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Reconstructive

Safety and Vascular Impact of Perforator Propeller Flaps during Distal Lower Limb Reconstruction

Tarek Eldahshoury, MRCS, FRCS, MSC*
Roberto Cacciola, MD†
Khaled El-Gazzar, MD‡

Background: In distal lower limb defects, the paucity of local tissues dictates a free-flap (FF)-based reconstruction frequently. The propeller perforator flap (PPF) offers a good alternative when the patient or the limb or both are not fit for FF-based reconstruction. Also, in contexts of restricted healthcare resources, armed conflict scenarios, or during pandemics like the ongoing COVID-19 pandemic, PPF is considered a valuable alternative to free-flap-based reconstruction. Additionally, PPFs are less sacrificing in terms of major limb vessels and distal limb vascularity. Yet, the distal lower limb vascular impact for PPF-based reconstruction has not been studied before.

Methods: In total, 23 patients with distal lower limb defects were reconstructed with PPFs. By using U/S arterial duplex, the peak arterial velocity (PA velocity) was measured pre and postoperatively in 15 (65.2%) out of the 23 patients. This measurement was done to the vessel segment distal to the used perforator.

Results: An estimated 21 out of 23 flaps succeeded to reconstruct the patients' defects safely and to give all patients stable coverage without further surgeries. Only two patients had flap failure, which was managed successfully through additional reconstruction sessions. The difference between pre- and postoperative PA velocity was not statistically significant.

Conclusions: PPFs are a safe cost-effective reconstruction modality for distal lower limb defects. This advantage is very valuable in cases of restricted healthcare resources, wars, and during pandemics. In terms of distal limb vascularity, PPFs have no significant impact and can be used safely. (*Plast Reconstr Surg Glob Open 2021;9:e3993; doi: 10.1097/GOX.0000000000003993; Published online 17 December 2021.*)

INTRODUCTION

The lower third of leg and ankle soft tissue defects represent a challenge for reconstructive plastic surgeons. The high variability of the defects' etiologies influences the selection of reconstruction modality. Often, free flaps (FFs) are preferred over other local reconstruction options because of their better predictability, improved functional outcome, and reduced donor site morbidity.[1,2]

However, the use of FFs is not ideal in all circumstances—specifically when significant comorbidities turn the patient's general condition unfit for major surgeries and prevent the routine use of FFs.[3] Also, in contexts of restricted healthcare resources, armed conflict scenarios, or during pandemics like the ongoing COVID-19 pandemic, alternatives to FF-based reconstruction should be considered.

Perforator propeller flaps (PPFs) are accepted as a reliable alternative technique to address defects of the lower third of the leg and ankle.[4–6] The benefits of PPFs are recognized as requiring less healthcare resources and anesthetic support, as well as being associated with less sacrifice of major limb vessels.[4,6–8]

The utilization of only a small branch of a main artery during PPF reconstruction should not affect the limb vascularity regardless of how many vessels are still in the limb.[3] Besides, no steal phenomenon was reported with PPFs as happens with end-to-side anastomosis of FFs on a single vessel limb.[9,10] Furthermore, in an initial experience study, the PPFs were safely used in recently revascularized limbs with grade IV peripheral arterial obstructive disease.[11] Yet, the impact of PPFs on distal lower limb vascularity was not evaluated in the literature before.

In this study, we describe our surgical strategy and highlight the safety of PPF-based reconstruction in distal lower limb defects. We also evaluate the vascular impact of this kind of reconstruction on distal lower limb vascularity.

PATIENTS AND METHODS

In our series we have included twenty-three consecutive patients who presented to Ain Shams University Hospitals outpatient clinic with distal lower limb defects between September 2016 and September 2020. All patients underwent reconstruction with PPFs. The indication to perform PPF reconstruction consisted of the presence of high risk of complications or lack of resources to perform FF-based reconstruction. The follow-up was performed in an outpatient clinic and was between 7 and 13 months after the reconstruction.

Preoperative Strategy and Planning of PPFs

Our preoperative strategy included clinical evaluation of the lower limb defect and patient status, supported by diagnostic evaluation. The hand-held Doppler (8 MHz) was the mainstay reliable tool in detection of the most suitable perforator vessels, as it increases the accuracy in evaluating the limb vasculature.

By using the U/S arterial duplex, the distal lower limb peak arterial velocity (PA velocity) was recorded in 15 patients (n = 15 = 65.2%) preoperatively. The PA velocity measurement targeted the vessel which the flap was based upon, distal to the used perforator. Therefore, in the case of posterior tibial artery based PPFs, the PA velocity of the posterior tibial artery distal to the used perforator was measured preoperatively. Similarly, this was applied to the peroneal artery vascular axis. The PA velocity measurement was repeated after at least 6 months postoperatively (Table 1). These measurements were used as an objective tool to evaluate the impact of PPF-based reconstruction on distal limb vascularity; the collected values were statistically analyzed.

Statistical Methods

The pre and postoperative PA velocity values were analyzed using the MedCalc Statistical Software, version 18.11.3 (MedCalc Software bvba, Ostend, Belgium). Normality of numerical data distribution was tested using

Takeaways

Question: Are perforator propeller flaps (PPFs) a safe alternative to free flaps during distal lower limb reconstruction? What is the impact of PPFs on distal lower limb arterial flow?

Findings: In this case series study, distal lower limb defects were reconstructed with PPFs. The impact on distal arterial flow was evaluated by U/S arterial Duplex. The PPFs-based reconstruction was found to be a safe, cost-effective modality. The PPFs have no significant impact on distal limb vascularity.

Meaning: The PPFs are a safe cost-effective reconstruction modality for distal lower limb defects.

the D'Agostino-Pearson test. Normally distributed numerical variables are presented as mean and SD. The paired-samples t test is used to compare PA velocity before and after surgery. Two-sided P value of less than 0.05 is considered statistically significant.

In a limited number of cases (n = 3), we consolidated our decision to perform PPF after bilateral lower limbs computerized tomography angiography. Such studies were available in three old trauma patients and clearly defined the patency of the lower limb vascular tree. Also, the review of the previous surgical notes has assisted us in such old cases in completing the preoperative assessment aimed to identify any injury occurring to major vessels of the leg.

The combination of clinical and radiological findings informed the decision for the appropriate surgical strategy and safe choice of arterial axis to base the PPFs upon. In our series, PPFs were based on peroneal artery in 12 patients, and were based on posterior tibial artery in 11 patients.

The Surgical Technique

The steps of performing a propeller flap for lower leg reconstruction have been described in the literature.[4,7,8,12,13] However we highlight specific relevant surgical details.

The Defect Preparation

The initial wound preparation began with meticulous wound/scar excision, hemostasis, and copious irrigation, which was followed by 1-cm edge undermining. One or two superficial veins were dissected for 1–2 cm to be ready for venous supercharging, if needed at the defect site. After initial wound preparation, the defect size and shape were measured, and a template was fashioned accordingly.

The Exploratory Incision

The exploratory incision is recommended to be at the posterior edge of the planned flap, starting from the defect to just above our target perforator. The benefit is represented by the easier conversion to FF-based reconstruction if no adequate perforator could be identified. Such approach may be particularly useful in the absence of comprehensive preoperative studies.

Table 1. Lower Limb Arterial Peak Velocity Preoperative and at least 6 Months Postoperative Values in the Vessels upon Which the Propeller Flaps Were Based

(n = 15)	Case No.	The Examined Lower Limb Vessel	Preoperative PA$_{velocity}$* (cm/s)	Postoperative PA$_{velocity}$* (cm/s)
1	2	PTA	52	50
2	4	PTA	47	44
3	6	PTA	60	60
4	10	PTA	44	40
5	11	PTA	42	44
6	12	Per. A	40	40
7	13	PTA	56	59
8	14	Per. A	48	47
9	15	Per. A	52	50
10	16	PTA	46	49
11	17	Per. A	49	46
12	18	PTA	55	53
13	20	PTA	43	40
14	21	Per. A	44	44
15	22	PTA	60	60

*PA$_{velocity}$ is the peak arterial velocity measured in centimeter per seconds; Per. A, the Peroneal artery; PTA, the Posterior tibial artery.

The Perforator Choice

Preoperative and intraoperative efforts were all directed to choose the nearest reliable perforator to the defect outside the zone of injury. Preoperative hand-held Doppler was used to detect an easily distinguishable high-pitched sound (tri/bi-phasic) perforator on the surface anatomy of the main leg vessel. This sound should be re-detectable and consistent with patient's heart rate.[3,4,13]

There were intraoperative clinical criteria which we considered crucial for the perforator choice. First, the perforator should have an adequate caliber (above 1.5 mm), and should be pulsatile after tourniquet deflation.[14] Furthermore, the length of the chosen perforator is preferred to be no less than 2 cm to tolerate a degree of twist.[15] We also marked the flap width at the chosen perforator site as wide as both flap arms (minimum 2 cm); this width would allow the inclusion of most of subcutaneous perforator's branches, maximizing the "arborization" in the flap territory.

Perforator Fascia and Neurovascular Bundle Fascia Dissection

We dissect the perforator fascia to avoid any tethering band, which may compress the perforator vein after the flap rotation. Dissection proceeds until visualization of the emergence point of the perforator from the main vessel clearly. Although it may be challenging to reach the peroneal artery during dissection, it is worth dissecting the perforator, as far and safe as possible, to gain an adequate length. Yet, we do not advocate dissecting the perforator vein from the artery.

The complete islanding of the flap may be attempted once the perforator is identified and checked after tourniquet deflation. The initial perforator bundle dissection is checked and completed from the opposite direction after islanding the flap.

Flap Design and Dimensions

The PPFs consist of two limbs on both sides of a pivotal point, which represents the landmark over the perforator bundle. The design for the propeller flap is projected in a recommended sequential manner (Fig. 1).

Flap Dissection

We raise our flaps in a subfascial plane until we find the perforator. Afterward, we employ some supra-fascial dissection to preserve the long saphenous vein and the saphenous nerve in case of a posterior tibial vessel–based PPF. Differently, the peroneal artery–based flap dissection is always subfascial; therefore, sural nerve irritation symptoms are expected postoperatively, and such information is clarified in our consent.

Flap Inset

The direction of the flap rotation influences the congestion rate, as demonstrated in a recent study using ultrasound signals in the perforator.[16] Generally, in propeller flaps, the shorter the arch of rotation is, the lower the venous congestion incidence will be witnessed. In case of equal arches of rotation in both directions, a 10-minute
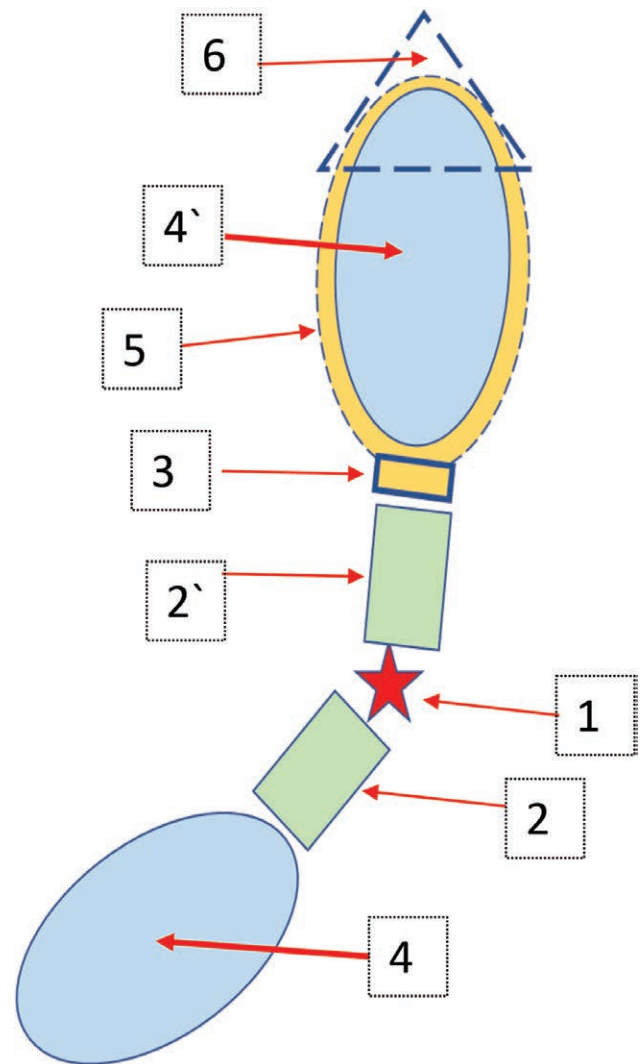

Fig. 1. A diagram showing the sequential recommended steps to design a perforator propeller flap in lower limb reconstruction. 1 = pivot point = perforator detected with preoperative Doppler/confirmed intraoperative. 2 = distal/short limb of the propeller flap. 2` = distal portion of the proximal/long limb of the propeller flap. 3 = 1 cm extension to relax area of perforator after flap rotation. 4 = defect after initial preparation. 4` = flap to cover the defect. 5 = 1 cm extension around the periphery of the designed flap to overcome flap contraction after skin incision, to cover the defect without tension. 6 = 0.5–1 cm of triangular extension to optimize partial direct closure of the proximal flap donor site without dog ear formation.

trial in both directions intraoperatively would guide our decision on the direction of the rotation. Commonly, in PPFs for anterior aspect leg defects, the flap rotation takes a trajectory over the chin of the tibia. The opposite will happen in case of posterior leg defects.

Venous Supercharge

At the proximal zone of the designed flap, one or two superficial veins are dissected and prepared for venous supercharging if indicated. In case of intraoperative flap congestion, 6× surgical loupes are used to anastomose these veins with the defect veins using 9/0 nylon. This

Table 2. Patients' Demographic Data, Characteristics of Leg Defects, and Reconstruction Modality Used

#	Age/Gender	Defect Size, cm (width × length)	Indications	Reconstruction Modality
1	48/man	3×5	Postinflammatory exposed tendoachilles repair	Peroneal perforator propeller flap
2	25/man	5×8	Posttraumatic exposed tibia at the fracture site	Posterior tibial perforator propeller flap
3	56/man	10×6	Posttraumatic exposed tibia at the fracture site with external fixator	Peroneal perforator propeller flap + *venous supercharging*
4	50/man	5×12	Posttraumatic unstable scar over nonunion facture tibia	Posterior tibial perforator propeller flap
5	47/man	11×5	Posttraumatic exposed lateral aspect of heel	Peroneal perforator propeller flap
6	39/man	12×9	Posttraumatic exposed medial distal tibia and ankle over fracture site	Posterior tibial perforator propeller flap
7	52/woman	10×4	Posttraumatic exposed lateral calcaneus with hardware	Peroneal perforator propeller flap
8	28/woman	11×6	Posttraumatic exposed tibia at the fracture site	Peroneal perforator propeller flap
9	60/man	4×12	Exposed tibia at the fracture site	Peroneal perforator propeller flap
10	43/woman	6×6	Posttumor excision exposed distal tibia	Posterior tibial perforator propeller flap + *venous supercharging*
11	59/man	7×12	Posttraumatic exposed tarsal and metatarsal bone	Posterior tibial perforator propeller flap
12	62/man	10×8	Posttraumatic exposed distal tibial fracture site with hardware	Peroneal perforator propeller flap + *venous supercharging*
13	28/man	7×10	Posttraumatic unstable scar over nonunion fracture tibia	Posterior tibial perforator propeller flap
14	35/man	8×6	Posttraumatic exposed tibia at the fracture site	Peroneal perforator propeller flap
15	54/man	6×9	Posttraumatic exposed tibia at the fracture site	Peroneal perforator propeller flap
16	49/man	6×11	Posttraumatic exposed medial distal tibia and ankle over fracture site	Posterior tibial perforator propeller flap
17	51/man	10×6	Posttraumatic exposed tibia at the fracture site	Peroneal perforator propeller flap
18	40/man	6×12	Posttraumatic unstable scar over nonunion facture tibia	Posterior tibial perforator propeller flap
19	53/man	11×14	Postinflammatory exposed tendoachilles and heel	Peroneal perforator propeller flap + *venous supercharging*
20	35/man	6×10	Posttraumatic exposed medial distal tibia	Posterior tibial perforator propeller flap
21	38/man	5×8	Posttraumatic exposed tendoachilles	Peroneal perforator propeller flap
22	57/man	6×12	Posttraumatic exposed medial distal tibia over fracture site	Posterior tibial perforator propeller flap
23	39/man	7×10	Posttraumatic unstable scar over nonunion fracture tibia	Posterior tibial perforator propeller flap + intramedullary nail fixation

Table 3. Data Summary of Patients, Defects, and Reconstruction Modalities Used

Patients				
Gender	Man = 20	Woman = 3		
Age	Range 25–62 y (average = 45.5 y)			
Comorbidities	No comorbidities (n = 11)	D.M. + (one or more other comorbidities) CRD, IHD, HTN, obesity (n = 11)	Other comorbidities COPD + HTN (n = 1)	
Defects				
Site	Lower third leg (n = 13)	Leg and ankle (n = 4)	Ankle (n = 2) Ankle and foot (n = 2)	Heel (n = 2)
Etiology	Posttraumatic (n = 20)	Postinflammatory (n = 2)	Post tumor excision (n = 1)	
Reconstruction modality				
Posterior tibial artery perforator propeller flap (n = 11)				
Peroneal artery perforator propeller flap (n = 12)				

COPD, chronic obstructive pulmonary disease; CRD, chronic renal disease; DM, diabetes miletus; HTN, hypertension; IHD, ischemic heart disease.

Fig. 2. A 52-year-old diabetic female patient with history of a motor car accident. A, Exposed lateral aspect of the right calcaneus with infected hardware. B, The orthopedic team exchanged the infected hardware with K-wire fixation. A peroneal artery perforator propeller flap was used to cover the exposed bone. C, One-week postoperative result with complete wound healing and skin graft take.
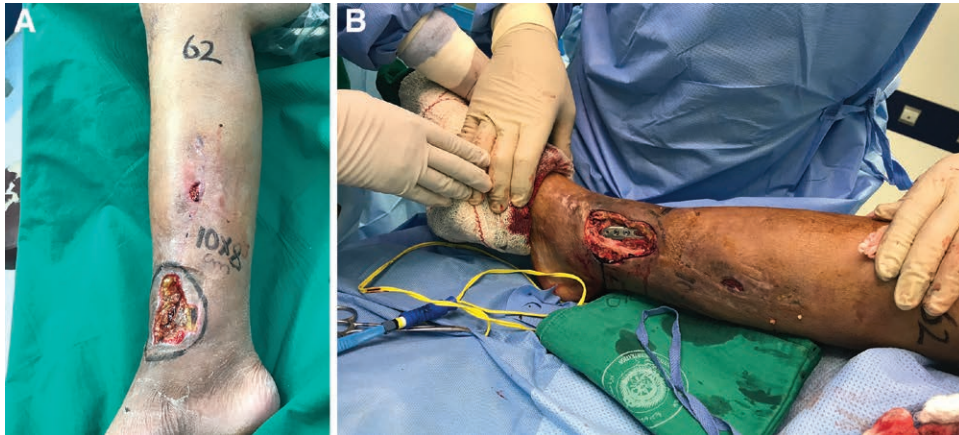
Fig. 3. A 62-year-old male patient with exposed distal tibial fracture site and exposed hardware. A, A 10x8 cm soft tissue defect over the right distal tibia. B, The same defect after surgical debridment of necrotic tissues.

Fig. 4. A 62-year-old male patient with exposed distal tibial fracture site and exposed hardware. A-C, A peroneal artery perforator propeller flap was used to cover the exposed bone and hardware. The peroneal artery U/S duplex examination documented arterial peak velocity 40 cm/s pre-operatively LL which was not changed 1 year postoperatively (C).

is not a rare occurrence in our experience; the necessity of addressing venous supercharging occurred in 17% of our cases (n = 4). Additionally, intraflap dissection may be needed to achieve adequate length for venous supercharge.

Donor Site Closure

We have a very low threshold to use meshed thin split thickness skin graft in the donor site. In medium-size defects, this is planned to avoid tension at the donor site, which might lead to several complications. Skin graft is harvested from the same limb with noncircumferential dressing application to the donor site.

Postoperative Protocol

We advised all patients to keep the limb elevated until complete wound healing. A light dressing was applied with a window exposing the distal zone of the flap for monitoring. Venous thromboembolism prophylaxis protocol was followed according to the Caprani score. We also attempted first graft and leg dressing 1 week postoperatively. Dangling protocol started on the third postoperative

Fig. 5. A 28-year-old male patient with unstable scar over nonunited right tibial fracture fixed with external fixator. A-B, On the day of trauma, operative surgical notes documented a high level injury of the anterior tibial neurovascular bundle. C-D, The orthopedic team exchanged external fixator with intramedullary nail fixation. The unstable scar was excised, and the exposed bone was covered with posterior tibial artery perforator propeller flap. One-year postoperative with complete healing of the tibial fracture and after stable soft tissue coverage.

day; physiotherapy and weight bearing were generally tailored according to patient's status.

RESULTS

In our series, 87% (n = 20) of the patients were men. Patient ages ranged from 25 to 62 years (average age: 45 years). The reconstructed defects were small to medium in size: the minimum dimensions were 3×5 cm, and the maximum were 11×14 cm.

The defects affected the lower third of the leg (n = 13), leg and ankle (n = 4), ankle (n = 2), ankle and foot (n = 2), and heel (n = 2). The etiologies of the defects were posttraumatic exposed bone with/without hardware (n = 15), unstable scar over nonunion fracture tibia (n = 4), exposed Achilles tendon (n = 3) due to trauma, and post tumor excision exposed tibia. Twelve patients had posttraumatic compromised anterior or posterior tibial vessels. Seven patients were diabetic with variable degrees of vasculopathy. Four patients showed a combination of single major vessel injury and diabetic vasculopathy. Patient characteristics and typology of defects are summarized in Tables 2 and 3.

The average total operative tourniquet time was 100 mins, and 20–30 minutes were needed for the skin grafting. The average inpatient stay was 10 days. The average follow up was 12 months (range: 7–13 month). The PPF success rate in our series was 91.3% (21 out of 23),

achieving satisfactory coverage without further surgeries (Figs. 2–5).

In our series, we have not observed postoperatively any case of distal limb vascular compromise. Relevantly, The PA velocity of distal lower limb arteries was measured in 15 (65.2%) out of the 23 patients. The PA velocity measurement targeted the vessel which the flap was based upon, distal to the used perforator. The mean PA velocity (SD) was 49.20 (6.41) cm per second before surgery compared with 48.40 (7.00) cm per second after surgery. The difference between preoperative and postoperative PA velocity was not statistically significant (mean difference = −0.80 cm/s, 95% CI = −2.02 to 0.42 cm/s, $P = 0.183$) (Fig. 6).

Overall, we observed two complications requiring surgical re-intervention. In one obese female patient, the flap was completely lost due to congestion 24 hours postoperatively. Immediate re-exploration of the already anastomosed venous supercharge failed to salvage the flap. Another session of reconstruction in the form of dermal substitute and skin graft successfully managed the condition. In another patient, the flap showed distal congestive necrosis, which was successfully treated with debridement and skin grafting session. We also observed two minor complications (8.7%), including delayed wound healing and partial skin graft loss at the flap donor site (Figs. 7, 8). Neither of them needed surgical intervention and both were managed conservatively (Table 4).
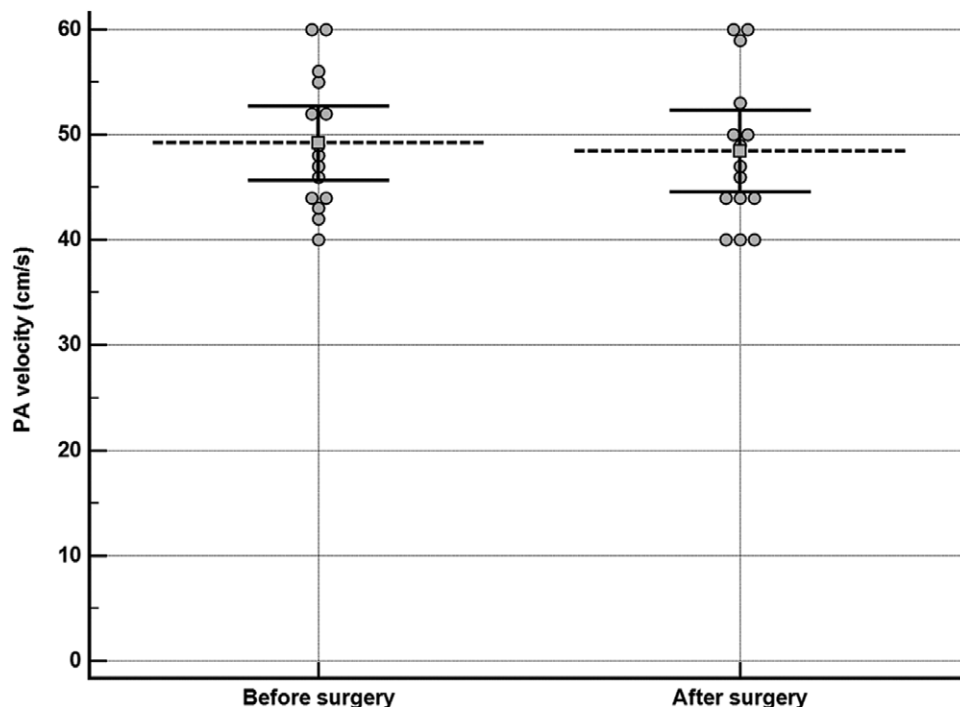

Fig. 6. Peak arterial velocity (PA velocity) before and after surgery. Rounded markers represent individual observations. Squared marker with dotted horizontal line represents the mean. Error bars represent the 95% confidence limits (95% CI). Difference between preoperative and postoperative value is not statistically significant (mean difference = −0.80 cm/s, 95% CI = −2.02 to 0.42 cm/s, $P = 0.183$).

Fig. 7. A right leg distal third defect. A, A 50-year-old diabetic male patient with unstable scar over non-united right distal tibial fracture. B-C, The unstable scar was excised, and the exposed tibial bone was covered with posterior tibial artery perforator propeller flap. The orthopedic team deferred intervention for later session. D, Delayed wound healing at the graft site was managed conservatively for 3 weeks until complete healing.

DISCUSSION

The PPF is a valuable option for distal lower limb defect reconstruction. In our series, PPFs are characterized by an extremely low failure rate and absence of vascular complications. In spite of the limited resources available, PPFs proved to have outcomes comparable to those of the published evidence.[5–8,15]

Frequently, the nature of the lower third of the leg integument hinders attempts of primary closure by undermining and/or random geometric flaps. Therefore, the use of leg perforators is essential for coverage, in terms of raising local flaps or even as recipient vessels in perforator-to-perforator anastomosis type of reconstruction.[3,14,15] Recently, an effective algorithm discussing coverage of lower limb defects was proposed. This algorithm implemented using local flaps hand in hand with FFs in a cost-effective approach. Also, this algorithm justified the selection between different types of perforators FFs.[17,18] However, the option of PPFs remained to match the operative and defect circumstances as well as the surgeon's experience and skills.

PPFs represent an efficient reconstructive technique when compared with other local advancement perforator flap designs. The advancement type designs of perforator flaps such as V-Y[19] and Keystone[20] are safer in terms of perforator kink; however, they do not result in an adequate advancement. This is attributed to the length of the perforator itself and the mobility of the main vessel. Therefore, we reserve them for small-size leg defects. On the other hand, the propeller design is actually very useful and can cover small- to moderate-size defects.

In terms of vascular safety, the PPF does not represent an increased risk to lower limb perfusion. It can even be used in diabetic single vessel limbs successfully.[21] Relevantly, in our series we have not encountered any ischemic signs or symptoms in the reconstructed limbs. This was supported in our study through the maintenance of the distal lower limb PA velocity measurements in the postoperative period. This observation supports the fact that using PPFs has no significant impact on distal lower limb vascularity, and PPFs can be used with considerable vascular safety.
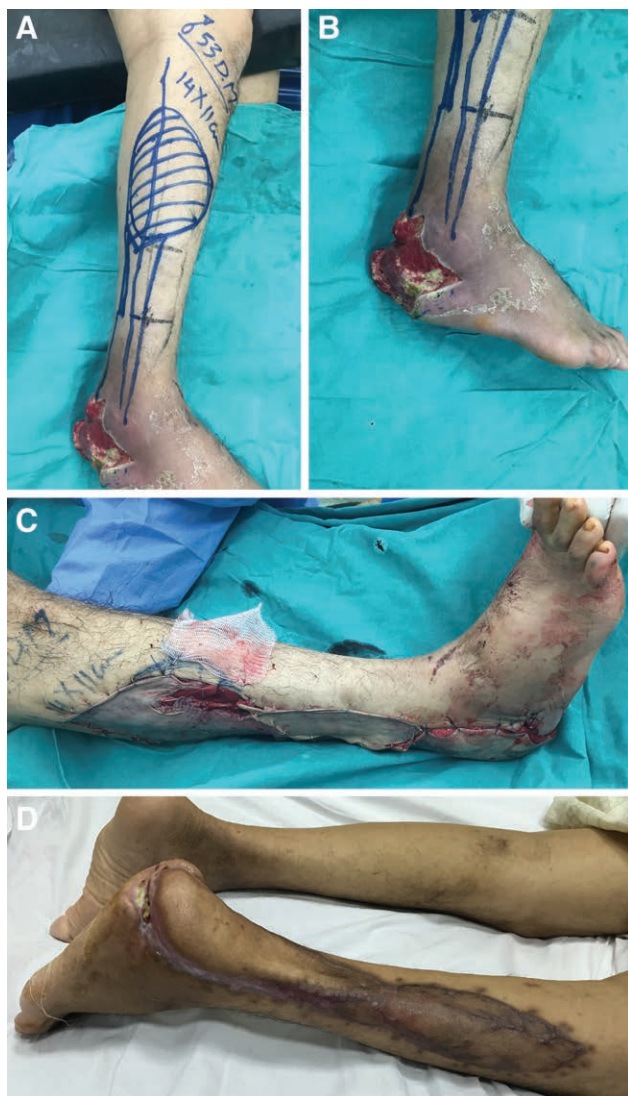
Fig. 8. Diabetic foot with soft tissue defect over the right ankle and heel. A-B, A 53-year-old diabetic male patient with postinflammatory exposed tendoachilles and heel of the right lower limb. C, The defect was reconstructed with peroneal artery perforator propeller flap. D, Eight-months postoperative photograph showed complete healing of the wound despite initial delayed wound healing.

Also, in secondary case scenarios, PPFs have the advantage of being safely re-raised in an axial pattern. This is due to the fact of long-term proved patency of the perforators in the propeller flaps.[22] Hence, PPFs are comparable with FFs in terms of safety during secondary surgeries.

The restricted resources available instructed our practice to identify the perforator vessels by hand-held Doppler ultrasound. Hence, our series also suggests that PPFs can be carried out safely with cheap accurate preoperative planning tools. Of course, this fact adds to the cost-effectiveness and reproducibility of PPF-based reconstruction. Ultimately, there would be more comprehensive preoperative planning if more advanced technologies were used. Recently, the measure of the size and the flow of the assessed vessels with color duplex[23–26] and/or CT angiography[27,28] is commonly used. Intraoperatively, the flap territory vascularization can be evaluated by indocyanine green fluorescence angiography.[29] Such investigations have a great impact on the intraoperative planning and outcomes, but such resources are not available in all institutions. In our study, the evaluation of the cases was conducted without requesting any of the expensive imaging modalities.

Beyond the evaluation and assessment of the perforator vessels arterial side, a similarly relevant challenge is the venous kink/twist causing congestion in pedicled flaps.[30,31] The adoption of venous supercharging is therefore contemplated to reduce the incidence of venous congestion in PPFs.[32,33]

We do acknowledge that the main limitation of our study is a relatively limited number of consecutive cases. However, despite the size of our cohort, the findings of our series may support the decision-making process and practice of many reconstructive surgeons operating in environments with limited resources like ours. It should also be mentioned that PPF-based reconstruction for distal lower limb defects is not the ideal reconstruction modality in certain scenarios involving young and/or female patients. In fact, the resultant scars may not be acceptable for young and/or female patients. Moreover, PPFs can result in nearly circumferential limb scarring, which in turn may cause variable degrees of distal limb edema. Scar management and limb edema conservative protocols help improve both drawbacks. In our study, this was clarified during patients' counseling and weighted against FF-based reconstruction.

A recent meta-analysis comparing the outcomes of FFs with PPFs in lower limb reconstruction found no difference in success of defect closure and rate of complications, apart from partial flap necrosis, which was higher in the pedicled perforator flap group.[6] However, our study does not suggest that PPFs are a better option than FFs. We believe that both techniques are complementary, and reconstructive surgeons should have them ready in their armamentarium to be used with great wisdom. Practically, there is a gray zone between the indications of local and FFs for distal lower limb reconstruction. The learning curve and experience with PPFs expands this gray zone further.

We believe in using FFs rather than PPFs in cases of large-size defects, high energy trauma with progressive

Table 4. Incidence of Major and Minor Complications among Patients

Case No.	Minor Complications (n = 2)	Management
2	Partial graft loss at the flap donor site	Dressing until healing with secondary intention
3	Delayed wound healing	Dressing until healing with secondary intention

Case No.	Major Complications (n = 2)	Management
7	Partial flap loss	Debridement + reconstruction with skin graft
10	Total flap loss	Debridement + reconstruction with dermal substitute and skin graft

zone of injury, high functional reconstruction needs, and trauma in venous compromised or lymphedematous limbs. In virtue of that, our threshold for PPFs for management of small to moderate defects is significantly lowered following the observation of comparable outcomes with FFs, as well as maintenance of safety, feasibility, and cost-effectiveness.

Considering the concurrent financial impact of COVID-19 on healthcare in general, and on plastic reconstructive surgery in particular, alternative cost-effective, safe modalities should be considered, aiming to conduct our medical services with lower cost compared with the pre-pandemic period.[34] The appropriate use of PPFs represents such principles. The PPF is a safe and cost-effective reconstruction technique for distal lower limb defects, especially when the resources are limited and/or in the presence of global crises such as wars and pandemics.

Khaled El-Gazzar, MD
Plastic and Reconstructive Surgery Department
Ain Shams University
Cairo, Egypt
E-mail: Khaled.elgazzar@gmail.com

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