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Original Research Article

Prospective study of propellar flaps vs. traditional local flaps in lower limb trauma reconstruction

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ABSTRACT

Background: Adequate coverage of traumatic complex lower extremity wounds is often challenging for reconstructive surgeons. Propeller perforator flaps have gained wide acceptance as an alternative in soft tissue coverage of complex lower extremity defects over the last decade. We report our experience with distal lower extremity reconstructions performed either with traditional local flaps vs. propeller perforator flaps. our aim here was to compare non-microvascular flaps with traditional local flaps for coverage of traumatic lower extremity wounds.
Methods: 30 patients operated for lower extremity defects and reconstructed either with traditional local flaps or propeller perforator flaps between November 2016 to December 2020 were included in the study.
Results: There were 22 male and 8 female patients. Mean age was 43.00±14.85 (range: 24 to 66 years) in the local flap group and mean age was 42.11±12.05 (range: 23 to 65 years) in the propeller perforator flap group. Hospital stays and overall operation time was significantly higher in the propeller flap group. There was no statistically significant difference in complication rates between either group.
Conclusions: Concerning many advantages, like decreased operative time, avoiding micro anastomosis, reconstruction with like tissues, we suggest that propeller perforator flaps can be first-line reconstructive choice. These flaps can be used successfully by reconstructive surgeons in small clinics to prevent unnecessary tertiary medical center referrals as well as extended hospitalizations, long operation times, and increased costs. However, propeller flaps do hold more complications compared to local flaps and do require technical expertise.

Keywords: Perforator flap, Propeller flap, Limb trauma reconstruction

INTRODUCTION

Adequate coverage of traumatic complex lower extremity wounds is not only difficult but also throws a challenge for reconstructive surgeons. In cases of exposed bone, tendon, or presence of prosthetic devices, implants, and for defects requiring large amounts of tissue, local flaps are often employed. Most local flaps like muscle flaps, reverse sural artery flap and transposition flaps based on medial and lateral perforators are major work horse flaps in lower limb especially in Trauma. In the last few years, the introduction of the propeller flaps gained great popularity; these flaps have been increasingly used for reconstruction of soft tissue defects of different parts of the body, and surgical technique has been refined and well described by several authors.[1-3] Perforator propeller flaps have a reliable vascular pedicle and can undergo wide mobilization and rotation; their harvest is fast and easy and does not require microsurgery; however, accurate patient selection, preoperative planning, and dissection technique along with hand Doppler are mandatory to prevent complications. The presence of multiple perforator alternatives around the distal leg has resulted in versatility in the design and choice of flaps available for defects of various locations and sizes. Major benefits of these flaps are sparing of the underlying

muscles and major leg vessels along with providing versatile shape, design, and composition. Reconstruction with neighbouring tissues is the most suitable choice with similar color, texture, and thickness. These flaps are harvested under loupe magnification even though they do not require micro surgical anastomosis. The goal of the current study is to prospectively compare the outcomes of 12 propeller flaps and 18 local flaps to analyze the reliability of these flaps, complication rates, and operative outcomes.

METHODS

Type of study and Place: This is a prospective study done from November 2016 to December 2020 in plastic surgery department at Sri Venkateswara institute of Medical sciences (SVIMS), Tirupati.

Inclusion and exclusion criteria

All patients with defects manifested as either exposed bone, tendon, or presence of prosthetic devices and implant or in combination, where flap reconstruction was mandatory were selected. Etiologically, road traffic accidents, work injuries, and injury due to fall were considered. Patients with chronic wounds, peripheral vascular disease, diabetes, and any known systemic comorbidities were excluded from the study. Only small to medium-sized defects were included, therefore defects greater than 100 cm2 were excluded. Strictly perforator-based propeller flaps and local flap reconstructions were included.

Procedure

Thirty patients operated on for acute lower extremity traumatic defects were included in the study. The defects were either reconstructed with local flaps or propeller perforator-based flaps following orthopedic intervention. distal leg, ankle, and foot traumatic defects that were operated on within one month of initial trauma were included in the study. All defects had undergone serial debridement and washout, and regular dressing to achieve necrosis-free wound bedding and negative cultures before flap closure was performed. All perforator flaps were used in a propeller fashion of varying degrees of rotational arc ranging between 90 to 180 degrees. The main feeding artery was either the posterior tibial artery or peroneal artery. The study outcomes were flap viability (lack of necrosis), donor-site complications, achievement of wound closure, need for revision surgery, total operation time, and hospitalization period.

Statistical analysis

Sample size estimation was performed using the Wilcoxon (Mann-Whitney) rank-sum test for ordered categories with a two-sided 0.05 significance level. A sample t-test was employed in the comparison of normally distributed data between the groups, and descriptive statistics are displayed in the form of mean (SD). The Mann-Whitney U-test was utilized in non–normally distributed data, and descriptive statistics are shown in median format (25^{th}-75th percentiles). The chi-square test was applied for the analysis of qualitative data, $p<0.05$ was considered statistically significant.

RESULTS

12 Propeller perforator flaps and 18 local flaps were included in this study. Of the local flaps, there were 10 reverse sural artery flaps, 4 Medial perforator-based flaps, and 4 lateral perforator-based flaps used (Figures 1-2). Of the 12 propeller perforator flaps, in 8 cases, peroneal artery perforators were employed, and in 4 cases, posterior tibial artery perforators were used (Figure 3-4). Among the 30 patients, there were 25 road traffic accidents, 3 cases were work injuries, and 2 cases of fall. Demographics, diagnoses, and defect sizes of patients are shown in (Table 1).

Table 1: Demographics, diagnoses, and recipient defects of 30 patients that underwent lower extremity reconstruction using perforator propeller flap and local flaps.

Parameters		Local flap	Perforator propeller flap
Sex	Male	14	8
	Female	4	4
Age (years)	Mean	43.50±14.85	42.11±12.05
	Range	24-66	23-65
Diagnosis/ etiology	RTA	14	11
	Fall	2	0
	Work related injuries	2	1
Defect size (cm^2)	Mean	62.36±16.24	64.35±20.26
	Range	40-108	46-136

There were 22 male and 8 female patients. The mean age was 43.00±14.85 in the local flap group, and the mean age was 42.11±12.05 in the propeller perforator flap group. Mean operation time in the local flap group was 1.63±0.67 hours and 2.35±1.27 hours in the propeller perforator flap group. There was a statistically significant difference between groups with regards to total operation time (p=0.0001). The mean hospital stay was 10.2±2.84 days in the local flap group and 15.3±3.85 days in the propeller perforator flap group. This difference was also statistically significant between groups (p=0.0001) (Table 2). In the propeller perforator flap group, one total flap loss occurred. There were three minor complications, venous congestion, and partial flap loss in two patients and wound dehiscence in one patient. The congested flaps were salvaged with serial debridement and with a small graft. In the local flap group, there was one venous congestion which healed delayed with small debridement.

Table 2: Clinical course.

Parameters		Local flap	Perforator propeller flap	P value
Operation time (h)	Mean	1.63±0.67	2.35±1.27	0.001
	Range	1.5-2.2	2.5-3.6	
Hospital stay (days)	Mean	10.2±2.84	15.3±3.85	0.001
	Range	8-16	12-21	
Follow up (months)		3.09±0.83	2.94±0,74	0.624
Complications		2	4	0.074

There were no donor-site healing problems in the Propeller perforator group, but one partial graft loss took place in the local group, so skin graft application was repeated.

Table 3: Complications.

Complication types	Local flap	Perforator propeller flap
Flap loss		
Partial	1	1
Total	0	1
Donor site complications	1	0
Re operation for defect closure	0	1
Dehiscence	1	1

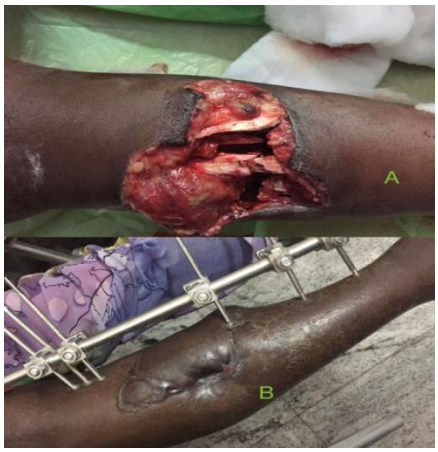

Figure 1: A) Fracture tibia and exposed bone, B) Local flap.

There were three minor transient venous congestions in the local flap group (Figure 5) that was resolved spontaneously without any intervention. There was no statistically significant difference concerning complication rates. The hospital stays and overall operation time was significantly higher in the propeller perforator flap group. The average follow-up period was 3.09 months in the local group and 2.94 months in the propeller perforator group (ranging from 2 to 4 months). All local flaps and 9 propeller perforator flaps were performed under spinal anesthesia; remaining surgeries were conducted under general anesthesia.

DISCUSSION

Traditionally, local flaps have been the workhorse reconstruction choice for complex distal lower extremity defects. Due to the conus-like shape of the lower leg, there is a shortage of local soft tissue for reconstruction of defects. Using a local fasciocutaneous flap, it is difficult to get enough healthy tissue into the defect without exposing the anterior tibial crest or the Achilles tendon, both of which are difficult to graft. The propeller flap circumvents these challenges/problems by transferring healthy tissue from the proximal calf into the primary defect. Thus, the secondary defect is moved to the area over the proximal muscle belly, which is easily grafted or even primarily closed, either through a direct mobilization and closure of the skin. Another advantage of the propeller flap, compared to the local flap, is that it avoids the awkward twisting at the base of the flap. This twist is unsightly, and it might even compress or stretch the pedicle, which may endanger the flap survival. it provides the possibility of reconstructing “like with like”, covering the defect with tissue of similar color and thickness, with easier inset but without the awkward dog ears. Following introduction, propeller perforator flaps have gained widespread popularity over traditional flaps in lower extremity reconstructions. These flaps are based on one or more reliable musculocutaneous or septocutaneous perforating branches of an underlying named artery. Even if complication rates are reasonable, total flap loss is also an important issue that needs to be addressed. These flaps are used generally as propeller flaps which according to Tokyo consensus, is 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.[4] These flaps provide reliable blood supply and adequate soft tissue and spare major vessels and muscles as well as avoid microvascular anastomosis. Furthermore, this Propeller perforator flap engenders the most suitable characteristics of skin texture and thickness for like reconstruction and prevents debulking and thinning procedures. Deterioration of another body site is prevented unless the donor site is limited to the same area of the body already affected and the donor site itself is partially covered by the flap.[5] Although harvesting of a perforator-based flap is more demanding than random alternatives, through direct visualization of the vessels, the surgeon can choose the pedicle with the best traits, both for position and

caliber, therefore increasing the potential of a successful reconstruction.

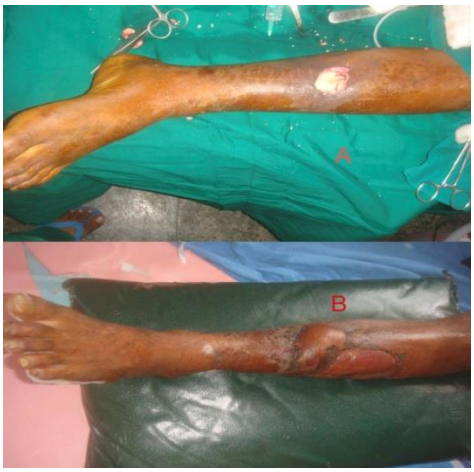

Figure 2: A) exposed fracture tibia, B) local flap.

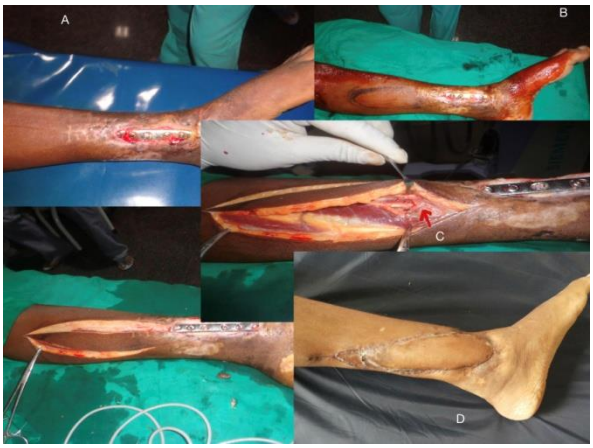

Figure 3: A) exposed implant, B) skin marking of flap and perforator with Doppler, C) dissected perforator of flap, D) post operative result.

According to the literature, the dissection plane is usually subfascial but cutaneous, adipose or adipofacial variants have been used favorably.[6] We have always employed subfascial planes for flap harvesting because in lower extremity reconstructions, bulkiness of the flap is not usually an important matter, and, as well, identification and dissection of the pedicle is relatively easy and advantageous in the subfascial plane. Although large defects are documented to be addressed with propeller flaps, generally these flaps are used for reconstruction of small- to medium-sized defects.[7] The ability to rotate the propeller perforator flaps up to 180 degrees, which we performed in 82% of the cases, makes it extremely versatile to reconstruct defects of the middle and distal third of the leg, as has been reported in other series.[8-11] In our practice, we also used these flaps in small- to medium-sized defects. In this study, the largest defect reconstructed with a local propeller was 10x12 cm and to gain homogeneity, defects greater than this reconstructed were not included in the study. In the literature, generally between 10-50 cm^2 defects are reconstructed with propeller perforator flaps during distal lower extremity reconstructions. We believe that when required, larger defect sizes up to 200 cm^2 can be reconstructed with propeller flaps if appropriate perforators are present. Types of complications reported in the literature are partial and total flap loss, epidermal necrosis, transient venous congestion, infection, hematoma, and wound dehiscence. Partial flap necrosis is the most common complication reported and 10.2% rates have been reported by Bekara et al in a recent outcomes study.[12] Total flap loss in propeller perforator flaps have been reported as 3.5% in a retrospective study by Fischer et al concerning complication rates of the flaps, there were no statistically significant differences between groups, and even though there were more venous problems in the propeller flap group, reoperation rates was similar.

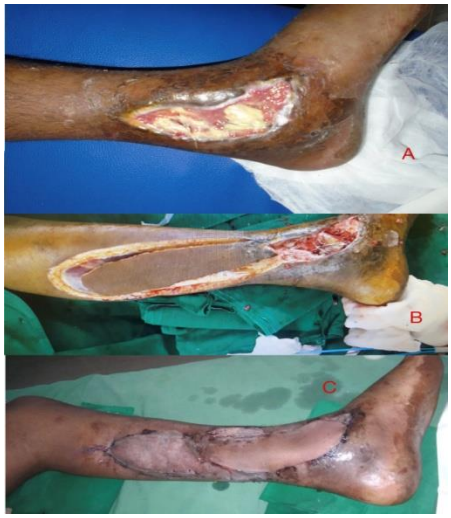

Figure 4: A) exposed bone and K-wire, B) dissected propeller flap, C) 180-degree movement of flap.

Figure 5: Congestion of flap.

Venous congestion is the most frequent complication of propeller flaps because veins are more prone to torsion than arteries. Venous insufficiency should be distinguished from the temporary congestion that often

characterizes perforator flaps and fades with stabilization of flow.[13] Venous problems are especially evident in flaps requiring more than 120 degrees of rotation, therefore in these flaps, extending the pedicle dissection as far as possible is necessary with follow-up. The main reason behind this venous congestion was thought to be the compression of venae comitantes around the pedicle. Experimental studies have demonstrated that the length of a vessel [l] is inversely proportional to the critical angle of twisting (Δt): $\Delta t = [l \times (1/\Delta t)]$.[14,15] Donor-site healing problems occurred in one subject within the propeller flap group, so the defect was reoperated on, and graft application performed after vacuum assisted closure (VAC) therapy. We believe that this is a major disadvantage of propeller perforator flaps, and it can be prevented with preservation of the fascia in the distal part if possible. Local (traditional) flaps can be applied to suitable defects in small facilities with less microsurgical expertise in terms of lacking the need for microanostomosis and where marking of perforators is not possible. Referral of patients with small- to medium-sized defects of distal lower extremity reconstruction requiring flap coverage can be prevented with wide application and acceptance of local flaps. We assume that local flap operations are also significantly more cost-effective versus propeller flaps which by and large require long periods of care and hospital stays. Selection of the suitable perforator is of prime importance; although propeller perforator flaps can be harvested under tourniquet control after identification of the pedicle, we released the tourniquet and checked for visible pulsation, an important hallmark of perforator adequacy. Even for the inexperienced surgeon, identification, selection, and dissection of suitable local perforators is not too arduous, and we believe that the learning curve for application of propeller perforator flaps is much more demanding than that for local (traditional) flaps. A useful tool in the planning of perforator flaps is the manual unidirectional acoustic Doppler, in all patients preoperatively as a guide for vessel location and flap design. In our practice, we used a handled Doppler with a 8 Mhz probe. Khan and Miller use a handheld Doppler with 8-10 MHz probes, reporting a sensitivity of 90% with a confidence interval of up to 95%, positive predictive value of 84% with a reliability interval of 74-91%.[16,17] The transducer is angled approximately 45 degrees to the surface of the skin, because performing it parallel to the skin may increase the possibility than an axial vessel; our source vessel will be selected instead of a perforator. Recently, there have been numerous studies on the reconstruction of traumatic lower extremity wounds with propeller flaps. However, though propeller flaps have been used to cover these types of defects with proven success, there is no evidence in the literature that compares local flaps to propeller flaps for the lower extremity reconstruction. In this prospective study, we sought to do this specifically. We believe that our 30-patient series is sufficient regarding the limited literature sample sizes. Underlying fracture, pathology, and orthopedic intervention may be of importance in the success of these operations that are not validated. Even though patients with comorbidities and distal circulation problems have not been included, applicability of these flaps in this struggling patient population is still to be determined.

Limitations

Limitation of the current study is surgery of either local flap or propeller perforator flap was selected randomly which might have influenced the outcome study.

CONCLUSION

All in all, we contend that local (traditional) flaps are still as reliable as propeller perforator flaps in reconstruction of moderate- to small-sized defects of the lower extremity. Concerning the many advantages, like decreased operative time, not needing Doppler marking and need for loupe dissection of perforators, relatively less venous congestion, and total flap loss. These flaps can be employed successfully by reconstructive surgeons in small clinics, and they prevent unnecessary tertiary medical center referrals as well as extended hospitalization, long operation times, and increased costs but propeller flaps do hold other advantages like reconstruction with like tissues, avoidance of another distant donor-site scar and dogears with more esthetic acceptance. So, where facilities of having marking and isolation of perforators are available, propeller flaps do offer aesthetic advantage and better acceptance by the patient.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Manohar N, Vathulya M, Mahakalkar S. A Novel Fasciocutaneous Flap Design for Reconstructions in Scarred Tissue: A Case Report. Cureus. 2021;13(7):e16402.
2. Lecours C, Saint-Cyr M, Wong C, Bernier C, Mailhot E, Tardif M, Chollet A. Freestyle pedicle perforator flaps: clinical results and vascular anatomy. Plast Reconstr Surg. 2010;126(5):1589-603.
3. Mateev MA, Kuokkanen HO. Reconstruction of soft tissue defects in the extremities with a pedicled perforator flap: series of 25 patients. J Plast Surg Hand Surg. 2012;46(1):32-6.
4. Pignatti M, Ogawa R, Hallock GG, Mateev M, Georgescu AV, Balakrishnan G, et al. The "Tokyo" consensus on propeller flaps. Plast Reconstr Surg. 2011;127:716-22.
5. Bekara F, Herlin C, Somda S, de Runz A, Grolleau JL, Chaput B. Free versus perforator-pedicled propeller flaps in lower extremity reconstruction:

What is the safest coverage? A meta-analysis. Microsurg. 2016.
6. Acartürk TO, Tunc S, Acar F. Versatility of the perforator-based adipose, adipofascial, and fasciocutaneous flaps in reconstruction of distal leg and foot defects. J Foot Ankle Surg. 2016; 55:362-7.
7. Vaienti L, Calori GM, Leone F, Brioschi M, Parodi PC, Marchesi A. Posterior tibial artery perforator flaps for coverage of Achilles region defects. Injury. 2014;45:S133-7.
8. Hyakusoku H, Yamamoto T, Fumiiri M. The propeller flap method. Br J Plast Surg. 1991;44:53-54.
9. Pignatti M, Ogawa R, Hallock GG. The "Tokyo" consensus on propeller flaps. Plast Reconstr Surg. 2011;127:716-22.
10. Gir P, Cheng A, Oni G, Mojallal A, Saint-Cyr M. Pedicled perforator (propeller) flaps in lower extremity defects: A systematic review. J Reconstr Microsurg. 2012;28:595-601.
11. Hallock GG. Direct and indirect perforator flaps: the history and the controversy. Plast Reconstr Surg. 2003;111:855-65.
12. Bekara F, Herlin C, Mojallal A, Sinna R, Ayestaray B, Letois F, et al. A systematic review and meta-analysis of perforator-pedicled propeller flaps in lower extremity defects: identification of risk factors for complications. Plast Reconstr Surg. 2016;137:314-31.
13. D'Arpa S, Toia F, Pirrello R, Moschella F, Cordova A. Propeller flaps: a review of indications, technique, and results. Biomed Res Int. 2014;2014:986829.
14. Bravo FG, Schwarze HP. Free-style local perforator flaps: Concept and classification system. J Plast Reconstr Aesthet Surg. 2009;62:602-8.
15. Bilgin SS, Topalan M, Ip WY, Chow SP. Effect of torsion on microvenous anastomotic patency in a rat model and early thrombolytic phenomenon. Microsurgery. 2003;23:381-6.
16. Panagiotopoulos K, Soucacos PN, Korres DS. Anatomical study and colour Doppler assessment of the skin perforators of the anterior tibial artery and possible clinical applications. J Plast Reconstr Aesthet Surg. 2009;62:1524-9.
17. Khan UD, Miller JG. Reliability of handheld Doppler in planning local perforator-based flaps for extremities. Aesthetic Plast Surg. 2007;31:521-5.

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