demanding. Conversely, when the distance is excessively short, there is a theoretical risk of pedicle crowding, mutual compression, or kinking during high-angle rotation (Figure 4).

Analyses focusing on geometric factors in propeller flap reconstruction have emphasized perforator-to-defect distance, flap dimensions, and rotation angle [18,19]; however, specific evaluation of pedicle-to-pedicle spacing remains limited. In the present series, interpedicle distances ranged from 32 to 37 mm and were technically manageable without evidence of venous compromise after rotation. Although this observation may suggest a feasible range in selected cases, it should be interpreted cautiously given the small sample size. Objective confirmation of pedicle patency after rotation also warrants further investigation. Future prospective studies incorporating standardized intraoperative perfusion assessment may help clarify the relationship between interpedicle geometry and post-rotation vascular stability. However, inappropriate interpedicle spacing may increase the risk of pedicle crowding, mutual compression, or kinking, highlighting the importance of careful intraoperative assessment and pedicle selection. Given only five cases, the interpedicle distance observed here (32–37 mm) should not be regarded as an absolute geometric criterion; cadaveric anatomical studies and larger clinical series with hemodynamic validation are warranted before it can inform surgical guidelines.

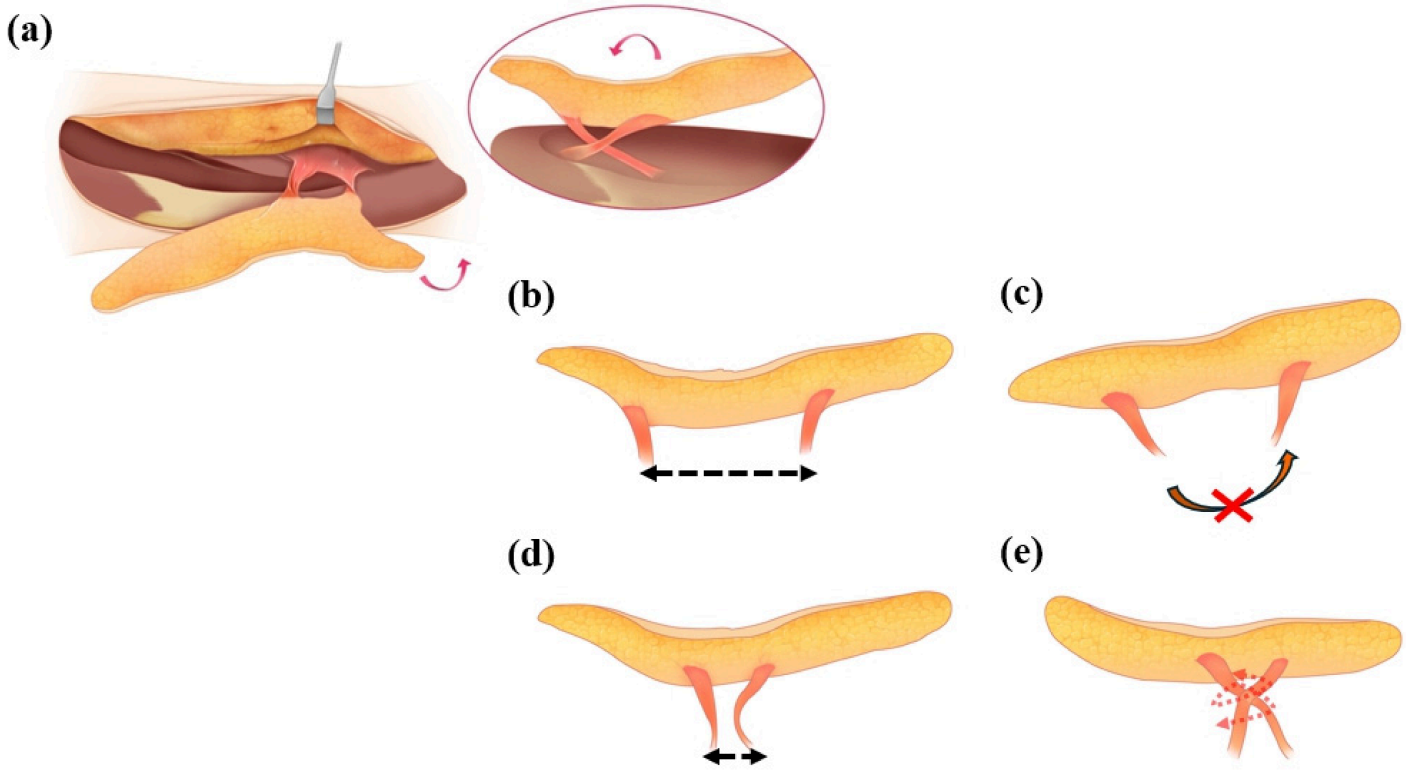


Figure 4. Schematic illustration of the influence of interpedicle distance on rotational feasibility in multiple pedicle propeller flaps. (**a**) The operative concept used in the present study, illustrating a propeller flap based on two perforators with an interpedicle distance comparable to that observed in the present series (32–37 mm). (**b**) A long interpedicle distance between perforators. (**c**) Excessive interpedicle distance may increase tension on one or both pedicles during rotation, limiting tension-free flap inset. (**d**) A short interpedicle distance between perforators, with limited space for independent pedicle movement during rotation. (**e**) When the interpedicle distance is too short, pedicles may become crowded, mutually compressed, or kinked after rotation.

The applicability of this technique appears to depend primarily on local vascular anatomy. In the present series, patients with peripheral vascular disease or inadequate perforator anatomy were excluded, and the multiple pedicle configuration was considered only when two or more suitable peroneal artery perforators could be preserved without compromising flap rotation. Because patient-related vascular risk factors were not systematically evaluated in this small series, specific patient-related indications or contraindications cannot be defined from the present data.

Potential theoretical effects of this single-source multi-perforator design include vascular redundancy and an additional venous outflow pathway within the same angiosome. These potential effects were not directly assessed in the present study. In perforator-based propeller flaps, pedicle dissection is commonly performed in a skeletonized fashion to increase the arc of rotation and allow tension-free inset [20]. However, excessive skeletonization may predispose the pedicle to vasospasm and compromise venous outflow, particularly in distal lower extremity applications where venous congestion is already a known concern [7,11]. Several authors have therefore recommended meticulous pedicle handling and preservation of a minimal cuff of surrounding tissue to maintain vascular stability [20]. In the present series, careful skeletonization permitted rotation of up to 180° without clinically observed venous compromise; however, the present data do not establish the vascular effects or safety of this dissection strategy. Experimental and clinical studies addressing perforator patency, multiple-perforator designs, and twisting mechanics have examined the potential vascular effects of preserving additional perforators [21–24].

However, these findings cannot be directly extrapolated to multiple pedicle propeller flaps, in which rotational mechanics may influence pedicle dynamics differently. The present cohort included three patients with infection-related defects and two with traumatic wounds. Reconstruction in the setting of prior wound infection carries additional challenges, as compromised local vascularity and altered tissue biology may theoretically affect flap perfusion and wound healing. Despite this concern, complete flap survival was achieved in all three infection-related cases without vascular compromise or wound breakdown. This finding is consistent with reports of peroneal artery perforator flaps demonstrating reliable outcomes across mixed etiologies including infection and osteomyelitis, provided that adequate debridement and wound bed preparation are performed prior to flap inset [25]. Furthermore, defect etiology has not been identified as an independent risk factor for complications in propeller flap reconstruction of the lower extremity [26]. Although the small sample size in the present series precludes definitive conclusions, these observations suggest that multiple pedicle peroneal artery perforator propeller flaps may retain clinical applicability even in infection-related wound settings, warranting further investigation.

From a practical perspective, the present findings should be interpreted as hypothesis-generating, providing preliminary guidance for surgical decision-making rather than definitive evidence.

Limitations

No venous complications were observed in this small cohort; however, several limitations should be acknowledged. The absence of a control group of single pedicle cases limits direct comparison, and only patients with favorable perforator anatomy were selected for multiple pedicle design, introducing inherent selection bias. Only five cases met the anatomical requirements for the multiple pedicle configuration during the five-year study period. Because the denominator of patients undergoing alternative reconstructive procedures was not systematically collected, the frequency of this favorable perforator configuration and the proportion of patients potentially suitable for the multiple pedicle technique cannot be determined from this series. Although designed flap dimensions were available, other geometric parameters, including perforator-to-defect distance and effective flap reach, were not systematically recorded and could not be reliably reconstructed retrospectively. Objective intraoperative perfusion assessment tools, such as indocyanine green angiography or laser Doppler flowmetry, were not utilized; therefore, the vascular effects of preserving multiple perforators could not be objectively assessed. Functional and patient-reported outcomes were not assessed using standardized measures, and objective assessments of range of motion, gait, scar quality, and donor site morbidity were not available. Therefore, the reported postoperative outcomes should be interpreted as clinical observations rather than standardized functional or patient-reported outcomes. The present results suggest technical feasibility in selected cases, but the limited sample size and retrospective design require cautious interpretation. Future investigations should incorporate standardized perfusion assessment and direct comparative analysis to clarify the clinical value, safety profile, and optimal indications of multiple pedicle peroneal artery perforator propeller flaps in distal lower extremity reconstruction. Larger studies should also evaluate whether patient-related factors, including age, diabetes mellitus, smoking, and other conditions affecting peripheral vascular status, influence the feasibility and clinical outcomes of this technique.

5. Conclusions

Multiple pedicle peroneal artery perforator propeller flaps were technically feasible for reconstruction of ankle and foot defects in this small case series. Complete flap survival without venous complications was observed in all five patients, including cases requiring

rotation of up to 180°. These preliminary findings support further investigation of this technique in appropriately selected patients. Larger studies incorporating comparative and objective vascular assessments are required to clarify its clinical value.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Yeouido St. Mary's Hospital, The Catholic University of Korea (approval No. SC26RISE0022, approved on 13 March 2026).

Informed Consent Statement: The requirement for informed consent to participate in this retrospective study was waived by the Institutional Review Board of Yeouido St. Mary's Hospital, The Catholic University of Korea (approval No. SC26RISE0022).

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to patient privacy restrictions.

Conflicts of Interest: The authors declare no conflicts of interest.

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