Original Article

Perforator Propeller Flap for the Coverage of Soft Tissue Defect of Distal Third of Lower Extremity

Authors
Pruthwiraj Singh¹*, Prasanta Kumar Bal²

¹MCh Plastic & Reconstructive Surgery, Assistant Professor, Plastic & Reconstructive Surgery
²MCh Plastic & Reconstructive Surgery, Assistant Professor, Plastic & Reconstructive Surgery, Department of Plastic & Reconstructive Surgery, SCB Medical College & Hospital, Cuttack

*Corresponding Author

Dr Pruthwiraj Singh
MBBS, MS Gen Surgery, MCh Plastic & Reconstructive Surgery Assistant Professor, Department of Plastic & Reconstructive Surgery, SCB Medial College & Hospital, Cuttack, Odisha, India

Abstract

Background: Soft tissue reconstruction of Lower third of lower extremity defects are major challenge to the reconstructive plastic surgeon, due to paucity of skin, absence of muscle bed, bony prominences, shape and biomechanics, around the lower third of the leg and ankle joint and foot.¹,² But in the recent year perforator propeller flaps has emerged as a viable option for reconstruction of soft tissue defects over the lower third of the lower extremity with promising results.

Objective: In this study we want to assess the safety and reliability of the perforator propeller flap for soft tissue defect cover of lower third of lower extremity.

Material & Methods: This is a prospective observational study conducted in the department of Plastic & Reconstructive Surgery, from Aug. 2014 to Dec. 2017. The procedure followed were in accordance with the ethical standards of the institutional ethics committee and Helsinki’s declaration of 1975, as revised in 2000. Informed consent was obtained from the patients included in this study. The sample consisted of 20 patients in whom a total of 20 flaps were performed for the reconstruction of the defects of distal third of the lower extremity.

Results: In this study, 20 patients with defects over the lower third of lower extremity had undergone 20 perforator propeller flap methods to cover the defects with an age ranging 16 years to 60 years (mean 33.4 years), Degree of rotation 100 to 180⁰ (mean 132.5⁰). Donor sites were closed partially by short arm of the propeller & rest of the donor defects were covered by split thickness skin graft (SSG), complications were, partial loss of flap in one case (5%), venous congestion in 4 cases (20%).

Conclusion: From the observations made from our study, it was found that perforator propeller flaps often give simple options to complex reconstructions. This technique provides us with a rapid and reliable reconstruction with acceptable aesthetic outcomes, especially when donor site is with less morbidity.

Keywords: perforator propeller flaps, distal third leg defects, lower extremity defect.
Introduction
Soft tissue reconstruction of extremity is difficult and challenging, due to limited mobility and availability of overlying skin, even a small defect in the extremity may require a microsurgical reconstruction. Local fascio-cutaneous flaps with limited availability in distal extremity resulted in donor site that always require skin grafting. Free microvascular transfer leads to donor site morbidity, is time consuming, requires expensive microsurgical facility and result always not guaranteed. The field of reconstructive surgery has taken a significant leap forward with the introduction of perforator flaps. This has been made possible with the development of knowledge in vascular anatomy and cutaneous circulation. According to the “Tokyo” consensus, perforator flaps are composed of skin and subcutaneous fat nourished by perforators arising from deep vascular systems, which reach the surface by passing mostly through muscle and intramuscular septa. Advantage of perforator flaps is that they are safe, reliable, and with minimal donor site morbidity. A Propeller flap has additional advantage of wider mobilization and rotation so as to increase reach of local flap and their versatility. This technique can be performed expeditiously and is beneficial in the management of multiple injured, systemically compromised and elderly patients. The propeller flap was first described in 1991 by Hyakusoku et al., as a fascio-cutaneous flap rotated 90 degree to cover defects resulted from release of post burn contracture in cubital and axillary area. Propeller flap was used earlier to reconstruct leg defects. In this study, the safety and reliability of perforator-based propeller flap are reported.

Material & Methods
A detailed clinical history was taken complete physical examinations was carried out and etiology, site, size and characteristics of the defects and surrounding area were recorded. In the planning of the flaps, the vascular axes, the distribution of perforators and the zone of trauma were taken into consideration. A hand-held Doppler ultrasound of 8-Mhz probe with an angulation of the probe of approximately 45 degrees to the skin surface was used preoperatively to detect the perforator vessels in the donor area along the course of posterior tibial and peroneal artery, whichever is adjacent to the defect. Once the perforator was marked a provisional flap was planned by planning in reverse procedure taking the perforator as pivot point and adequate correction of primary contraction of the flap by taking extra 1cm of tissue all around the flap. The procedures were performed using an intelligent pneumatic digital tourniquet with 300mm Hg pressure, by elevating the lower limbs for 2 minutes. This technique helped in making the perforator prominent. With the aid of an surgical operating loupe of 4.0x magnification the procedure was undertaken. An exploratory incision was made till the deep fascia and a search was made for the adequate size perforator, if the designated perforator was of adequate size then the flap was elevated according to the pre-operative planning. But if the perforator was not of adequate size then nearby perforator was chosen and then accordingly the flap was planned or other vascular axes were looked for.

Meticulous dissection was carried out with Tenotomy scissors and microtoothed Adson’s tissue forceps. All the fibrous septa and muscular branches were ligated with micro sutures, and the perforator pedicle was traced till the main vascular axes for approximately 2cm length to allow tension free and kink free rotation. Traction on the pedicle and tension while dissecting the flaps were avoided. Once the flap was completely islanded, the tourniquet was deflated. Hemostasis of the donor area was meticulously achieved. The flap was left for perfusion for 10 minutes, papaverine, soaked, gauze pieces were put near the perforator pedicle for vasodilation. During that 10 minutes period, patients blood pressure, operation theater room temperature, all were made conducive for capillary perfusion of the flap. Flap viability was
checked by looking for free flow of bright red colored dermal bleed. Once the flap viability was convinced, flap was rotated in a direction in which less kinking or torsion on the pedicle was appreciated. Final suturing of the flap was undertaken. During the surgery the flap size, degree of rotation, complications if any, were recorded. Then the Donor was covered with split thickness skin graft. 

Post operatively the limb was covered with floppy dressings, plaster of Paris slab was applied in relax position of the flap if needed. A window was left uncovered for monitoring of the flaps and the limb was kept elevated on pillows.

Post operatively flaps were monitored for viability by looking for color and turgor of the skin and bleed to skin scratch and when need arises intervention was made in the form of removing distal stitches or by returning the flap to its native place.

In the event of venous congestion distal stitches were removed and the limb was kept elevated and intravenous infusion of one liter of normal saline with 5000 IU heparin @ 20 microdrops per minute over 24 hours was continued for 5 to 7 days. During this period prothrombin time & Activated Partial thromboplastin time were measured to monitor heparin anticoagulation over dose.

Patients were discharged from hospital on the 10th post operative day, and advised for follow-up on outpatient department basis after one week then monthly interval for three months. On follow up the patients evaluated for any infection donor area healing, scar hypertrophy, or for any additional surgery if required.

**Results**

In this study, 20 patients with defects over the lower third of lower extremity had undergone 20 perforator propeller flap methods to cover the defects with an age ranging 16 years to 60 years (mean 33.4 years), M/F ratio 3:1, etiology Trauma 15 cases (75%), post burn contracture (PBC) 3 cases (15%), third degree thermal burns 1 case (5%), Infection 1 case (5%), size of flaps ranging 48 cm to 119 cm (mean 71 cm), Degree of rotation 100 to 180 degrees (mean 132.5 degrees). Donor sites were closed partially by short arm of the propeller & rest of the donor defects were covered by split thickness skin graft (SSG), complications were, partial loss of flap in one case (5%), venous congestion in 4 cases (20%) (Figure-1).

### Table showing: Summary of Perforator Propeller Flaps of this Series

<table>
<thead>
<tr>
<th>Case Sl. No.</th>
<th>Age</th>
<th>Sex</th>
<th>Morbidity</th>
<th>Defect Location</th>
<th>Etiology</th>
<th>Flap size (in sq.cm)</th>
<th>Vascular Axis</th>
<th>No. of perforators</th>
<th>Angle of rotation</th>
<th>Donor site closure</th>
<th>Complications</th>
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<td>SSG</td>
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</table>

MMD = Medial Malleolus Defect, LMD = Lateral Malleolus Defect; TAD = Tendo Achilles Defect, PBCD=Post Burn Contracture Defect, PTA = Posterior Tibial Artery, PA = Peroneal Artery.
Figure -2
a) Perforator location with Handheld Doppler
b) Postmatic defects over medial malleolous
c) Propeller Flap with posterior Tibial Artery lower most perforator.
d) Relaxed position of the flap on the defect.
e) Showing venous congestion
f) Skin grafting over the partial loss of flap.
g) Six months follow-up.
**Figure – 3**

a) Defect over Tendo Achilles.
b) Covered with peroneal perforator propeller flap.
c) Follow up after 3 months.

d) **Figure – 4**

a) Post burn contracture of Ankle joint.
b) Defect of the ankle joint following release of post burn contracture.
c) Covered with posterior Tibial Artery Perforator propeller flap.
d) Follow up after 6 months.
Discussion

Taylor and Pan found that the branches of the cutaneous vessels radiate after piercing the deep fascia in all directions and interconnect to form a continuous vascular network within the integument. \[14\]

The work of Saint-Cyr and his coworkers, which defined the vascular territories of perforators as perforasomes, helped to better understand the dynamic potential of these perforasomes and their importance in harvesting pedicled perforator flaps in lower leg. As the adjacent angiosomes are connected through choke and true anastomotic arteries, between neighboring perforasomes there are direct and indirect linking vessels. \[15\]

According to Rubino et al the harvesting of a flap based on a single perforator produces a hyperperfusion of this perforator, contribution to the recruitment of adjacent perforasome territories, what can explain the large dimensions of some flaps. \[16\]

Mendieta M et al\[7\] has reported the flap dimensions ranged from 12 to 156cm² with an average size of 50²cm, with partial loss of flap at 10.71% and 100% flap survival and largest flap being 156² cm. Our series matches with flap dimensions of 48²cm to 119²cm with mean of 71²cm, total loss of area of interest at 5% and venous congestion and partial loss at 20%.

Yasir et al in a series of 23 cases reported venous congestion rate at 17.4% and partial loss of flap at 13%. \[9\] Two patents (10%) in our series of 20 cases had the defect over the Tendo Achilles regions was resulted due to foot being slipped inside the Indian type latrine pan (commode injury) and was removed forcefully. One study by Yasir et al had mentioned about commode injury 4.4% in his series of 23 cases.

Prasad et al in their series of 20 cases, reported venous congestion rate at 40%. \[8\]

Karki and Narayan\[12\] reported 5% flap loss due to venous congestion, in their series of 20 cases, which matches with result of our series of 20 cases with 5% flap loss.

The mean age of the patient was 33.4 yrs & the median age group was 21yrs among patient of trauma. Depicting preponderance of trauma in adulthood, adult people are involved in outdoor activities & more commonly adult males are more prone to RTA & sports injuries.

In the present study there was male preponderance, the percentage of male patient was 66.6% and female patient was 33.4%. In the study there was male preponderance among patients who had suffered trauma, because males were more exposed to outdoor activities & involved in motor vehicle accidents & sports activities.

In our study maximum dimension of flap was (17x7) cm 119²cm in lower limb, based on distal peroneal artery perforator for heel defects reconstruction. As lower limb vessel perforators are of good caliber, larger length & superficial location of vessels larger propeller flaps can be harvested. In our series success rate was 95%, we give credit to the meticulous dissection of the perforator till its source vessel, prevention of dehydration of patient by infusing normal saline with 5000 IU heparin for 5 to 7 days in the event of earliest signs of venous congestion with removal of distal tension stitches and elevation of the limb.

In our study degree of rotation of propeller flap required to cover defect was predominately in range of 121-180, that means 75% flaps degree of rotation flap was in range of 121-180. 20% of flaps that developed congestion had more than 160⁰rotation.

In our study out of 20 patients 4 patients developed some form of complications. In 4 patients (20%) flap developed congestion, even after treatment in the form of limb elevation & removal of tension suture 1 flap developed distal partial thickness skin necrosis, which was treated by debridement followed-by split thickness skin graft.

A perforator-based propeller flap for the limb combines the advantages of pedicled local flaps (good tissue match), pedicled regional flap (180⁰ arc of rotation), pedicled distant flap- (reliable),
and free flap (tissue away from zone-of-injury). In addition, literature review suggests that it allows linear closure of the donor defect in smaller defects. This is made possible by the propeller design of the flap, which on rotation brings the bridge segment of the flap into the donor defect, making closure easier. In our series however, we were able to achieve partial primary closure of the donor defect and rest of the area skin grafted. This was because of our larger defect size. In a resource poor country like India; these flaps have a definite role to play in soft tissue reconstruction of the extremity. The major drawback of a perforator-based propeller flap is that the perforator must be intentionally twisted to allow the flap to rotate, We, however feel that when a rotation is performed, one of the veins accompanying the perforator gets kinked, and the other one opens up; and unless the veins are filled it is difficult to determine the proper direction of rotation and after the flap is harvested we release the tourniquet and flap is allowed to perfuse. To select the actual rotation, we rotate the flap clockwise and counter clockwise after the release of tourniquet with a couple of minute’s interval between the two rotations to prevent spasm to the perforator. The direction causing the least torsional effects is selected. It is also important to isolate the pedicle and obtain as much length as is safely possible when a 180° rotation is planned. This minimizes the torsion effects on the pedicle and hence venous congestion.

Conclusions
It is a safe, reliable & covers defects at distal extremities rotating the proximal long axis skin up to 180° with minimal donor site morbidity. Freedom of choosing the skin island, wider mobilization & rotation adds to its versatility. Flaps elevated from the same limb satisfies reconstructive principles. Stable coverage with good contour, color match & less operative time, so perforator propeller flap is one of the appropriate choices for soft tissue defect of extremity in the reconstructive ladder of reconstruction.

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Conflicts of Interest: None
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References


