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Outcome of Pedicled Perforator Flaps in Reconstruction of Soft Tissue Defects in Lower One-Third of the Leg

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ABSTRACT

Objective: To assess the versatility of pedicled perforator flaps in lower one third of leg in terms of outcomes, postoperative complications and role in early rehabilitation of patients.

Study Design: Observational study.

Place and Duration of Study: Department of Plastic Surgery, Combined Military Hospital, Rawalpindi Pakistan, from Dec 2019 to Dec 2020.

Methodology: Thirty-seven patients meeting the exclusion and inclusion criteria for reconstruction of lower 1/3rd of leg were included. Pedicled perforator flaps based on the perforators of anterior tibial artery, posterior tibial artery or peroneal artery was harvested for wound reconstruction. Outcomes of the flaps were measured in terms of wound healing time, donor site management, its complication and return to the work of all patients.

Result: Overall success of pedicled perforator flaps in lower one third of leg was seen in 33(81.1%) patients. Donor site was covered with partial thickness skin graft in 33(89.2%) patients. Complications included 4(10.8%) wound infection, 2(5.4%) partial flap necrosis and 1(2.7%) case of flap failure. Mean healing time of flap was 18.56±11.50 days and patients returned to work in 3±1.39 months.

Conclusion: Pedicled perforator flaps are a technically straightforward procedure, provide localized like-for-like skin coverage of complex wound in lower 1/3rd of leg with excellent results and significantly low complication rate.

Keywords: Anterior Tibial Artery, Lower Leg, Pedicled Perforator flap, Plastic Surgery, Surgical Flaps.

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INTRODUCTION

The traditional approach to soft tissue reconstruction in proximal 2/3rd of the leg is local muscle flap, and free tissue transfer for distal 1/3rd of leg and foot.[1] Over the past two decades, pedicled perforator flap has become a more appealing option for wound coverage of distal 1/3rd.[2]

A pedicled perforator flap is an anatomical unit of skin and subcutaneous tissue vascularized by a perforator, perforator traverses through or between the deeper tissues.[3] The most common arch of rotation of flap is 180° for wound coverage designed as a propeller flap but in selected cases can be harvested as a transposition, rotation, island or advancement flap.[4-6] A sound knowledge regarding anatomy of the perforators of lower limb is mandatory for harvesting a flap. Identify and mark perforators with hand-held Doppler. Cutaneous and subcutaneous tissue along, with perforator, is meticulously dissected and mobilized for wound coverage.[7]

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Advantages of the perforator flap are like-for-like tissue replacement for wound reconstruction and reduced donor-site morbidities with preservation of major anatomical structures and probability of partial or complete closure of donor site defect.[1] This has a significant role in the coverage of soft tissue defects in old age, patients with multiple injuries or comorbidities.[7] It has no prerequisite of fancy instruments or a microsurgery specialist center.[1] One of the main drawbacks of the flap is that it is harvested from the zone of injury in which blood circulation is usually compromised.[7] Pedicled perforator flap has updated the reconstructive option for wound management in distal one third of leg. This study aims to evaluate the functional outcomes of the pedicled perforator flap for wound defect in the lower 1/3rd of the leg in terms of wound healing time, donor site management, its postoperative complications and its role in early rehabilitation of the patient.

METHODOLOGY

This observational study was conducted in the Department of Plastic Surgery, Combined Military Hospital, Rawalpindi Pakistan, from Dec 2019 to Dec

2020. Ethical approval was taken from hospital Ethical Review Committee (IERB no:176/6/21).

Inclusion Criteria: Patients of either gender, of all age groups, having a soft tissue defect in lower one third of the leg, with exposed structures such as bone, tendon, or neurovascular bundle, which cannot be healed by primary closure or secondary intention or skin graft were included.

Exclusion Criteria: Patients who had peripheral vascular disease; insulin dependent diabetes; perforators located in zone of injury were excluded.

Sample size was calculated using WHO sample size calculator, which came to 37.[7] Patients were recruited using non-probability consecutive sampling, and written informed consent was taken. Study included basic demographics, wound etiology, site and size of wound defect, type of perforator flap, donor site management, its outcomes, postoperative complications, duration of wound healing and return to work of each patient. Lower one third of leg divided into anterior, posterior, lateral and medial sites. Wound size less than 10cm^2 was classified as small, 10-50cm^2 medium and more than 50cm^2 was considered large.

After obtaining all information about demographics (including age and gender). We examined patients and assessed wound defect for type of perforator used for reconstruction, including extent of tissue damage. Surrounding tissue was checked for any discoloration, bruises, edema, delayed capillary refill or venous congestion. We assessed perforators in the surrounding area for wound coverage.

Wound reconstruction with pedicled perforator flap in lower one third of leg proceeded after adequate wound debridement under spinal or general anesthesia. Any orthopedic fixation needed was done before flap coverage by orthopedic team. Preoperative, suitable perforators of anterior tibial artery, posterior tibial artery, or peroneal artery were identified and marked with hand-held Doppler on skin according to their anatomical territories. Proximal perforators of anterior tibial artery were located 21-25cm superior to intermalleolar line between peroneus longus and extensor digitorum longus and distal perforators located 5-9cm superior to intermalleolar line between tibia and tibialis anterior. Peroneal artery was located 13-18cm superior to intermalleolar line within the posterior peroneal septum. Proximal, middle and distal perforator of posterior tibial artery was located at 21-25, 13-18, and 5-9 cm superior to intermalleolar line respectively located between soleus and flexor digitorum longus. The design of flap was according to wound site and size, location of selected perforator and arc of rotation. Pedicled perforator flap was harvested under tourniquet control at 300mmHg pressure. First, we incised only lateral border of the flap and dissection was done in subfascial plan under loupe magnification. Once a suitable perforator was identified, incision was extended to proximal end and medial side of the flap. Flap was harvested in proximal to distal direction. After the flap had been harvested, tourniquet was deflated and the flap was assessed for vascularity by prick method. Vascularity of flap was confirmed by the presence of bright red ooze at the distal end of flap. After confirming vascularity, flap was inset in the defect (Figure-1). In most cases, donor site was covered with a partial thickness skin graft. Flap was covered with a soft and light dressing to avoid compression, and regular monitoring was done through a small window left in dressing over flap by color, turgor, temperature, capillary refill and needle-prick method for 03 days. Follow up was maintained in all participants until wound had completely healed.

Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 25.00. Mean and SD was calculated for quantitative variables like age, size of flap, healing time and return to work. Qualitative variables like gender, wound etiology, location of wound, type of flap, donor site coverage and complications were recorded in terms of frequencies and percentages. Independent samples t-test was applied to check for a relationship between wound healing time and return to work with outcome of pedicled perforator flap. A p-value of ≤ 0.05 was considered as significant.

RESULT

A total of 37 patients, including 26(70.3%) males, and 11(29.7%) females were operated upon for reconstruction of lower one third of the leg with perforator flap. Mean age of the patients was 39.18±14.72 years (range 05 to 65 years). Most common etiology of wound defect in lower one third of leg was trauma (75.7%), followed by oncological resection (13.5%) and chronic non-healing ulcer (10.8%). Most common site of wound defects were lateral in 13(35.1%) patients, posterior in 9(24.3%), anterior in 8(21.6%) and, medial in 7(18.9%) patients. Out of 37 patients, 7(18.9%) had small size wounds, 25(67.6%) had medium size wounds and 5(13.5%) had large size wounds.

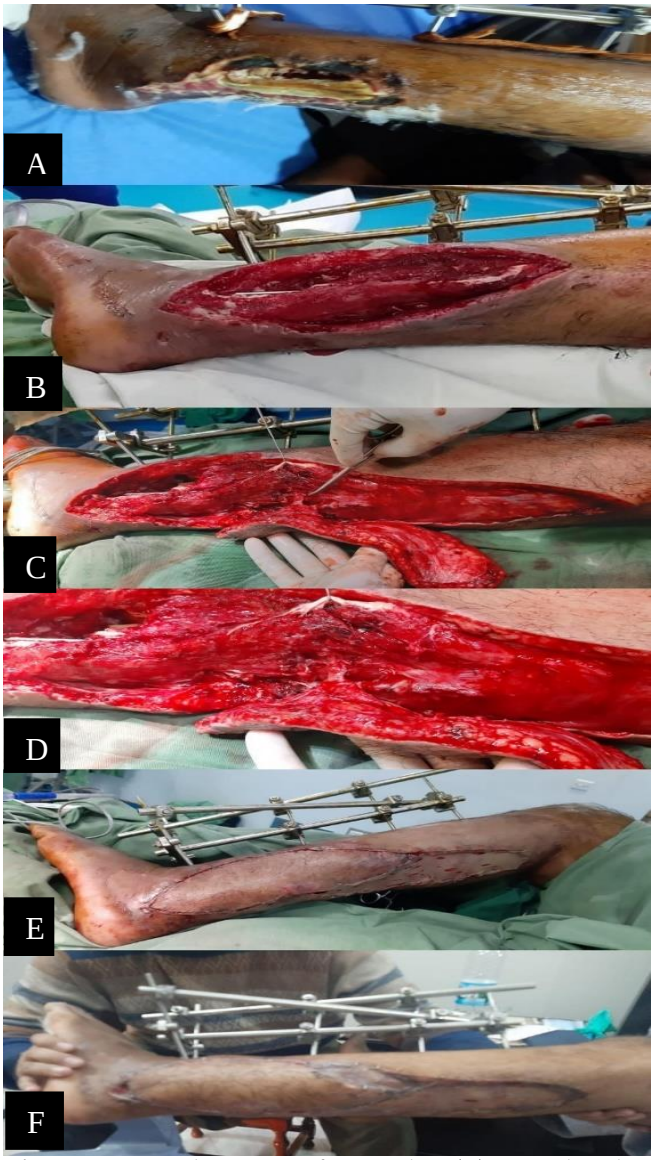

Figure-1: Peroneal Artery Perforator Flap. (A) Wound on leg. (B) After wound debridement. (C) Flap dissection. (D) Peroneal artery perforator (E) Flap inset with grafting on donor site (F) Postoperative wound healing.

Fourteen (37.8%) patients underwent bone fixation for fractures in leg. Wound defects were covered with peroneal artery perforator flaps in 16(43.2%), posterior tibial artery flaps in 14(37.8%) and anterior tibial artery flaps in 7(18.9%) patients. Donor site was closed primarily in 4(10.8%) patients and covered with partial thickness skin graft in 33(89.2%). Average wound healing time was 18.56±11.50 days.

Total number of small, medium, and large size wound defect coverage with anterior tibial artery perforator, posterior tibial artery perforator, and peroneal artery perforator is shown in Table-I.

Table-I: Type of Perforator Flaps for Different Wound Sizes (n=37)

Wound Size	Anterior tibial artery perforator	Posterior tibial artery perforator	Peroneal artery
Small	--	3(8.11%)	4(10.81%)
Medium	6(16.22%)	9(24.32%)	10(27.02%)
Large	1(2.70%)	2(5.41%)	2(5.41%)

Type of pedicled perforator flap harvested, based on location of wound defect in lower one third of leg is shown in Table-II.

Table-II: Location of Wound Defects and Type of Perforator flap for Wound Coverage (n=37)

Type of flap	Anterior	Medial	Posterior	Lateral
Anterior tibial artery	3(8.11%)	_	_	4(10.81%)
Posterior tibial artery	3(8.11%)	7(18.91%)	4(10.81%)	_
Peroneal artery	2(5.41%)	_	5(13.51%)	9(24.32%)

Postoperative complication rate was 18.9%, which included wound infection in 4(10.8%) patients, partial necrosis of flap observed in 2(5.4%), and complete flap failure in 1(2.7%) patient, based on anterior tibial artery perforator flap (Figure-2). In postoperative wound infection, defects were healed by secondary intention. Partial flap necrosis and complete flap failure were managed with wound debridement than followed by partial thickness skin graft.

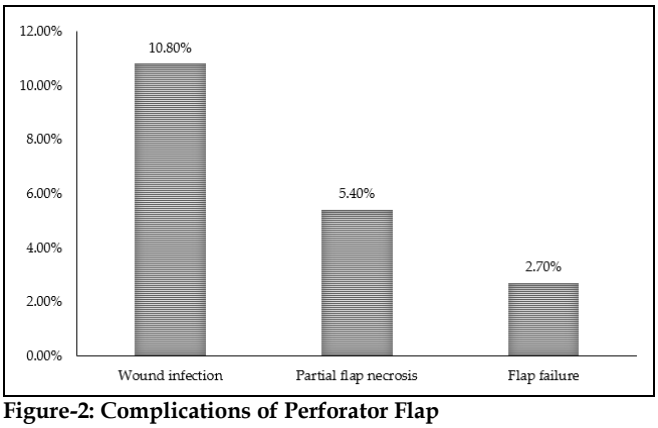

Figure-2: Complications of Perforator Flap

Average patients returned to work in 3.10±1.36 months. Mean duration of return to work was 2.3±0.82 months in patients with soft tissue injury and 4.42±1.01 months in orthoplastic patients. A statistically significant difference observed in wound healing time and return to work between patients

without complications and did not require a secondary procedure for wound coverage, and those with defects that required secondary procedure for wound coverage (p<0.05) as shown in Table-III

Table-III Comparison Among Patients for Wound Healing Time and Return to Work (n=37)

Variables	Non-Complicated Wounds n-33	Complicated Wounds n-4	*p*-value
Wound healing time	15.45±6.27	44.45±13.50	<0.001
Return to work	2.93±1.29	4.50±1.29	0.029

DISCUSSION

Lower limb reconstruction is a challenging task for a surgeon because of anatomical features, bone exposure secondary to trauma and paucity of soft tissue for wound coverage. Traditionally, micro-surgical tissue transfer was considered the first line of treatment for defects on lower one third of the leg. Pedicled perforator flaps have refashioned the options for reconstruction. Kroll *et al*., were the first to use the terminology of perforator-based flap.[8] Over the past two decades, it is a preferred option because of preservation of major anatomical structures and reconstruction with a pliable and similar texture of skin. It has significantly reduced the requirement for free flaps. Pedicled perforator flaps are a step forward in the reconstructive ladder for the management of the lower extremities wound.

In 2011, the Gent consensus defined a perforator flap as the anatomical unit of skin and/or sub cutaneous tissue supplied by a single perforator that runs through or in between deep tissue. It can be a septal perforator flap or muscle perforator flap depends on its pathway.[4]

The growing burden on orthoplastic departments in hospitals is mostly due to trauma secondary to high-speed road traffic accidents. Devare *et al*., analyzed in their study that most common cause of open wound in leg was trauma.[9] In our study, most common etiology of a defect in lower one third of leg was also found to be trauma (75.7%).

Wound surface area is one of the major factors for not only flap survival, but also for functional and aesthetic outcomes on both donor and recipient sites. Bajantri *et al*., analyzed that pedicle perforator flaps had a significant role in wound reconstruction in small-and-medium sized defects (up to 50cm^2).[10] In our study, out of five, one flap failure was noted in wounds sized larger than 50cm^2.

One of the prerequisites for perforator topography in leg is hand held Doppler, which we used to detect the location and quality of perforators. Martinez *at el*., reported that sensitivity of hand-held Doppler in locating perforator was 90.6%.[11]

The Perforasome is a term used for vascular territory supplied by a single perforator. It is interlinked with adjacent perforasomes with linking vessels either directly or indirectly. Large sizes flaps can be harvested based on a single perforator due to these linking vessels.[12] Cheng *et al*., found in his study that maximum length to width ratio of pedicled perforator flap in lower limb should be 8:1.[13]

In our study, we performed pedicled perforator flaps based on posterior tibial artery in 18(48.6%) patients, peroneal artery in 14(37.8%) and anterior tibial artery in 5(13.5%) patients. Posterior tibial artery perforator flap is the most versatile flap for reconstruction of lower one third of the leg. Koshima *et al*., described in their study that the most convenient method of reconstruction of defects located on anteromedial side of the lower leg is perforator flap based on posterior tibial artery.[14] In his study, he harvested 19x13cm^2 flap with a single, large perforator. We harvested two posterior tibial artery perforator flaps larger than 50cm^2 and no postoperative complications were noted. Mendeita *et al*., harvested 03 pedicled peroneal artery perforator flap for reconstruction of soft tissue defects on middle and lower one third of leg based on a single perforator. Flap size was 36cm^2, 56cm^2, and 60cm^2 and they did not report postoperative complications regarding peroneal artery perforator flap.[15] Zang *et al*., reported 14x4 to 29x8 cm^2 pedicled peroneal artery perforator flap harvested for lower leg reconstruction and found partial flap necrosis in 10% of cases.[16] In our study, we performed two peroneal artery perforator flaps of size larger than 50cm^2. Both flaps healed without any complication. An anterior tibial artery pedicled perforator flap is also a reliable and versatile alternative for wound coverage in lower one third of the leg. Lin *et al*., reported a 20x8 cm^2 propeller flap based on a single perforator of anterior tibial artery for soft tissue coverage of ankle and heel.[17] We harvested one flap of large size (over 50cm^2) based on perforator of anterior tibial artery which resulted in complete failure.

During flap harvesting, we dissected flaps in the subfascial plan. This facilitates the dissection of flap, but better aesthetic outcomes of the donor site are

noted in suprafascial dissection. Although in terms of complications, no significant difference has been noted in supra fascial or subfascial dissection.[17]

Ha *et al*. reported that a donor site width greater than 4.5cm on the anterolateral surface of the leg needs skin grafting.[18] It can be primarily closed in older age due to skin laxity. In our study, donor site was covered with partial thickness skin graft in 33(89.2%) patients.

In our study, overall complication rate was 18.9%, including partial flap necrosis in 2(5.4%) and complete flap failure in 1(2.7%) patient. Adams *et al*., observed a 10% flap tip necrosis and 18% partial necrosis of propeller flap for wound coverage in lower limb.[19] Bekara *et al*., performed a 45% pedicled perforator flap in distal one third of leg and found no significant difference between complications in lower one third of the leg and other territories of the lower limb. He reported flap failure in 3.5% of cases. He noted risk factors for complications in pedicled perforator flap were age more than 60 years, diabetes mellitus, and vascular anomalies.[6]

In our study, flaps healed within 18.56±11.50 days, and average return to work was observed in 03±1.39 months.

Pedicled perforator flaps have evolved the options for flap selection in lower limb. However, flap outcomes depend on wound bed, appropriate perforator selection for wound coverage, meticulous dissection, and postoperative wound care.

CONCLUSION

Pedicled perforator flaps in lower one third of leg are a remarkable addition to reconstructive ladder. It provides thin and pliable skin coverage of defects with good functional outcomes. It significantly reduces hospital stay and postoperative complication rates.

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Authors' Contributions:

Following authors have made substantial contributions to the manuscript as under:

AA & SHC: Conception, study design, drafting the manuscript, approval of the final version to be published.

AM & SF: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

LK & MUQ: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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