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CLINICAL RESEARCH

Are There Risk Factors for Complications of Perforator-based Propeller Flaps for Lower-extremity Reconstruction?

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Abstract

Background Conventional pedicled flaps for soft tissue reconstruction of lower extremities have shortcomings, including donor-site morbidity, restricted arc of rotation, and poor cosmetic results. Propeller flaps offer several potential advantages, including no need for microvascular anastomosis and low impact on donor sites, but their drawbacks have not been fully characterized.

Questions/purposes We assessed (1) frequency and types of complications after perforator-based propeller flap reconstruction in the lower extremity and (2) association of complications with arc of rotation, flap dimensions, and other potential risk factors.

Methods From 2007 to 2012, 74 patients (44 males, 30 females), 14 to 87 years old, underwent soft tissue reconstruction of the lower extremities with propeller flaps. General indications for this flap were wounds and small- and medium-sized defects located in distal areas of the lower extremity, not suitable for coverage with myocutaneous or muscle pedicled flaps. This group represented 26% (74 of 283) of patients treated with vascularized coverage procedures for soft tissue defects in the lower limb during the study period. Minimum followup was 1 year (mean, 3 years; range, 1–7 years); eight patients (11%) were lost to followup before 1 year. Complications and potential risk factors, including arc of rotation, flap dimensions, age, sex, defect etiology, smoking, diabetes, and peripheral vascular disease, were recorded based on chart review.

Results Twenty-eight of 66 flaps (42%) had complications. Venous congestion (11 of 66, 17%) and superficial necrosis (seven of 66, 11%) occurred most frequently. Eighteen of the 28 complications (64%) healed with no further treatment; eight patients (29%) underwent skin grafting, and one patient each experienced total flap failure (2%) and partial flap failure (2%). In those patients, a free anterolateral thigh flap was used as the salvage procedure. No correlations were found between complications and any potential risk factor.

Conclusions We were not able to identify any specific risk factors related to complications, and future multicenter studies will be necessary to determine which patients or wounds are at risk of complications. Propeller flaps had a low failure rate and risk of secondary surgery. These flaps are particularly useful for covering small- and medium-sized defects in the distal leg and Achilles tendon region and are a reliable and effective alternative to free flaps.

Level of Evidence Level IV, therapeutic study. See the Instructions for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
This work was performed at Careggi University Hospital (Florence, Italy) and at CTO-M. Adelaide (Turin, Italy).

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Introduction

Reconstruction of soft tissue defects of the lower limb by means of pedicled flaps relies most commonly on conventional myocutaneous or muscle flaps and, rarely, on axial fasciocutaneous flaps. These options, however, are associated with some unfavorable features. In addition, few, if any, local options are available to cover defects of the distal ⅓ of the leg and the Achilles tendon region. Some authors [1, 19, 23] have advocated the use of free flaps as the gold standard to cover soft tissue loss in these areas.

The advent of perforator flaps has radically changed this perspective. According to the Gent consensus [2], perforator flaps consist of a skin paddle, with or without its fascia, nourished by perforator branches, originating from the deep vascular axis, with an intramuscular (musculocutaneous perforator flap) or septal (septocutaneous perforator flap) course. Local perforator flaps may be transposed to the recipient area either according to a VY pattern or rotated up to 180° [5, 6, 9]. The Tokyo consensus on propeller flaps [16] defines a perforator propeller flap as "a perforator flap with a skin island made of two paddles, one larger and one smaller, separated by the nourishing perforating vessel that corresponds to the pivot point." These flaps offer several advantages: they spare major vessels, have low donor-site morbidity, repair "like with like," are available virtually anywhere, and their harvesting time is relatively short. For these reasons, propeller flaps have gained increasing popularity for soft tissue reconstruction during the past 10 years [10–13, 17, 25, 27]. However, complications do occur after these procedures, and the risk factors for complications and flap failures have been only incompletely described [3, 7, 14, 20, 21]. If some patients or kinds of soft tissue defects are at particular risk for failure or complications, this would be important to know.

We therefore assessed (1) the frequency and types of complications after perforator-based propeller flap reconstruction in the lower extremity, and (2) the association of these complications with several potential risk factors such as patient age, etiology of the defect, type and size of flap, and amplitude of the arc of rotation.

Patients and Methods

Study Population

Seventy-four patients (44 males, 30 females) with lower-extremity defects treated with propeller flaps were seen during a period of 6 years (from 2007 to 2012) and were reviewed in this study. Patients were treated in two different centers by two senior surgeons (MI, PT) with comparable microsurgical expertise and similar cultural background, following the same surgical rationale. During the study period, the general indications for this flap were wounds and defects of small and medium size located in distal areas of the lower extremity, not suitable for coverage with myocutaneous or muscle pedicled flaps. This group represented 26% (74 of 283) of patients treated during that time with vascularized coverage procedures for soft tissue defects in the lower limb. Only poor condition of the skin in the proximity of the defect, such as irradiated skin, extended infection, and lymphatic congestion, were considered contraindications to the use of propeller flaps. Smoking, diabetes, and peripheral arterial or venous diseases were not contraindications for surgery. The mean patient age was 54 years (range, 14–87 years). The size of the flaps ranged from 5 x 2 cm to 25 x 15 cm. Minimum followup was 1 year (mean, 3 years; range, 1–7 years); eight patients (11%) were lost to followup before 1 year.

Post-traumatic defects (27 of 66, 41%), oncologic resection (18 of 66, 27%), and postoperative complications of orthopaedic surgery (17 of 66, 26%) were the three main causes of the soft tissue loss. The location of the wounds we covered with these flaps was the knee, the distal ⅓ of the leg, and the Achilles region. Flaps were nourished by perforators arising from eight deep vascular sources: posterior tibial artery, anterior tibial artery, deep femoral artery, peroneal artery, lateral femoral circumflex artery, medial superior genicular artery, lateral popliteal cutaneous artery, and medial plantar artery. Flaps nourished by the posterior tibial artery (n = 41) and the deep femoral artery (n = 10) accounted together for 77% of all flaps.

Operative Technique

Surgery usually was performed with the patient under spinal anesthesia (62 of 66 patients). We used general anesthesia only in patients in whom coagulation problems or local anomalies of the spine contraindicated or impeded spinal anesthesia. The harvest of propeller flaps can be done under loupe magnification, and there is no need for a microscope. The extremity was exsanguinated and a thigh tourniquet inflated. The choice of flap design and of the main vascular source depended on several variables, with location and size of the defect being the most important. Namely, propeller flaps based on perforators arising from the posterior tibial artery have been used in defects located in the Achilles region and the medial malleolus and medial aspect of the foot (Fig. 1), while peroneal artery propeller flaps were preferred in defects involving the lateral malleolus and lateral aspect of the foot. Defects around the knee were covered either by flaps based on perforators of

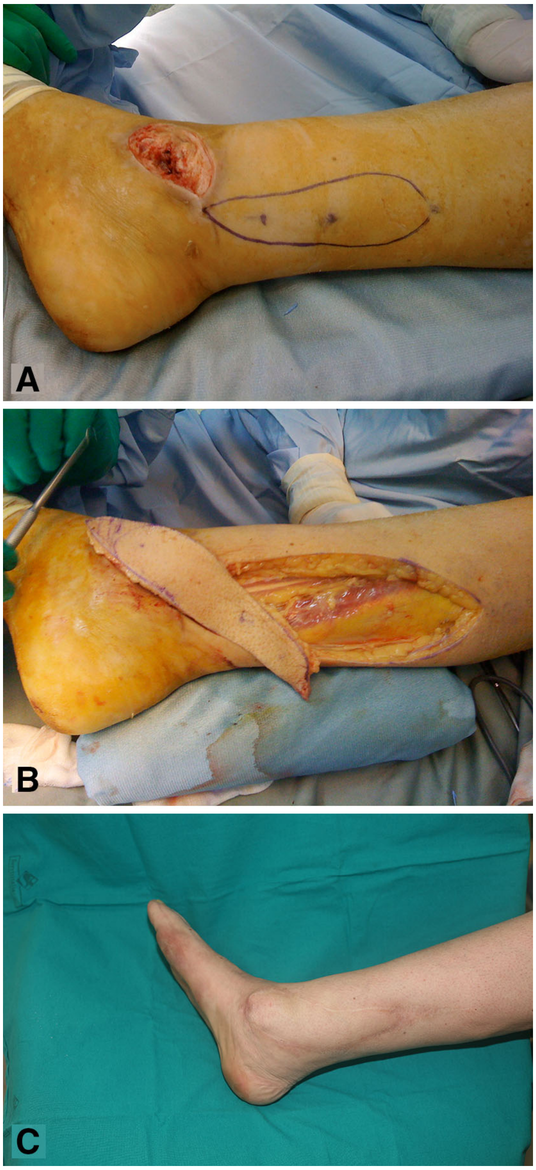

Fig. 1A–C (**A**) A propeller flap based on a perforator of the posterior tibial artery is harvested to cover a dehiscence of the wound after medial malleolus fracture in a 57-year-old woman. (**B**) The rotation was 120° and (**C**) the donor site was closed primarily.

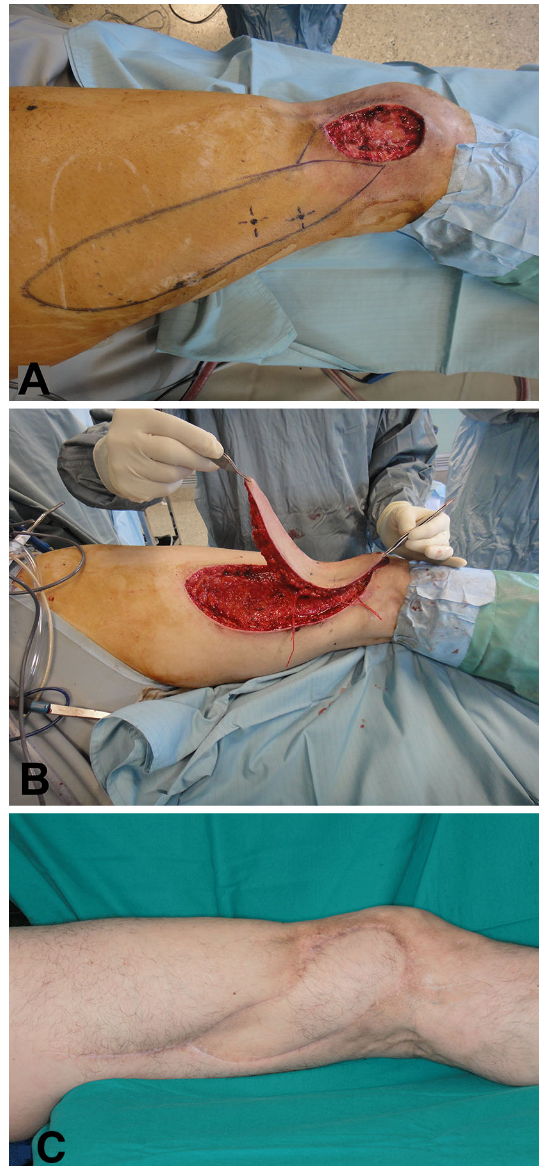

Fig. 2A–C (**A**) A propeller flap based on a perforator of the deep femoral artery is used to cover a post-traumatic defect around the knee. (**B**) The flap is raised on the chosen perforator. The recipient site is covered by the major blade, while the donor area is partially closed with the small blade and partially directly sutured. (**C**) The result after 1 year is shown.

the deep femoral artery or the medial superior genicular artery (Fig. 2). The distance between the recipient site and the suitable perforator was taken into account, keeping in mind that the ideal propeller flap was a healthy skin paddle adjacent to the defect with the major axis located over the projection of the deep artery from which the perforator originated (Fig. 3).

Once the main vascular source was selected, we evaluated the location and size of the perforators by means of color Doppler imaging. According to Panagiotopoulos et al. [15], this imaging technique is an inexpensive and reliable tool to detect septocutaneous perforators 1 mm or larger. The final decision however was made only after direct observation and assessment of the perforator's dimension, location, and pulse. The flap then was provisionally planned and designed around the chosen perforator, which was the pivot point. The typical design of a propeller flap was longitudinally oriented and proximal to the defect. A major paddle whose length equaled the defect's length from the pivot point upward, and a minor paddle, which included the skin between the pivot point and the proximal edge of the defect, formed the flap (Fig. 4). We designed the major paddle of the flap 1 to

Fig. 3 The defect is located posterior to the medial malleolus. The ideal design of this propeller flap based on a perforator of the posterior tibial artery is with the main axis located on the projection of the source vessel.

1.5 cm longer and 0.5 to 1 cm wider than the defect to avoid tension and allow tissue retraction (Fig. 5A).

Perforators from any major artery are usually located on a single row along the vascular longitudinal axis [20]. After location, we then performed a first longitudinal exploratory skin incision on one of the margins of the flap to observe all the possible perforators. The most suitable one was selected according to its location, dimension, and pulse (Fig. 5B). The most suitable one was selected according to its location, dimension, and pulse. Afterward, the definitive shape of the flap was designed and the incision completed. Propeller flaps may be raised either including the fascia or not; however, in our experience, it is safer to perform a subfascial dissection as it provides a better view of the pedicle. The selected perforator was dissected carefully from the surrounding tissue for at least 2 cm, if possible up to its origin from the main vessel. This reduces the risk of compression after rotation of the pedicle [25]. The flap then was raised (Fig. 5C) and rotated (Fig. 5D) around the pivot point, which corresponded to the selected perforator (Fig. 5E). The distance of the perforator from the proximal edge of the defect determined the length of the minor paddle used to cover or partially cover the donor site. If direct closure of the donor site was not achievable, a skin graft was used to close the residual defect.

Postoperatively, the limb was elevated for 48 hours to reduce the risk of venous congestion, which is the most common complication. Any compression on the flap was avoided. Regular wound care was provided up to definitive healing of the wound. For all patients, postoperative anticoagulation prophylaxis with low-molecular-weight heparin has been used.

Surgical time spent in raising and rotating the flap to recipient site, without considering additional procedures such as bone fixation or tendon reconstruction if needed, ranged from approximately 60 to 120 minutes (with 100 minutes being a rough average) and the length of hospital stay of the patients ranged from a minimum of 3 days (for patients with successful flaps) to a maximum of 10 days (for patients with complications requiring additional surgery).

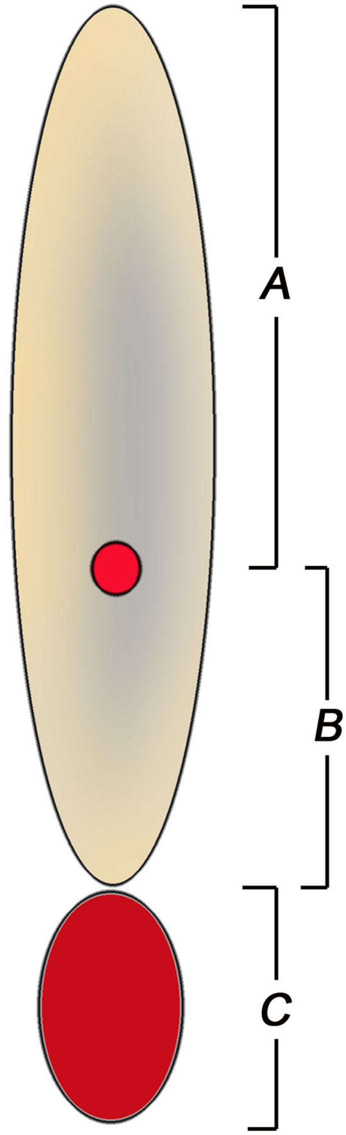

Fig. 4 Assuming that the perforator corresponds to the pivot point, a propeller flap consists of two blades: a longer one proximal to the perforator and a shorter one distal to it. The length of the major blade (A) must be equal to the length of the short blade (B) plus the distance between the proximal and the distal edge of the defect (C). After the rotation of the flap, the short blade is used to cover at least partially the donor site.

Outcomes

Survival rate and complications of the flaps were evaluated by chart review. The frequency and types of complications (eg, necrosis, venous congestion, epidermolysis, wound dehiscence, hematoma) were recorded.

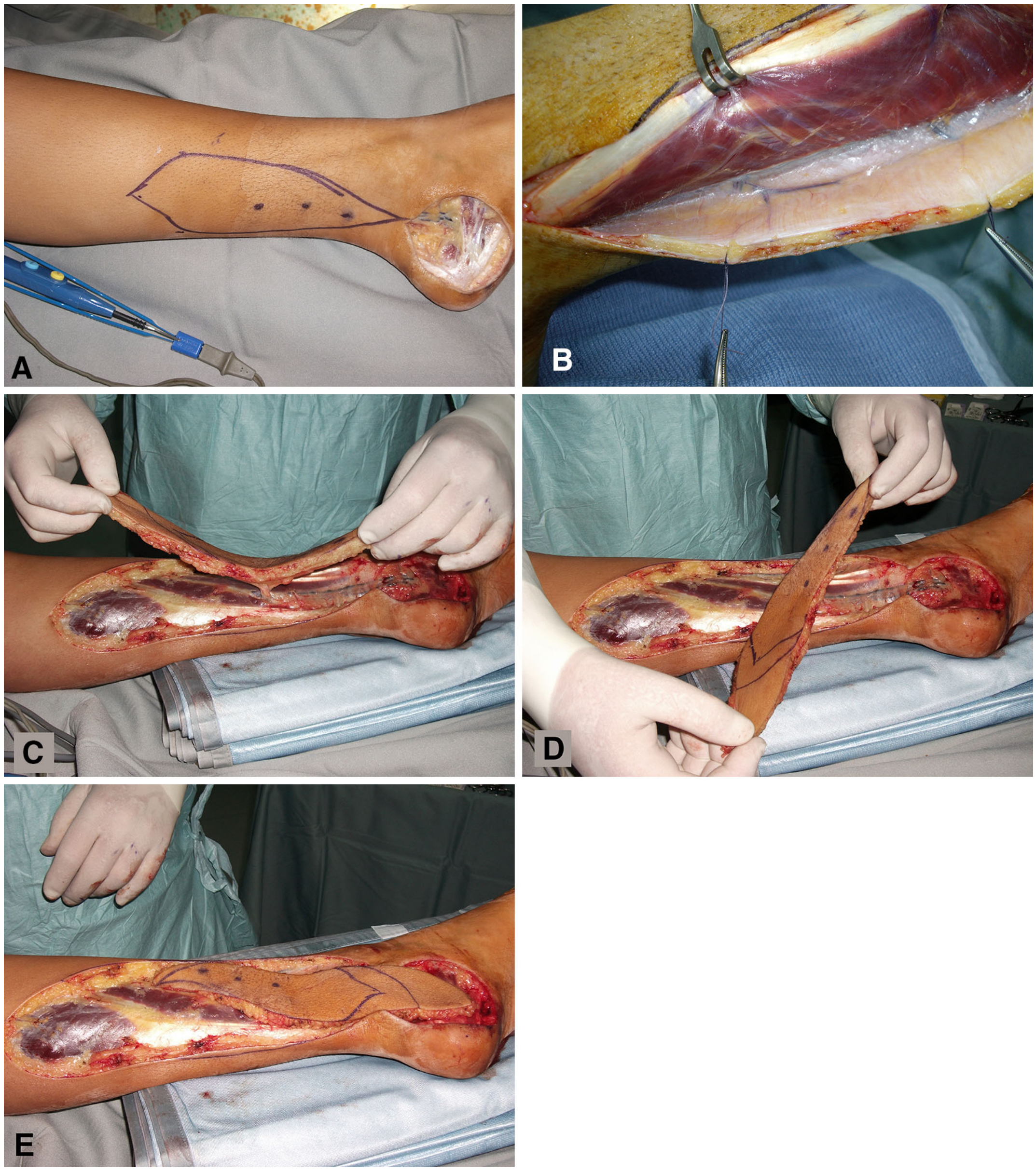

Fig. 5A–E (**A**) Three perforators of the posterior tibial artery are marked on the skin preoperatively, according to color Doppler imaging. After surgical débridement of the recipient site, the flap is planned and designed. After preoperative mapping of the perforators, direct observation of them is needed to make the critical decision regarding which perforator to use. (**B**) A long explorative incision is made on one of the major margins of the flap and the best perforator is chosen, taking into account its size and location. (**C**) Once the pedicle is dissected, raising the flap is straightforward. After release of tourniquet, (**D**) the perfusion of the skin paddle is checked and (**E**) the flap then is rotated to the desired location. In case of rotation of 180°, it is advisable to turn the flap first clockwise and then counterclockwise into the defect and eventually choose the direction that has less affect on the patency of the pedicle.

Current knowledge of the vascular territories [18, 24] potentially supplied by one perforator is based on cadaveric dissection and injection studies. These methods however do not evaluate the dynamic vascular changes that occur in any single perforator after ligation of adjacent perforators and muscular branches. Therefore it is unknown how far the flap design can be extended. The real potential of any single perforator supplying a propeller flap is understood only after completing elevation of the flap and having released the tourniquet. Using data from operative reports, we therefore determined whether the dimensions of the flap or the amplitude of the arc of rotation were related to flap survival or complication rate. We also recorded other potential risk factors, including age, sex, defect etiology, smoking, diabetes, and peripheral vascular disease, from medical records.

We divided patients into two groups according to flap length (5–14 cm [n = 44] versus 15–25 cm [n = 22]) and according to arc of rotation (0°–90° [n = 17] versus 91°–180° [n = 49]) (Table 1). The groups then were compared to determine differences in complication and survival rates. These rates also were compared between male and female patients and between younger (14–65 years) and older (66–87 years) patients.

Statistical Analysis

A descriptive statistical analysis was performed to summarize the variables of interest. Continuous variables were summarized by median and range. Pearson's chi-square test of independence was performed to compare survival and complication rates between the groups. Multiple logistic regression analysis was performed to identify the association between flap length and complication rate and between arc of rotation and flap failure. Smoking, diabetes, hypertension, and other comorbidity variables that could affect flap survival were adjusted for the analysis. We considered p values less than 0.05 significant. All patient data were recorded in a table in STATA® 12.1 (StataCorp LP, College Station, TX, USA).

Statistical Power

A post hoc calculation was performed using arc of flap rotation (0°–90° versus 91°–180°) and flap length (5–14 cm versus 15–25 cm). With the numbers available, the power to detect a statistically significant difference was 25% between the first two groups and 4% between the latter two groups.

Results

Frequency and Types of Complications

Twenty-eight of the 66 flaps (42%) had complications (Table 1). Venous congestion was the most common complication (11 of 66, 17%). In the majority of patients, the venous congestion resolved spontaneously without the need for additional surgery. Superficial necrosis of the skin, requiring débridement and skin graft, was observed in seven patients (11%). Total flap necrosis attributable to poor arterial supply occurred in one patient. Débridement of the necrotic skin and coverage with a free anterolateral thigh flap were performed. One partial full-thickness necrosis of the most distal portion of the propeller flap exposing bone underwent coverage with a free anterolateral thigh flap. A second deep partial necrosis of the distal ⅓ of the flap was observed. In this patient, however, some subcutaneous tissue and fascia survived and simple split-thickness skin graft after vacuum-assisted closure therapy was performed (Fig. 6). Overall, 10 of 66 patients (15%) underwent secondary surgery. Donor-site morbidity in general was minimal, and flap design often allowed for direct closure of the donor site, which in our series was achieved in 34 patients (52%) (Fig. 7A). In large flaps, it is not advisable to close the donor site under undue tension; skin graft is a reasonable alternative option to complete the closure of the secondary defect without tension in these situations (Fig. 7B).

Risk Factors for Complications

With the numbers available, we found no association between complications and age, sex, etiology of defect, and type of flap. Likewise, the dimensions of the flap were not related to its survival or complication rate: flaps whose length ranged from 5 to 14 cm did not show a higher failure rate than those between 15 and 25 cm long (odds ratio = 0.83; p = 0.93), even adjusting for smoking, diabetes, hypertension, and other comorbidities (confounding factors) through logistic regression (odds ratio = 1; 95% CI, 0.34–2.97).

With the numbers available, there was no difference in the proportion of patients who had complications between those whose arc of rotation was less than 90° and those whose arc of rotation was between 91° and 180°; however, the study was underpowered to detect differences on this end point. The complication rate was 29% (five of 17) in patients with an arc of rotation between 0° and 90° and 47% (23 of 49) in patients with an arc of rotation between 91° and 180° with (odds ratio = 0.45; 95% CI, 0.13–1.5) and without (odds ratio = 0.47) adjusting for smoking, diabetes, hypertension, and other comorbidities through logistic regression (p = 0.33).

The same analysis was performed between male and female patients and younger and older patients. Although male patients had a greater complication rate than female patients (odds ratio = 1.46), this difference was not significant (p = 0.63). Additionally, although younger (14–65 years) patients were less prone to complications (odds ratio = 0.41), this difference also was not significant (p = 0.18).

Discussion

The ideal reconstruction of soft tissue defects in the lower extremity should replace like with like tissue, minimize the

Table 1. Study population

Vascular source	Parameter	Number of patients	Median	SD	Number of patients with complications	Number of patients with comorbidities
Posterior tibial artery	Age (years)					
	14–65	31 (76%)	44	14.3	10	17
	66–87	10 (24%)	77	5.6	6	10
	Flap length (cm)					
	5–14	28 (68%)	11	2.3	10	21
	15–25	13 (32%)	20	3.2	6	6
	Pedicle rotation (°)					
	0–90	10 (24%)	90	14.2	2	8
	91–180	31 (76%)	180	29	14	19
Anterior tibial artery	Age (years)					
	14–65	4 (100%)	52	7.9	1	2
	66–87	0 (0%)			0	0
	Flap length (cm)					
	5–14	4 (100%)	12	2.8	1	2
	15–25	0 (0%)			0	0
	Pedicle rotation (°)					
	0–90	1 (25%)	90		0	0
	91–180	3 (75%)	180	0	1	2
Deep femoral artery	Age (years)					
	14–65	7 (70%)	49	9.9	4	4
	66–87	3 (30%)	80	5.1	3	2
	Flap length (cm)					
	5–14	6 (60%)	13	1.4	4	4
	15–25	4 (40%)	18	1.7	3	2
	Pedicle rotation (°)					
	0–90	4 (40%)	90	0	3	2
	91–180	6 (60%)	180	24.5	4	4
Peroneal artery	Age (years)					
	14–65	3 (60%)	40	5.9	1	1
	66–87	2 (40%)	70	0	1	2
	Flap length (cm)					
	5–14	4 (80%)	10	0.8	2	3
	15–25	1 (20%)	15		0	0
	Pedicle rotation (°)					
	0–90	0 (0%)			0	0
	91–180	5 (100%)	170	37.4	2	3
Other (medial superior genicular artery, lateral popliteal cutaneous artery, medial plantar artery, lateral circumflex femoral artery)	Age (years)					
	14–65	2 (33%)	42	7.1	1	1
	66–87	4 (67%)	76	8.1	1	3
	Flap length (cm)					
	5–14	2 (33%)	10	4.2	1	1
	15–25	4 (67%)	22	2.1	1	3
	Pedicle rotation (°)					
	0–90	2 (33%)	53	10.6	0	1
	91–180	4 (67%)	180	10	2	3

Fig. 6A–D A propeller flap based on a perforator of the deep femoral artery is used to reconstruct a post-traumatic defect in a 26-year-old man. (**A**) The flap is shown sutured in place. (**B**) Skin necrosis of the distal angiosome with a neat border occurred a few days after surgery. In this case, (**C**) the subcutaneous tissue survived and (**D**) a skin graft was the only additional surgery needed.

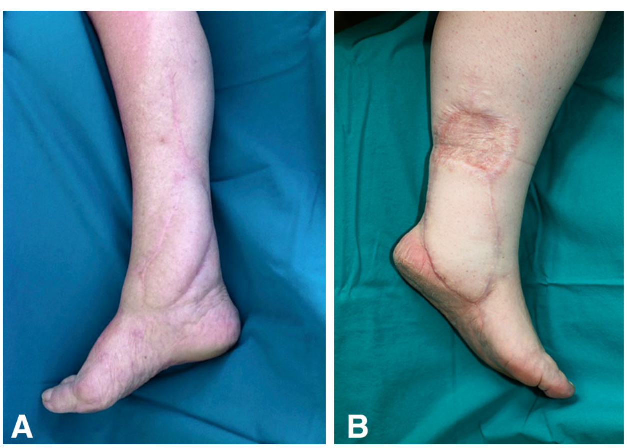

Fig. 7A–B Owing to the dimensions of the flap and quality of the soft tissue (pliability, thickness, elasticity) in the same anatomic area, direct closure of the donor site (**A**) may or (**B**) may not be possible. In the latter case, a skin graft needs to be performed.

morbidity of the donor site, preserve the main vascular axis, and reduce operating and hospitalization time [4, 10, 11, 13, 17, 27]. Theoretically, propeller flaps fulfill all of these requirements, but in the clinical setting, they are associated with some complications, which need to be well understood to be avoided. In the current study, we found that 42% (28 of 66) of patients treated with lower-extremity perforator-based propeller flaps had complications after surgery, and 15% underwent secondary surgical procedures; with the numbers available, we identified no risk factors pertaining to the patient, defect, flap size, or arc of rotation associated with complications after these reconstructions.

This study had some limitations. Eight patients (11%) were lost to followup before 1 year, therefore it is possible that these patients had other complications or additional procedures. The patient population, etiology, and site of the defects were not homogeneous, and two main surgeons in two different institutions performed the procedures. Indications and surgical procedure however had been discussed previously and fully shared by the two groups of surgeons participating in this study, thus providing a homogeneous approach to the pathologic features with comparable surgical technique. Given these factors and our relatively small numbers, it is possible that associations of particular risk factors with complications or flap failures might have been missed related to insufficient sample size. Our study was underpowered to detect key end points, therefore our no-difference findings, in particular on complication frequency (where the statistical power was 25%), should be interpreted in light of that. It is possible, with larger numbers, the difference of 29% versus 47% might have been determined to be significant. Even so, our data should be considered useful pilot data for future, larger, multicenter studies on this topic.

Two recent review articles analyzed the frequency of complications in propeller flaps used for lower-extremity reconstruction. Gir et al. [7] studied 186 cases performed in 15 different institutions and Nelson et al. [14] studied 310 flaps performed in 21 centers. The results of the two studies in terms of flap survival are comparable, with 11% of partial flap necrosis in both reviews and 1% and 5% of total necrosis in the reviews of Gir et al. [7] and Nelson et al. [14], respectively. Only Gir et al. [7] reported the incidence of secondary surgery, occurring in 6% of cases. In our series, we observed a lower incidence of partial flap necrosis but a higher percentage of secondary surgery.

No reports of which we are aware compare free flaps and propeller flaps; however, a recent revision of 2019 free flaps reported by Wu et al. [28] provides useful information. In that report, 201 (10%) flaps required revision and major surgery and total flap necrosis occurred in 3.8%. In our series, only one patient (1.5%) had total flap loss and only two patients (3%) required complex secondary surgery (free flap), while in the remaining eight patients (12%) a minor surgery was sufficient (skin graft). Although additional investigations are necessary to analyze our data to compare the outcomes of free and perforator flaps performed in the same anatomic district and institution, our experience seems to confirm that propeller flaps are a valuable tool, are faster to raise than free flaps, are less invasive for the patient, and have a comparable rate of complications and a lower incidence of major secondary surgery.

We did not find any association between complications and age, sex, etiology of defect, and type of flap. None of the comorbidities we evaluated, such as smoking, diabetes, and vascular diseases, were associated with complications. These data are substantially in accordance with those reported in a review article on propeller flaps [7]. Neither the size of the flap nor the amplitude of the arc of rotation has been specifically analyzed in other studies; thus, our findings cannot be compared with those of others. In our series, the dimension of the flap did not influence the survival rate of the transferred tissue, suggesting that we did not exceed the dimensional limit allowed by one perforator. However, the question "how far can we go?" remains unanswered.

The perforasome theory [18], based on the mechanism of opening of "potential" vascular territories by means of linking vessels after ligation of adjacent perforators, provides a logical explanation of the sequence of events that ultimately guarantee a sufficient blood supply to the skin far beyond the anatomic territory belonging to any given perforator. However, the dimensional limit of a safe flap is difficult to study in a cadaveric model because the recruitment of adjacent angiosomes is a dynamic phenomenon that should be studied in vivo and, in addition, probably is related to numerous local and general factors. For this reason, it is difficult or impossible to predict with certainty the size of the skin area vascularized by one perforator.

Whether the amplitude of the arc of rotation may reduce the blood supply to the skin paddle was the second important question we tried to answer. With the numbers available, there was no difference between the proportion of patients who had complications between those whose arc of rotation was less than 90° and those whose arc of rotation was between 91° and 180°; however, the study was underpowered to detect differences on this end point. Nevertheless, if a propeller flap is perfectly supplied before rotation, but something changes after rotation, the reason must be related in some way to the torsion of the pedicle. Namely, the two venae comitantes may be compressed around the artery, which is centrally located. This finding accounted for the majority of venous congestion versus reduced arterial inflow we found in our series. Experimental experience [8] seems to suggest that a rotation of as much as 360° does not affect the patency of the vessels, providing that the pedicle is dissected extensively and free from all potential constrictions. It also has been stated that pedicle length is inversely proportional to the critical angle of twisting [22, 26], suggesting, the longer the pedicle is, the wider a safe arc of rotation will be (Fig. 8). It is reasonable to conclude that an inappropriate dissection of the pedicle, from quantitative and qualitative standpoints, will

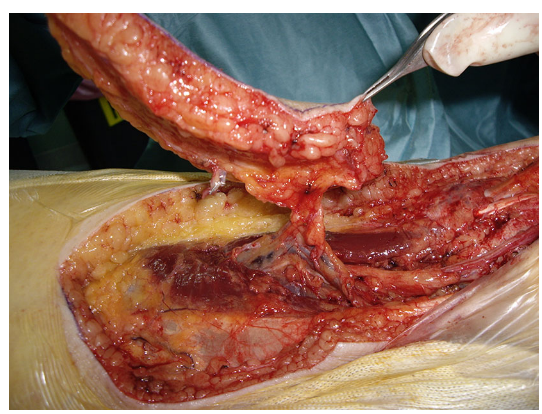

Fig. 8 Meticulous dissection of the pedicle is the key to prevent complications. All the muscular branches must be divided and the perforator must be cleared of all the fascial strands for at least 2 cm. If any potential reason for extrinsic compression is removed, the twist of the pedicle after rotation to the recipient site will be gentle and distributed on the entire length of the pedicle.

proportionally reduce the potential arc of rotation of any single flap. In other terms, wider arcs of rotation will be more prone to inadequate dissection of the pedicle and an increasing rate of complications is logically predictable as long as the arc of rotation approaches 180°.

We found propeller flaps to be a reliable tool for lower-extremity coverage, with a low rate of failure and secondary surgery. With the numbers available, the amplitude of the arc of rotation and flap dimension did not seem to be variables affecting the likelihood of complications. These flaps are particularly useful for covering small- and medium-sized defects in the distal ⅓ of the leg and the Achilles tendon region and they represent a reliable and effective alternative to free flaps. Although we did not compare the outcomes of propeller and free flaps, propeller flaps seem to have an incidence of total flap necrosis similar to that of free flaps. However, even if minor problems occurred more frequently with propeller flaps, in the majority of patients revision surgery was minor and limited to débridement of small superficial necrosis of the skin, usually at the tip of the flap, and then placement of a skin graft. Propeller flaps provide a like with like reconstruction, with minimal morbidity at the donor site and no need for microvascular anastomosis. They can be done under regional anesthesia, and they are relatively quick to harvest. Nevertheless, we caution surgeons using these flaps to pay particular attention to adequate dissection of the pedicle and to avoid compression from edema or other extrinsic causes, which may reduce the drainage of the venae comitantes and may lead to complications.

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