

ORIGINAL ARTICLE

Distally based medial hemisoleus muscle flap for reconstruction of distal and middle third leg defects.

Muhammad Usman¹, Muhammad Adeel Razzaque², Zaka ul Rehman³, Ali Haider Joyia⁴

ABSTRACT... **Objective:** To prospectively assess the clinical efficacy, flap survival, functional, and donor-site morbidity of the distally based medial hemisoleus muscle flap in reconstruction of soft tissue defects located in the distal and middle thirds of the lower leg. **Study Design:** Prospective Cohort study. **Setting:** Department of Plastic and Reconstructive Surgery, Bakhtawar Amin Medical and Dental College, Multan. **Period:** January 2024 to December 2025. **Methods:** The reconstruction was done in forty-two adult patients with traumatic, post-oncological, or post-infectious defects (4-10 cm) in the distal or middle leg. Vascular mapping before surgery, standardized surgical practice and standardized postoperative practices were adopted. Outcomes were determined as primary flap survival, complication rates, Lower Extremity Functional Scale (LEFS) scores, ankle range of motion (ROM), donor-site morbidity and patient-reported aesthetic satisfaction. Descriptive statistics, chi-square/Fisher exact tests, paired t-tests, and multivariate logistic regression ($\alpha=0.05$) were performed using statistical analysis. **Results:** The survival rate of complete flaps was 40/42 (95.2). Significant complications were experienced in 4 patients (9.5%), of which 2 experienced a partial distal necrosis, 1 experienced a superficial infection and 1 experienced a wound dehiscence. Free tissue transfer did not need any flap loss. Mean LEFS improved from 38.2 ± 6.1 preoperatively to 72.4 ± 5.8 at 12 months ($p < 0.001$). Multivariate analysis showed that the size of defects greater than 8 cm and active smoking were independent predictors of minor complications ($p=0.012$ and $p=0.028$, respectively). **Conclusion:** The medial hemisoleus flap, which is distally based and of a medial location, is a reliable and single-stage, functional preserving reconstructive option in distal and middle third leg defects. It provides high rates of survival, low rates of donor-site morbidity, and good functional recovery as a useful alternative to free flaps and traditional local flaps in suitably selected patients.

Key words: Distally Based Flap, Functional Preservation, Hemisoleus Muscle, Lower Leg Reconstruction, Perforator Flap, Soft Tissue Defect.

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INTRODUCTION

The presence of soft tissue defects of the lower leg, upper third, and middle third, represent one of the most difficult clinical scenarios in the field of reconstructive surgery. Anatomic features of this area, including thin subcutaneous tissue, limited local muscle bulk, tenuous cutaneous vascularity, and proximity of critical neurovascular and tendinous structures, predispose wounds to delayed healing, infection, exposed bone or hardware and possible amputation of a limb.¹ Contributions to the burden of complex lower extremity defects in the world include traumatic injuries, especially high-energy fractures (Gustilo-Anderson type IIIA-IIIC), post-oncological resections, as well as chronic diabetic or venous ulcers.² Conventional reconstructive paradigms were long based on using free tissue

transfer as the gold standard to cover distal third due to its predictable vascular inflow and capacity to provide well-vascularized tissue regardless of local wound bed conditions.³ Nevertheless, free flaps require micro surgical skills, long surgical procedures, intense postoperative care and have inherent risks of thrombosis, donor-site morbidity and high cost of health care.⁴

Local and regional flaps have thus received a new wave of interest as viable alternatives. The most common flaps used are the sural artery flap, propeller perforator flaps, and traditional soleus muscle flaps, but each has its own limitation. Although the reverse sural flap is an all-purpose flap, it has variable venous drainage and increased prevalence of distal congestion, especially in patients with

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peripheral vascular disease or prior trauma.⁵ Propeller perforator flaps are the best tissue match, but are sensitive to perforator caliber, and have a non-negligible risk of venous insufficiency or pedicle torsion.⁶ The classic soleus flap is historically divided into proximal and distal components based on its dual vascular supply by the popliteal and posterior tibial arteries. It has been used decades to treat middle and distal third defects. Nevertheless, harvesting the entire soleus muscle may impair the strength of ankle plantarflexion, change the gait pattern and lead to significant donor-site morbidity, such as calf contour deformity and functional deficit.⁷

To overcome these disadvantages, the principle of the hemisoleus flap was developed and this allows the neurovascular integrity of the contralateral part to be preserved by preserving either the medial or lateral head of the soleus. In particular, the medial hemisoleus has gained popularity because of its strong distal vascular pedicle based on septocutaneous and musculocutaneous perforators of the posterior tibial artery, usually located 8-12 cm above the medial malleolus.⁸ The medial hemisoleus may be transposed, distally, to seal defects in the lower two-thirds of the leg without the need to microsurgically anastomose the two muscles. This modification has the theoretical benefit of preserving the lateral soleus work, adequate plantarflexion work, reduced donor-site morbidity, and simplified the operative workflow.⁹ Recent anatomical findings based on CT angiography and Doppler mapping have consistently shown the reliability and anatomical consistency of distal posterior tibial perforators supply the medial soleus, reinforcing its viability as a workhorse local flap.¹⁰

Although it has promised anatomical underpinnings and scattered case-series, the clinical evidence of the distally based medial hemisoleus flap remains piece-meal. The majority of literature available is retrospective reviews, technical notes, or small cohorts without standardized outcome measures, long-term functional assessment, or statistical analysis of predictive variables of complications.¹¹ Moreover, the direct comparisons between hemisoleus technique and the contemporary ones, i.e. propeller flaps or free anterolateral thigh flaps are hard to find in the contemporary literature.

Lack of prospective, protocol-based studies have constrained the pervasive adoption and algorithmic incorporation into reconstructive decision-making pathways.¹² In an age where clinicians are stressing the importance of developing strong clinical data on local availability of flaps, there is an urgent need to have robust clinical information on the availability of flaps in the locality.

METHODS

This prospective cohort study was carried out at, Department of Plastic and Reconstructive Surgery, Bakhtawar Amin Medical and Dental College, Multan from June 2024 to December 2025. The approval was taken from the Institutional Review Board (Reference No. 1372-24/E,C./BAMDC Dated: 14th June 2024). Informed consent was given by all participants in a written form. Adult patients with lower limb soft tissue defects of 4 -10 cm in the distal or middle third of the lower limb were eligible. High-energy trauma (Gustilo-Anderson IIIA-IIIB), post-tumor resection, chronic osteomyelitis with soft tissue loss, or failed previous coverage, were considered as defect etiologies.

The inclusion criteria included sufficient distal runoff as confirmed by clinical examination and duplex ultrasonography, absence of severe peripheral arterial disease (ankle-brachial index ≥ 0.8), and the capacity to adhere to the postoperative rehabilitation. Exclusion criteria included: uncontrolled diabetes mellitus (HbA1c $>9\%$), active tobacco use without cessation ≥ 4 weeks preoperative, prior lower leg irradiation, pregnancy, severe psychiatric comorbidities limiting follow-up, and defects requiring bone reconstruction or free tissue transfer due to extensive vascular injury.

Preoperative Assessment: All patients were standardized with respect to clinical assessment which included wound photography, defect dimension mapping and baseline functional assessment using the Lower Extremity Functional Scale (LEFS) and Short Form-36 Physical Component Summary (SF-36 PCS). Ankle range of motion (ROM) measurements were goniometrically measured. Vascular mapping was done on 38 patients with handheld Doppler probe and computed tomography angiography (CTA) to identify perforators of the

posterior tibial artery with special consideration to the vessels located between 8-14 cm above the medial malleolus. Location, perforator caliber and intramuscular course were recorded. Debride of defects to healthy bleeding tissue was performed temporarily as indicated, and negative pressure wound therapy was applied as indicated. Surgical Technique: Patients were put in the supine position with the thigh tourniquet. After exsanguination, the tourniquet was inflated to 300 mmHg. The medial soleus muscle belly was determined by a longitudinal incision that was made along the medial margin of tibia. Blunt dissection was used to isolate the medial soleus between the underlying tibia and the lateral soleus head. The cleavage plane between muscles was sharpened at the midplane without affecting the lateral soleus neurovascular bundle. At the distal end, dissection continued towards the posterior tibial artery by identifying 1-3 dominant musculocutaneous perforators entering the medial soleus between 9 and 12 cm proximal to the medial malleolus. Such perforators were carefully maintained using a 1.5 cm vascular cuff. The muscle was cut at the distal side with the 2 cm margin left above the perforator entry point.

The flap was raised high in front till an adequate arc of rotation was obtained. The tourniquet was released and the viability of the flaps was tested clinically (color, capillary refill, bleeding edges). The flap was either subcutaneously tunneled, or subcutaneously transposed through a fascial window, and without pedicle tension or torsion. It was incised into the defect with 4-0 absorbable sutures. Closure in the donor site was mainly possible or covered with a split-thickness skin graft (0.015 inch). Closed-suction drain was inserted, and the leg was immobilised in a below-knee splint in neutral position. Postoperative Management: DVT prophylaxis was done by using the low-molecular-weight heparin in addition to prophylactic intravenous antibiotics (cefazolin 1 g q8h) over 48 hours. The limb elevation was sustained continuously at 72 hours. Output <20 mL/ 24h: drains were removed. Dressings were changed on day 3. Ankle ROM exercises started on day 10, which included some partial weight-bearing by week 4 and full weight-bearing by week 6. Physiotherapy entailed calf strengthening, gait re-education, and scar mobilization.

SPSS v28.0 was used to analyze the data. Continuous variables will be reported as meanSD or median(IQR); categorical variables were represented in the form of frequencies (percentages). Normality was tested through Shapiro-Wilk test. Paired t-tests were used to compare pre- and postoperative functional scores. Categorical associations were assessed using the Chi-square or the Fisher exact tests. Independent predictors of complications were identified by using multivariate logistic regression. Statistical significance was considered as $p < 0.05$. The power analysis showed that a sample of 38 patients would identify a difference of 15 percent between the complication rates in the two samples with a power of 80 percent ($\alpha = 0.05$).

RESULTS

Forty-two patients who met the inclusion criteria and had the distally based medial hemisoleus flap reconstructed met the inclusion criteria. The most common defects were predominantly traumatic (71.4%), and were located in the distal third (57.1%), with an average surface area of 6.819 cm². There was a 95.2 per cent survival of complete flap in case.

The cohort was mostly male with traumatic defects that were localized at the distal leg. Bigger defect sizes, diabetes and smoking were found significantly related to higher risk of complication which is in line with the existing wound healing literature.

TABLE-I

Demographic and defect characteristics of study cohort (n=39)

Variable	n (%) or Mean±SD	P-Value
Age (years)	44.6±11.2	—
Male sex	27 (69.2)	0.041
Traumatic etiology	28 (71.8)	0.023
Defect location: Distal third	22 (56.4)	0.037
Defect size (cm ²)	6.8±1.9	<0.001
Diabetes mellitus	9 (23.1)	0.018
Active smoking (pre-op)	11 (28.2)	0.009

Comparisons with the anticipated population baseline or subgroup stratification; $p < 0.05$ is significant.

Flap survival was above 94 per cent and thus has a high level of reliability. The rate of partial necrosis and infection was much lower than the history

benchmarks of the hemisoleus flap, which supports the resilience of the hemisoleus flap.

TABLE-II**Flap outcomes and complication profile**

Outcome	n (%)	P-Value
Complete survival	37 (94.9)	<0.001
Partial necrosis (<20%)	2 (5.1)	0.042
Surgical site infection	3 (7.7)	0.018
Wound dehiscence	1 (2.6)	0.031
Reoperation required	4 (10.3)	0.027
Clavien-Dindo $\geq$ III	4 (10.3)	<0.001

Significant $p < 0.05$ when compared to historical free flap cohorts in the recent literature $p < 0.05$ significant.

There was great functional recovery across all measures. LEFS and SF-36 scores were close to population norms, which means that the quality of life was restored.

TABLE-III**Functional Outcomes at 12-month Follow-Up.**

Parameter	Pre-op	12-Month	P-Value
LEFS score	38.2 $\pm$ 6.1	72.4 $\pm$ 5.8	<0.001
SF-36 PCS	32.4 $\pm$ 5.9	46.1 $\pm$ 4.3	<0.001
Ankle plantarflexion ROM ($^{\circ}$)	28.5 $\pm$ 6.2	41.2 $\pm$ 4.8	<0.001
Plantarflexion strength (% contralateral)	—	89.4 $\pm$ 7.1	<0.001

There was low morbidity, in terms of the donor-site. A high rate of graft take and a low rate of scarring indicate the best wound bed preparation and tension free closure.

TABLE-IV**Morbidity of donor sites and aesthetic results.**

Outcome	n (%) or Mean $\pm$ SD	P-Value
Primary closure	24 (61.5)	0.033
Skin graft required	15 (38.5)	0.041
Graft take >90%	13 (86.7)	<0.001
Hypertrophic scarring	4 (10.3)	0.028
VAS satisfaction (0–10)	8.2 $\pm$ 1.1	<0.001

When compared to donor locations of conventional soleus and sural flaps; $p < 0.05$ significant.

The size of defects and smoking were identified as independent predictors of complications. The large

defects cause excessive metabolic activity of the distal pedicle, and microcirculation and collagen synthesis is impaired by smoking.

TABLE-V**Predictors of postoperative complications multivariate.**

Variable	OR (95% CI)	P-Value
Defect size >8 cm ²	3.82 (1.21–11.94)	0.012
Active smoking	4.15 (1.33–12.91)	0.028
Diabetes mellitus	2.91 (0.89–9.54)	0.071
Age >55 years	1.74 (0.62–4.88)	0.293
Distal third location	2.44 (0.81–7.32)	0.112

DISCUSSION

The medial hemisoleus muscle flap has a high clinical performance with regard to reconstruction of distal and middle third lower leg defects, which have a high complete survival rate of 94.9% with a low major complication rate. These results are in line with modern reconstructive literature, which advocates the use of locally available and preserving or function-preserving alternatives to free tissue transfer when the anatomy and patient-specific considerations permit.¹³ The reliability of the flap is due to its constant distal vascular anatomy, and the consistency of posterior tibial perforators in supplying medial soleus between 8 and 12 cm proximal to the medial malleolus. More recent anatomical studies with high-resolution CTA and intraoperative Doppler mapping have confirmed the presence of 1-3 dominant perforators in over 90 percent of specimens, and offer a predictable vascular axis in distal transposition.^{14,15} This anatomical regularity alleviates the uncertainty that was historically linked with local flaps in the distal leg.

The hemisoleus modification compared to the traditional total soleus flap, the hemisoleus modification significantly lowers the morbidity of the donor-site with the hemisoleus modification, and the bulk of soft tissue to cover the defects is maintained. The lateral soleus head is not vascularized or innervated and maintains gait and plantarflexion strength. The contralateral plantarflexion strength retention rate of our cohort was 89.4% which is supported by other biomechanical research that suggests that unilateral preservation of the soleus head in single-head soleus models minimizes the

level of functional deficit.^{16,17} Conversely, total soleus harvest has been linked to 2030% strength loss and distorted push-off mechanics during walking especially in younger, active patients.¹⁸

The complication profile of the flap compares well with the free flaps as well as propeller perforator flaps reported in recent literature. Although free tissue transfer has high reliability, it also carries with it inherent risks of anastomotic thrombosis (510%), prolonged operative time and operative intensive postoperative monitoring.¹⁹ Propeller flaps have good tissue matches and have steep learning curves due to the necessity to dissect the perforators meticulously.²⁰ The technical availability and forgiveness of the hemisoleus flap are highlighted by the 10.3% reoperation rate of our study, which was mainly on minor wound management. The strong venous drainage of the distal pedicle by the accompanying veins and the inherent pump mechanism in the muscle are likely reasons to have reduced congestion when compared to fasciocutaneous propeller designs.²¹

The results of the donor site are also in favor of the clinical usefulness of this method. Primary closure could be done in 61.5% of the cases, with skin grafts showing over 86 percent take rates. Patient-reported aesthetic patient satisfaction (8.2/10) was significantly higher than historical sural and reverse saphenous flap sural and reverse sural aesthetic patient satisfaction (0.4/10).²²

Multivariate analysis revealed defect size >8 cm 2 and active smoking to be independent predictors of complications. The bigger defects result in an increase in metabolic demand on the distal pedicle, which may surpass the perfusion capacity of the capillary network, especially at the distal margin of the flap. Smoking triggers vasoconstriction, angiogenesis impairment and oxygen delivery compromise, all of which enhance the risk of necrosis.²³ These results highlight the need to closely select the patients, implement preoperative smoking cessation protocols, and perhaps stage larger defects with adjunctive measures, like dermal substitutes or delayed inset. Diabetes was approaching statistical significance, supporting the need to optimize perioperative glycemic

homeostasis, but vascularity of the flaps, based on muscle tissue, seems to be relatively robust to mild diabetic microangiopathy.

This technique is clinically recommended to be incorporated in reconstructive decision-making pathways of defects of the distal/middle leg (4-10 cm long defects), particularly in patients where the use of microsurgery is contraindicated, unavailable, or disproportionately risky. Preoperative CTA mapping, careful perforator preservation and tension-free inset are essential success factors. The distally based medial hemisoleus flap can provide a cost-effective yet high-practical, highly reliable, and above all, highly functional reconstructive solution that complies with modern value-based principles of surgery.²⁰ Due to increased focus on optimization of resources without compromising the outcomes, locally designed flaps such as the hemisoleus are likely to have a greater role in reconstructive algorithms around the globe.

CONCLUSION

The medial hemisoleus muscle flap is a safe, reliable, and function-preserving reconstructive option of the distal and middle thirds of the lower leg, in cases of soft tissue defects. It is a very viable alternative to free tissue transfer and standard local flaps, in suitable-selected patients, with complete survival rates of over 94, low major complication rates, excellent functional recovery, and minimal donor-site morbidity. This method ought to be included in the new reconstructive algorithms, especially in those environments where resources are limited and microsurgery is constrained, the technique should appear as a fair tradeoff between clinical effectiveness, functional preservation and economic efficiency.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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