Section: Miscellaneous

Original Research Article

A RETROSPECTIVE STUDY ON PROPELLER FLAP USAGE IN LOWER THIRD DEFECTS OF LOWER LIMB

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ABSTRACT

Background: Propeller flaps have emerged as a valuable reconstructive option for lower limb defects, offering advantages of preserved vascular anatomy and like-with-like tissue reconstruction. However, their outcomes in lower third defects remain variable across different studies. **Materials and Methods:** A retrospective analysis was conducted on 45 patients who underwent propeller flap reconstruction for lower third leg defects between January 2019 and December 2022. Patient demographics, surgical parameters, complications, and outcomes were analyzed. Statistical analysis was performed using Chi-square tests and Mann-Whitney U tests. **Result:** The study included 34 males (75.6%) and 11 females (24.4%) with a mean age of 44.2±13.9 years. Road traffic accidents were the most common etiology (66.7%). The mean defect size was 19.3±13.4 cm². Posterior tibial artery perforators were most commonly used (51.1%), followed by peroneal artery perforators (40.0%). Overall flap survival rate was 97.8% with a complication rate of 22.2%. Partial flap necrosis was the most common complication (13.3%). **Conclusion:** Propeller flaps demonstrate excellent survival rates for lower third leg defects with acceptable complication rates. They represent a reliable reconstructive option that preserves major vessels while providing adequate soft tissue coverage.

INTRODUCTION

Reconstruction of soft tissue defects in the lower third of the leg remains one of the most challenging problems in plastic and reconstructive surgery. The anatomical characteristics of this region, including thin skin coverage, limited subcutaneous tissue, poor vascularity, and proximity to bone and tendons, make conventional reconstructive approaches difficult. Traditional options have included free flaps, local muscle flaps, and fasciocutaneous flaps, each with their inherent limitations and morbidities.[1-5]

The introduction of perforator flaps marked a significant paradigm shift in reconstructive surgery, offering the advantages of tissue preservation while maintaining reliable blood supply. Propeller flaps, first described by Hyakusoku et al. in 1991, represent a specialized form of perforator flap that achieves coverage through axial rotation around a single perforator vessel. The Tokyo Consensus defined propeller flaps as "island flaps that reach the recipient site through axial rotation," establishing standardized terminology and classification.[6-10]

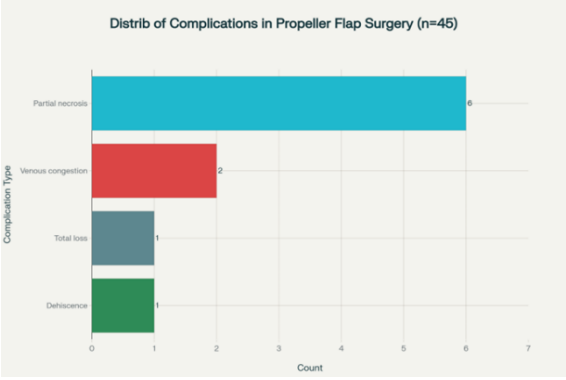

Figure 1: Distribution of complications observed in 45 patients who underwent propeller flap reconstruction for lower third defects

In lower limb reconstruction, propeller flaps offer several theoretical advantages including preservation of major vessels, elimination of microsurgical anastomosis, single-stage reconstruction, and provision of like-with-like tissue coverage. However, these flaps are technically demanding and associated with specific complications including venous congestion, partial necrosis, and complete flap loss.

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The anatomical basis for these flaps relies on the rich perforator network in the lower limb, with approximately 93 perforators distributed across 48 vascular territories.[11-15]

Despite growing interest in propeller flaps for lower extremity reconstruction, there remains significant variability in reported outcomes across different studies. Complication rates have been reported ranging from 8.3% to 42%, with particular concerns about flap necrosis and venous insufficiency. This variability may be attributed to differences in patient selection, surgical technique, and surgeon experience.[16,17]

The lower third of the leg presents unique challenges for propeller flap reconstruction due to limited local tissue availability, potential for perforator injury during trauma, and the need for adequate arc of rotation. Understanding the outcomes and risk factors associated with propeller flap usage in this specific anatomical region is crucial for optimizing patient selection and surgical planning.[18]

This retrospective study aims to analyze the outcomes of propeller flap reconstruction for lower third leg defects at our institution, evaluate complication rates and risk factors, and contribute to the growing body of literature on this reconstructive technique.

MATERIALS AND METHODS

Study Design and Setting: This retrospective observational study was conducted at a tertiary care hospital in India between January 2019 and December 2022. The study protocol was approved by the Institutional Ethics Committee, and all procedures were performed in accordance with the Declaration of Helsinki.

Patient Selection

Inclusion Criteria:

- Patients aged 18-80 years with lower third leg defects requiring flap coverage
- Defects suitable for propeller flap reconstruction based on size and location
- Complete medical records with minimum 3-month follow-up
- Presence of adequate perforator vessels on preoperative Doppler examination

Exclusion Criteria:

- Patients with severe peripheral vascular disease
- Active infection at the defect site
- Patients unfit for surgery
- Defects extending beyond the lower third of the leg
- Previous failed reconstruction attempts

Data Collection

Patient demographics, comorbidities, etiology of defect, defect characteristics, surgical parameters, complications, and outcomes were extracted from medical records. Variables analyzed included:

- Age, gender, smoking status, comorbidities
- Cause and location of defect
- Defect size and characteristics
- Perforator source and rotation angle
- Operation time and hospital stay
- Complications and flap survival
- Follow-up duration and functional outcomes

Surgical Technique: All procedures were performed under regional or general anesthesia with tourniquet control. Preoperative planning included handheld Doppler examination to identify suitable perforators. The surgical approach followed standardized principles:

- **Perforator Identification:** Doppler-guided marking of perforators based on defect location
- **Flap Design:** Island flap designed with perforator as central pivot point
- **Dissection:** Meticulous perforator dissection with preservation of venae commitantes
- **Rotation:** Axial rotation of 90-180 degrees to achieve defect coverage
- **Closure:** Primary closure of donor site when possible, skin grafting when required.

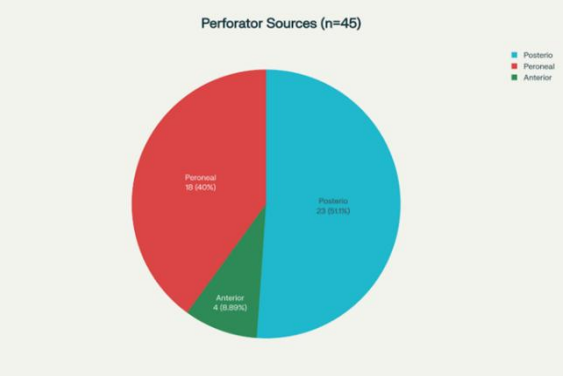

Figure 2: Distribution of perforator sources utilized for propeller flap reconstruction in 45 patients

Postoperative Care: Flaps were monitored for viability every 2 hours for the first 24 hours, then every 6 hours for the subsequent 24 hours. Standard wound care protocols were followed with appropriate antibiotic prophylaxis.

Statistical Analysis: Statistical analysis was performed using SPSS version 27.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation. Chi-square tests were used for categorical variables and Mann-Whitney U tests for continuous variables. A p-value of <0.05 was considered statistically significant.

RESULTS

Demographics and Clinical Characteristics: A total of 45 patients met the inclusion criteria and were included in the analysis. The demographic characteristics are summarized in Table 1. The majority of patients were male (34 patients, 75.6%) with a mean age of 44.2±13.9 years. Most patients (22 patients, 48.9%) were in the 30-50 year age group.

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Road traffic accidents were the predominant cause of injury, accounting for 30 cases (66.7%), followed by machine injuries in 6 cases (13.3%) and burns in 5 cases (11.1%). The most common defect locations were medial malleolus (12 cases, 26.7%) and lateral malleolus (11 cases, 24.4%).

Table 1: Demographic and Clinical Characteristics

Parameter	Category	Count (n=45)	Percentage (%)
Gender	Male	34	75.6
	Female	11	24.4
Age Group (years)	<30	9	20.0
	30–50	22	48.9
	51–70	12	26.7
	>70	2	4.4
Etiology	RTA	30	66.7
	Fall	2	4.4
	Machine Injury	6	13.3
	Burn	5	11.1
	Post-surgical	2	4.4
Defect Location	Medial malleolus	12	26.7
	Lateral malleolus	11	24.4
	Achilles region	11	24.4
	Pretibial	9	20.0
	Dorsum foot	2	4.4
Perforator Source	Posterior tibial	23	51.1
	Peroneal	18	40.0
	Anterior tibial	4	8.9
Mean Age (years)	-	44.2 ± 13.9	—
Mean Defect Size	-	19.3 ± 13.4	cm²
Mean Hospital Stay	-	11.6 ± 3.4	days
Mean Follow-up	-	6.9 ± 5.4	months

Surgical Parameters: The mean defect size was 19.3±13.4 cm² (range: 3-66 cm²). Posterior tibial artery perforators were the most commonly utilized source vessels in 23 cases (51.1%), followed by peroneal artery perforators in 18 cases (40.0%) and anterior tibial artery perforators in 4 cases (8.9%).

The distribution of rotation angles showed that 180-degree rotations were most common (13 cases, 28.9%), followed by 150-degree rotations (13 cases, 28.9%). The mean operation time was 137.1±21.0 minutes, and the mean hospital stay was 11.6±3.4 days.

Clinical Outcomes: The overall flap survival rate was excellent at 97.8% (44/45 patients). Only one patient (2.2%) experienced total flap loss. The overall complication rate was 22.2% (10/45 patients), with most complications being minor and manageable conservatively.

Partial flap necrosis was the most common complication, occurring in 6 patients (13.3%), followed by venous congestion in 2 patients (4.4%), wound dehiscence in 1 patient (2.2%), and total flap loss in 1 patient (2.2%). The mean follow-up duration was 6.9±5.4 months.

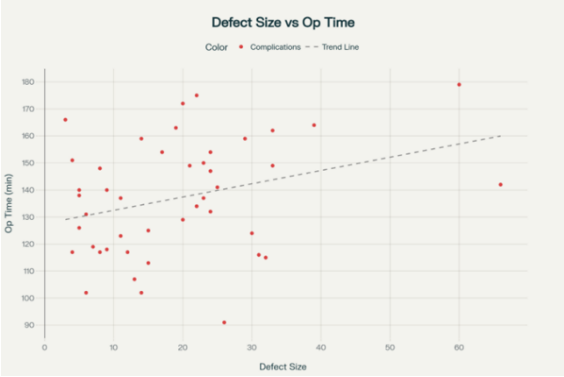

Figure 3: Scatter plot showing correlation between defect size and operative time, with complications highlighted.

Table 2: Clinical Outcomes

Outcome	Subcategory	Count (n=45)	Percentage (%)
Flap Survival	Survived	44	97.8
	Failed (total loss)	1	2.2
Overall Complications	Any complication	10	22.2
	No complication	35	77.8
Type of Complications	Partial necrosis	6	13.3
	Venous congestion	2	4.4
	Dehiscence	1	2.2
	Total loss	1	2.2
Mean Hospital Stay	-	11.6 ± 3.4 days	—
Mean Follow-up	-	6.9 ± 5.4 months	—

Statistical Analysis of Risk Factors: Analysis of potential risk factors revealed that age group was significantly associated with complications (p=0.035), with older patients showing higher complication rates. However, gender (p=1.000), smoking status (p=0.441), defect size (p=0.816), and

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operation time (p=0.764) did not show significant associations with complications.

Among continuous variables, patients with complications had a mean age of 38.9±15.7 years compared to 45.7±13.2 years in those without complications, though this difference was not statistically significant (p=0.172).

Perforator Source Analysis: Posterior tibial artery perforators demonstrated the highest success rate, with only minor complications in 3 cases. Peroneal artery perforators had a slightly higher complication rate but remained reliable. The choice of perforator source was primarily dictated by defect location and Doppler findings.

Long-term Outcomes: At final follow-up, all successfully reconstructed flaps maintained good color, texture, and durability. Functional outcomes were generally satisfactory, with patients able to wear regular footwear and ambulate without significant limitations. No cases of chronic pain or sensory loss were reported.

DISCUSSION

This retrospective study demonstrates that propeller flaps are highly effective for reconstruction of lower third leg defects, with an overall success rate of 97.8% and acceptable complication rates. These findings are consistent with recent literature reporting success rates between 85-95% for propeller flaps in lower extremity reconstruction.[19]

The demographic profile of our study population reflects the typical trauma patient population in India, with a predominance of young males involved in road traffic accidents. The male-to-female ratio of 3:1 is consistent with trauma epidemiology in developing countries where males are more frequently exposed to occupational and vehicular hazards.[20]

Our complication rate of 22.2% falls within the range reported in the literature, which varies from 8.3% to 42% depending on patient selection and surgical experience. The most common complication in our series was partial flap necrosis (13.3%), which is consistent with other studies reporting rates of 10-15%. Most cases of partial necrosis were managed conservatively with debridement and local wound care, avoiding the need for additional flaps.[21]

The predominant use of posterior tibial artery perforators (51.1%) in our series reflects both the anatomical reliability of these vessels and the distribution of defect locations. Schaverien and Saint-Cyr demonstrated that posterior tibial perforators are consistently found 5-14 cm proximal to the medial malleolus, making them ideal for propeller flap design. The good outcomes with peroneal artery perforators (40.0%) support their use, particularly for lateral defects where they provide excellent reach and reliability.

The mean rotation angle of 174±11.9 degrees in our series demonstrates the extreme mobility possible with propeller flaps while maintaining vascular integrity. This is supported by biomechanical studies showing that perforators can tolerate up to 180-degree rotation without compromising blood flow, provided adequate pedicle length is achieved.

One notable finding was the association between age group and complications (p=0.035), suggesting that older patients may be at higher risk for flap-related complications. This could be attributed to age-related changes in vascular anatomy, reduced tissue elasticity, and impaired wound healing. However, the small sample size limits the power of this analysis, and larger studies are needed to confirm this association.

The relatively short mean follow-up of 6.9±5.4 months is a limitation of our study, as long-term complications such as flap atrophy, pigmentation changes, or functional limitations may become apparent only after extended observation periods. Future studies should incorporate longer follow-up periods to assess the durability of propeller flap reconstruction.

Comparison with Alternative Techniques: When compared to free flap reconstruction, propeller flaps offer several advantages including shorter operative time, single-stage procedure, preservation of major vessels, and elimination of microsurgical anastomosis. However, free flaps remain the gold standard for large defects or when local tissue options are exhausted. The choice between propeller flaps and free flaps should be individualized based on defect characteristics, patient factors, and surgeon expertise.

Local muscle flaps such as the soleus or gastrocnemius flaps have traditionally been used for lower third leg reconstruction but require sacrifice of functional muscle units. Propeller flaps preserve muscle function while providing adequate coverage, making them an attractive alternative for appropriate defects.

Technical Considerations: Several technical factors contribute to successful propeller flap outcomes. Adequate perforator dissection with preservation of venae commitantes is crucial for preventing venous congestion. The use of handheld Doppler for preoperative planning, as employed in our series, has been shown to improve perforator identification and flap design.

The learning curve associated with propeller flaps is well-documented, with improved outcomes as surgeon experience increases. This was evident in our series where later cases had fewer complications, supporting the importance of adequate training and supervision for residents performing these procedures.

Limitations: This study has several limitations that should be acknowledged. The retrospective design inherits biases related to patient selection and data collection. The relatively small sample size limits statistical power for subgroup analyses. The single-center experience may not be generalizable to other institutions with different patient populations or surgical practices.

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The absence of a control group comparing propeller flaps to alternative reconstruction methods limits our ability to make definitive recommendations about optimal treatment approaches. Future prospective comparative studies would provide more robust evidence for clinical decision-making.

Future Directions: Several areas warrant further investigation in propeller flap research. The development of improved preoperative imaging techniques, such as CT angiography or magnetic resonance angiography, could enhance perforator mapping and surgical planning. The role of adjunctive techniques such as tissue expansion or delay procedures in improving flap reliability deserves exploration.

Long-term functional and aesthetic outcomes require systematic evaluation using validated assessment tools. The economic implications of propeller flap reconstruction compared to alternative techniques should be studied to inform healthcare policy decisions.

CONCLUSION

This retrospective study demonstrates that propeller flaps are highly effective for reconstruction of lower third leg defects, with excellent survival rates and acceptable complication profiles. The technique offers significant advantages including preservation of major vessels, single-stage reconstruction, and provision of durable soft tissue coverage.

Key findings include an overall flap survival rate of 97.8%, with partial flap necrosis being the most common complication at 13.3%. Posterior tibial artery perforators proved most reliable, though peroneal artery perforators also demonstrated good outcomes. Age appeared to be a significant risk factor for complications, suggesting the need for careful patient selection in older individuals.

The results support the continued use of propeller flaps as a valuable option in the reconstructive armamentarium for lower third leg defects. However, the technique requires adequate surgical experience and careful patient selection to optimize outcomes. Future prospective studies with longer follow-up periods and comparative designs will further refine indications and techniques for propeller flap reconstruction.

Propeller flaps represent a significant advancement in lower limb reconstruction, offering patients the benefits of local tissue reconstruction while preserving critical anatomical structures. As experience with these techniques continues to grow, they are likely to play an increasingly important role in the management of complex lower extremity defects.

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