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Perforator-Based Propeller Flap with Additional Venous Pedicle for Lower Limb Reconstruction

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Abstract

Propeller flaps are effective reconstructive tools for small-to-medium sized defects of the lower limb and a reasonable alternative to free flaps. A major vessel of the lower limb remains undisturbed while raising the flap and the flap donor and recipient areas are addressed in the same operative field. Perforator-based propeller flaps are based on single perforator arising from a major vessel and during rotation of the larger paddle there is a possibility of kink in the venous component leading to congestion of flap. In our modification, one superficial vein of the lower limb namely the great saphenous or short saphenous vein was included in the flap territory to enhance the retrograde or antegrade venous drainage of the flap. We observed, no flap congestion or necrosis in the postoperative period. Also, the patency of the incorporated vein was confirmed using handheld and color Doppler.

Keywords
- ► propeller flap
- ► modified propeller flap
- ► perforator propeller flap
- ► lower extremity reconstruction

Introduction

Lower limb soft tissue defects are often challenging due to a lack of local soft tissue. Even a small-sized defect makes the surgeon plan, replan, and think before execution for optimal outcome. In the lower limb, for distal defects, the propeller flap recruits the proximal soft tissue and meets the basic principles of reconstruction; replacement with similar tissue, simple to execute and with minimal donor site morbidity. The limiting factor for the execution of the propeller flap is the availability of a sizeable perforator near the defect and the kink in the perforator during flap rotation leading to congestion and flap necrosis. To prevent flap congestion, venous supercharging is helpful but getting a suitable vein at the defect site for anastomosis is difficult. We propose to incorporate an axial subcutaneous vein in the flap territory and maintain the continuity of this vein at the smaller paddle for additional venous drainage (►**Fig. 1A, B**).

Materials and Methods

Patients with lower limb trauma reconstructed with the modified propeller flap during the last 2 years were analyzed. Patient's document and procedure notes were analyzed (►**Table 1**). Five patients were included in the analysis. During planning, the perforator nearest to the defect was marked, and the course of the superficial axial vein was traced. The provisional skin paddle was planned along the longitudinal axis of the course of the vein to incorporate it. The patency of the superficial and deep venous system was checked using Doppler preoperatively. The flap donor site was skin grafted as there was tension in the primary closure.

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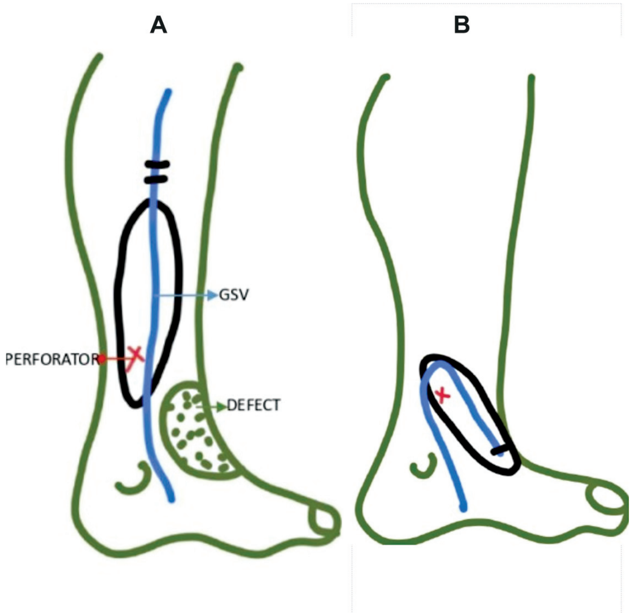

Fig. 1 (A) Perforator marked in the flap with great saphenous vein (GSV) included in the flap. (B) Flap along with GSV propelled to the defect.

Fig. 2 Great saphenous vein included in the flap by clipping it proximal to the flap with its continuity maintained distally through the smaller limb of the flap.

Postoperatively, the venous drainage of the flap and patency of the incorporated superficial vein (►Fig. 2) were confirmed by handheld and color Doppler on day 8 (case 3, ►Fig. 3) and on 5 months follow-up (case 3).

The maximum and minimum follow-up periods were 1 year and 3 months, respectively. Due clearance from the ethical committee of the institute has been taken up for the study.

Results

All patients in the study were males. The average soft tissue defect size was 6 × 5cm. The maximum and minimum dimensions of the flap used in our series were 14 × 7cm and 10 × 6cm, respectively, with an average flap dimension of 12.8 × 6cm. In our study, the flaps underwent rotation from 90 to 180 degrees. The average distance of the perforator from the edge of the defect in our series was 3.2 cm. There was no flap loss or marginal necrosis in patients. The donor site was split skin grafted. Partial closure was done in one case. In three cases, peroneal artery perforator was used, while in two cases posterior tibial artery perforator was used (►Table 1).

Representative Cases

Case1: Peroneal Artery Perforator-Based Propeller Flap with Short Saphenous Vein

A 52-year-old male patient presented with exposed Achilles tendon following the trauma of the right lower limb (►Fig. 4A). After debridement, the deeper part of the tendon was found viable. A 15 × 6 cm size peroneal artery perforator flap was harvested. During flap harvest, the short saphenous vein was ligated proximally, and the distal part was incorporated along the longitudinal axis of the flap. The flap was

Table 1 Details of defect and type of the flap used with incorporated superficial vein

Sl. no.	Age in year/ (gender)	Defect size (cm)	Flap size (cm)	Defect location	Perforator	Incorporation of veins	Range of rotation (degrees)	Flap complications	Donor site	Distance of the perforator from the edge of the defect (cm)
1	52/M	8 × 6	15 × 6	Ankle	Peroneal A	SSV, retrograde drainage	180	Nil	SSG	2.6
2	35/M	5 × 4	10 × 6	Upper leg	Posterior tibial A	GSV, antegrade venous drainage	90	Nil	SSG	3
3	67/M	6 × 5	14 × 6	Lower leg	Posterior tibial A	GSV, retrograde venous drainage	135	Nil	SSG	4
4	32/M	4 × 4	11 × 5	Lower leg	Peroneal A	SSV, retrograde venous drainage	120	Nil	SSG + partial closure	3.2
5	47/M	7 × 6	14 × 7	Lower leg	Posterior tibial A	GSV, antegrade venous drainage	110	Nil	SSG	3.4

Abbreviations: GSV, great saphenous vein; SSG, split skin graft; SSV, small saphenous vein.

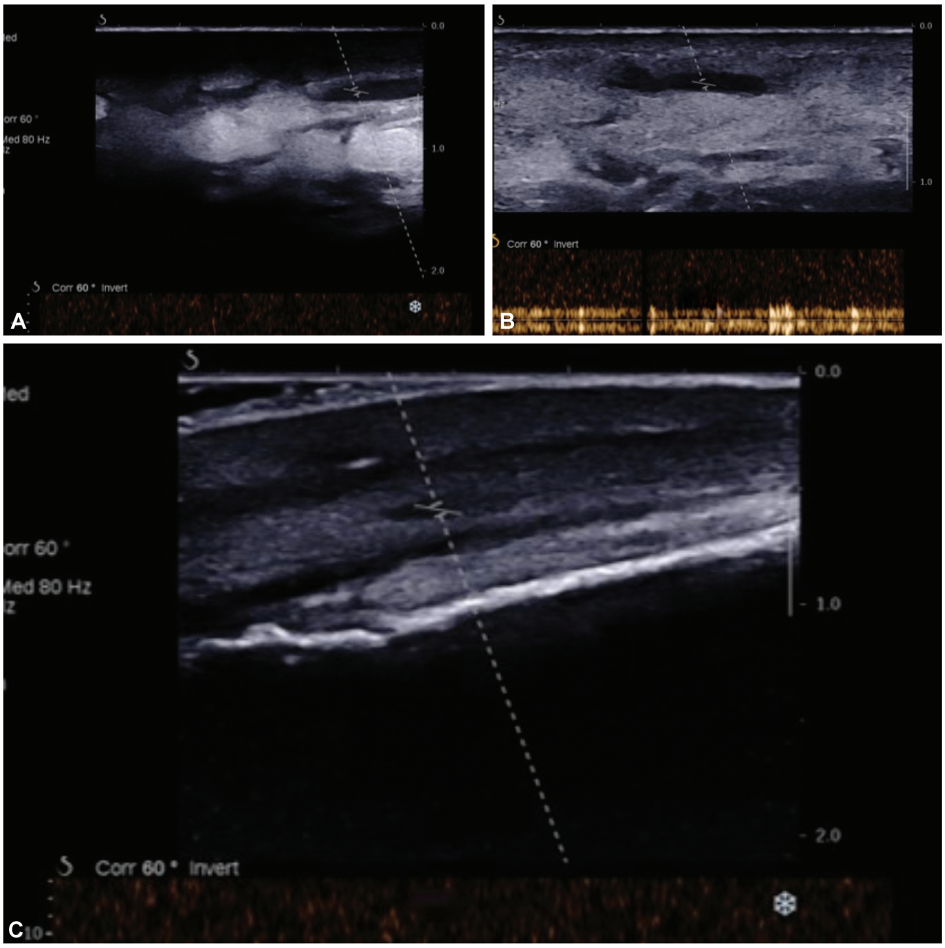

Fig. 3 (**A**) Doppler image showing flow in the great saphenous vein in the middle third of the flap. (**B**) Doppler image showing flow in the great saphenous vein in the proximal third of the flap. (**C**) Doppler image showing flow in the distal great saphenous vein beyond the flap.

Fig. 4 (**A**) Exposed Achilles tendon in the right leg following trauma. (**B**) Islanded peroneal artery perforator propeller flap with the short saphenous vein included in the flap and continuity of vein maintained distally. (**C**) Three months follow-up image.

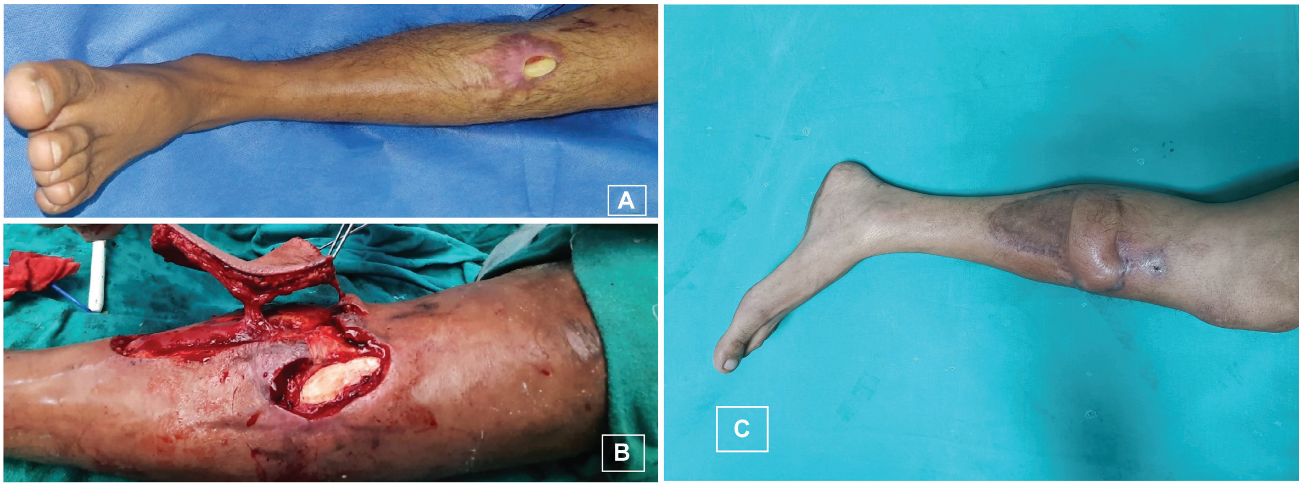

Fig. 5 (A) Soft tissue defect over the left upper tibia. (B) Islanded posterior tibial artery perforator propeller flap with the great saphenous vein included in the flap and continuity of vein maintained proximally. (C) One-year follow-up image.

islanded over the perforator except at the distal end of the flap, where the distal part of the short saphenous vein was only continuous (►**Fig. 4B**) The distal portion of the short saphenous vein was released from the soft tissue attachment and its tributaries beyond the distal flap/small paddle by meticulous dissection and undermining. This allowed the flap to rotate approximately 180 degrees to cover the defect with the distal vein in continuity. In follow-up, the flap settled well (►**Fig. 4C**).

Case 2: Posterior Tibial Artery Perforator-Based Propeller Flap with Great Saphenous Vein

A 35-year-old male presented with exposed 5 × 4cm of upper tibia left leg following trauma (►**Fig. 5A**). A propeller flap based on the posterior tibial artery of 10 × 6cm size was raised (►**Fig. 5B**). The distal paddle was rotated approximately 90 degrees to cover the defect. The great saphenous vein was included along the long axis of the flap after clipping it at the distal limit of the flap and maintaining its continuity through the smaller paddle of the flap for anterograde venous drainage. The great saphenous vein was mobilized at the proximal end of the flap beyond the flap territory to allow flap mobility to avoid kink in the vein. After 1 year of follow-up, the flap was well settled (►**Fig. 5C**). After 1 year, flow in the great saphenous vein is detected with a handheld Doppler.

Discussion

The propeller flap received recognition in the first Tokyo meeting and was classified as a subcutaneous pedicled propeller flap, perforator pedicled propeller flap, and supercharged propeller flap.[1] Cordova et al introduced the axial propeller flap, which includes a known vessel and not a perforator.[2] In the new comprehensive classification of propeller flaps, three more subtypes, axial pedicled propeller flaps, muscle propeller flaps, and chimeric propeller flaps, were added to the previous classification.[3]

In a perforator-based propeller flap, the perforator is chosen near the defect. The flap is islanded based on the single perforator originating from a known underlying vessel. Perforator propeller flaps based on perforators from the posterior tibial artery and peroneal artery are commonly used for lower limb reconstruction.[4–6]

Though perforator propeller flaps meet most of the ideal reconstruction characteristics, they are not without complications, notably congestion. In their systematic review on pedicled perforator propeller flaps in lower extremity propeller flaps, Gir et al had a 26% overall complication rate, with venous congestion being a potential problem in 8% of cases.[7] In the study of risk factors for complications of perforator-based propeller flaps for lower-extremity reconstruction, Innocenti et al reported 42% complications, out of which venous congestion was the most common complication 17%.[8] In most series of the perforator propeller flap, venous insufficiency is the most common complication.[9] The most common method to relieve the flap congestion is leech therapy.[10] Using modification as described in our study may encourage young surgeons to take up propeller flap as a reconstructive option whenever indicated and possible.

The venous component of a perforator is prone for kink during the axial rotation of propeller flap leading to congestion. To avoid this, many surgeons supercharge the flap by additional venous or arterial anastomosis with vessels near the defect site. Iida et al suggested adding an extra pedicle if the isolated perforator is not providing sufficient arterial inflow or venous outflow.[11]

In our cases, we modified the perforator-based propeller flap by designing the flap skin paddle along the course of a superficial vein of the lower limb so that the vein traverses along the longitudinal axis of the flap. The flap is islanded based on the perforator except for the venous pedicle, which exits through the small paddle of the flap. The vein beyond the flap territory was skeletonized, and a good length of the vein was released from the soft tissue either by undermining or by making an incision over the adjacent overlying skin. These maneuvers prevent kinking of the vein while the flap is axially rotated, and the large paddle covers the defect through a variable angle of rotation. The addition of the vein in our cases did not compromise or restricted the flap rotation.

The anterograde and retrograde drainage in the flap through the additional venous pedicle has been checked with a handheld Doppler postoperatively between 5 and 10 days. As flow was detected in the vein, the venous kink due to flap rotation is being ruled out.

Inclusion of axial vein and establishing a retrograde or antegrade venous flow from the flap add to the venous return. This modification obviated the need for venous supercharging of the flap. Many a times, supercharging is not possible due to a lack of suitable recipient vessels near the defect site due to damage. For the planning of the propeller flap with additional venous drainage, as in our modification, the superficial vein and the communication between the superficial and deep venous system should be patent. The retrograde venous flow becomes established by proximal ligation of the venous pedicle (in three cases; ►**Table 1**). In others, venous drainage was antegrade by ligating the vein at the distal end of the flap. This modification does not fit into the described classification of propeller flap and may be added to the perforator-based propeller flap subclassification of propeller flap. Incorporating the superficial vein along the flap is technically easy and hardly increases the operative time. This is a small series. To evaluate the long-term effect of incorporating additional venous pedicle, a large comparative study with the conventional propeller flap can be done. Also, this technique can be performed only if a nearby perforator is traced in preoperative planning as when the perforator is feeding the flap at the middle or away from the edge of the defect, our modification might lead to an acute kink in the vein and thereof, hamper the venous drainage through the superficial vein adding to the limitation of this technique.

Conclusion

A perforator-based propeller flap is a well-established tool for lower limb reconstruction. Our modification is technically easy to execute and does not add any additional flap donor site morbidity. Including a venous pedicle improves the venous return of the flap and prevents flap congestion. We recommend this modification to a perforator-based propeller flap where patent superficial veins traverse the propeller flap territory.

Conflict of Interest
None declared.

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