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Original Article

Surgery Section

Efficacy of Locoregional Perforator Flaps for Resurfacing of Peri-ankle Soft Tissue Defects: A Single Centre Prospective Cohort Study

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ABSTRACT

Introduction: The foot and ankle serve as vital components in supporting mobility. When afflicted by trauma, infections, burns, or tumours, they often present challenging defects that expose tendons, bones, joints, and nerves. Managing soft-tissue reconstruction in this area is complex, primarily due to limited local tissue resources and inadequate muscle coverage. A range of reconstructive options exists, encompassing local, locoregional, and distant flaps, with microvascular free flaps as the gold standard. Recent studies have explored newer pedicled and perforator-based flaps as promising alternatives for lower extremity soft-tissue defects.

Aim: To explore the efficacy of perforator-based local and locoregional flaps for resurfacing peri-ankle defects.

Materials and Methods: This prospective cohort study was conducted at the Department of Plastic Surgery, SSKM Hospital, and IPGME&R, Kolkata, West Bengal, India, from April 2019 to March 2022. A total of 49 patients with soft-tissue defects around the ankle were included. The reconstructive approach primarily involved perforator-based flaps from various arterial sources. Outcomes were categorised as complete defect coverage, minor flap necrosis without intervention, or major necrosis necessitating additional surgical intervention. For this descriptive study, proportion was used to compare categorical variables such as the number of cases with different aetiology, and the number of different flaps used were compared. For the continuous variable like age, mean has been used as a measure of central tendency.

Results: The mean age of the study population was 39.6±4.1 years. Thirty-four out of 49 patients (69.38%) presented with defects stemming from Road Traffic Accidents (RTA), and the posterior aspect of the ankle was the most common defect location (14 out of 49 patients, 28.57%). Peroneal Artery Perforator Flaps (PAPF) exhibited the highest success rate, with 18 out of 20 cases where this flap was used (90%), closely followed by Lateral Supramalleolar Flaps (LSF), with 13 out of 15 cases (86.7%). Overall, in 42 out of 49 cases (85.7%), the perforator-based flaps effectively resurfaced the defects.

Conclusion: Pedicled perforator-based flaps, including those based on the peroneal artery and lateral supramalleolar, have emerged as valuable options for the reconstruction of soft-tissue defects around the ankle.

Keywords: Microvascular flaps, Posterior aspect ankle, Pedicled flaps, Reconstruction, Resurfacing of wound

INTRODUCTION

A plastic surgeon frequently encounters patients with soft tissue defects at or around the ankle, which may result from the excision of tumours, infections, burns, and traumatic injuries, notably Road Traffic Accidents (RTAs). Reconstruction of soft tissue defects in the foot and ankle remains a challenging problem for reconstructive surgeons due to thin tissue coverage and poor blood supply, often leading to the exposure of underlying structures such as bone and tendons [1,2].

Numerous reconstructive options are available for addressing defects at or around the ankle, including local flaps, locoregional flaps, and distant flaps. Each procedure possesses distinct advantages and limitations based on specific indications, technical requirements, flap size, length of the vascular pedicle, and the patient's overall health. Microvascular flaps are often considered the preferred choice in cases where local tissues are severely compromised [3]. However, free flaps have the disadvantage of requiring microsurgical skill, suitable recipient vessels, and prolonged operation time. The reported rates of partial free flap failure range from 6.0% to 12.7%, and complete flap failure ranges from 3.2% to 8.5% [4].

In recent years, the management of lower extremity defects has advanced with the introduction of various innovative techniques for coverage, including perforator flaps, propeller flaps, and negative pressure wound therapy. The improved understanding of lower extremity anatomy has also contributed to the successful management of soft tissue defects in this region. The aim of this study was to explore the efficacy of perforator-based local and locoregional flaps for resurfacing peri-ankle defects.

MATERIALS AND METHODS

A prospective cohort study was conducted at the Department of Plastic Surgery, SSKM Hospital, and IPGME&R, Kolkata, West Bengal, India. The study spanned from April 2019 to March 2022, with the last patient being included in September 2021. All patients were followed-up for six months postoperatively, resulting in an actual study period from April 2019 to March 2022. Prior to the study, clearance from the Institutional Ethics Committee was obtained (No. IPGME&R/IEC/2019/294, dated 10/04/2019). The study involved a total of 49 patients and employed a purposive sampling approach throughout the study period.

Inclusion criteria: Patients, aged from 6 years to 70 years, with soft tissue wounds in the ankle and its adjacent areas, including the proximal part of the dorsum of the foot and the heel, irrespective of the underlying cause, were included in the study.

Exclusion criteria: The patients above 70 years of age and those with severe co-morbidities such as concomitant head injury or severe systemic illness were excluded from the study.

Study Procedure

The study population was drawn from patients attending the plastic surgery OPD and emergency department, diagnosed with defects in the ankle and its adjacent areas requiring soft tissue reconstruction. Patients' medical histories were recorded, and clinical examinations were performed. Plain radiographs of the ankle joint and foot were conducted to rule out underlying bone fractures, with fractures being evaluated and treated by the Department of Orthopaedics.

Resurfacing plans for the defects were devised based on the location and size of the defect and the suitability of local and locoregional perforator flaps, such as PAPF (Peroneal Artery Perforator Flaps), PTAPF (Posterior Tibial Artery Perforator-Based Flaps), LSFs (Lateral Supramalleolar Flaps), MPA (Medial Plantar Artery flaps), and LCF (Lateral Calcaneal Flaps). When selecting a particular flap, examination of the donor site for any scar and assessment of the availability and condition of the perforator based on the Doppler signal were important considerations.

Patients within the study population were optimally investigated and assessed for pre-anaesthetic fitness. Detailed explanations of the entire surgical procedure, including risks, benefits, potential complications, and donor area morbidity, were provided to the patients, followed by obtaining informed consent. Defect measurements were taken after debridement or excision. A lint piece template of the defect was taken, and flap marking was done using a "planning in reverse" approach. A handheld Doppler was utilised to identify and mark the perforator location. Patients underwent surgery under regional or general anaesthesia. Flap harvesting was done under tourniquet control in all cases. Standard techniques were followed for harvesting the lateral supramalleolar artery flap, medial plantar artery flap, and lateral calcaneal artery flaps. In the case of PTAPF and PAPF, a suitable perforator was first searched by making an incision on one border of the flap, after which other incisions were made. After harvesting was complete, the tourniquet was released, the vascularity of the flap was checked, and the flap was inserted into the defect, ensuring full mobility of the ankle joint. Donor sites were primarily closed or managed with skin grafts. Flaps were lightly dressed postoperatively, and in most cases, postoperative splinting was applied to avoid any compression or traction effects on the flap or the pedicles.

Postoperative flap monitoring was performed through periodic clinical assessments and with the aid of a handheld Doppler. Clinical examination included assessing the colour and temperature of the flap, as well as evaluating skin turgor and performing a pin prick test to assess the vascular status of the flap, such as vascular insufficiency or venous congestion. Both postoperative flap survival and complications at the flap and donor site were meticulously documented.

The follow-up schedule included bi-weekly assessments for the first month, followed by subsequent evaluations every two months. During follow-up visits, the condition of both the flaps and the donor site were evaluated, especially for the development of any complications such as ulcer formation or contracture. In cases where conservative treatment was followed after partial flap failure, the condition of that area was evaluated for complete healing or the requirement of any subsequent surgical procedures.

The various parameters studied included the characteristics of the wound, such as size, depth, location of the defect, and aetiology, as well as the type of perforator-based flap chosen. The extent of wound coverage achieved with the perforator flap was categorised as:

- effective and complete coverage,
- minor necrosis of the flap with no further procedures required, or
- major or complete necrosis of the flap necessitating another flap.

STATISTICAL ANALYSIS

The statistical analysis for this study was performed using Microsoft excel Software, version 2010. In this descriptive study, the proportion was used to compare categorical variables such as the number of cases with different aetiologies, and the number of different flaps used. For the continuous variable age, the mean was utilised as a measure of central tendency.

RESULTS

The age group involved ranged from 14 to 62 years, with a mean age of 39.6±4.1 years. In this study, the most common cause of the defect was RTAs (69.39%), followed by non-healing ulcers (16.33%) [Table/Fig-1]. The posterior ankle region flap coverage showed the highest percentage [Table/Fig-2]. The average size of the reconstructed defect using various perforator-based flaps was 10.5×4.7 cm. The largest flap measured 14×6 cm, while the smallest flap measured 3×3 cm.

Aetiology	Male	Female	Total	Percentage
RTA	31	3	34	69.3%
Tumour	1	2	3	6.12%
Non-healing ulcer	6	2	8	16.33%
Burn	2	2	4	8.16%
Total	40	9	49	100%

[Table/Fig-1]: Distribution of cases according to aetiology.
RTA: Road traffic injury

Location	Number of cases	Percentage
Anterior ankle	10	20.41%
Anterior ankle with dorsum of foot	8	16.33%
Posterior ankle	14	28.57%
Medial ankle	3	6.12%
Lateral ankle	6	12.24%
Heel	8	16.33%
Total	49	100%

[Table/Fig-2]: Location of the defects on various aspects of Peri-ankle region.

Among the 49 patients, 20 (38.23%) underwent surgery using PAPFs [Table/Fig-3]. [Table/Fig-4] shows the harvesting of the flap, while [Table/Fig-5,6] show immediate postoperative and seven days postoperative images of this flap. Fifteen (32.65%) patients received lateral supramalleolar flaps. [Table/Fig-7] shows the image of the LSF in the harvesting stage in a 23-year-old patient with a defect in the Tendo Achilles area, while [Table/Fig-8] shows the seven days postoperative image of this flap on a 19-year-old patient for the defect on the anterior aspect of the ankle. [Table/Fig-9] shows the image of PTAPF performed on five patients.

Flaps	Number	Percentage
Peroneal Artery Perforator Flap (PAPF)	20	40.82%
Posterior Tibial Artery Perforator Flap (PTAPF)	5	10.20%
Lateral Supramalleolar Flap (LSF)	15	30.61%
Medial Plantar Flap (MPA)	6	12.24%
Lateral Calcaneal Flap (LCF)	3	6.12%
Total	49	100%

[Table/Fig-3]: Table showing different perforator based flaps used in this study.

[Table/Fig-4]: Peroneal Artery Perforator Flap (PAPF) being harvested. The arrow head indicates the perforator.

[Table/Fig-5]: Peroneal Artery Perforator Flap (PAPF) after inset in the defect.

[Table/Fig-6]: Peroneal Artery Perforator Flap (PAPF) 7 days after operation.

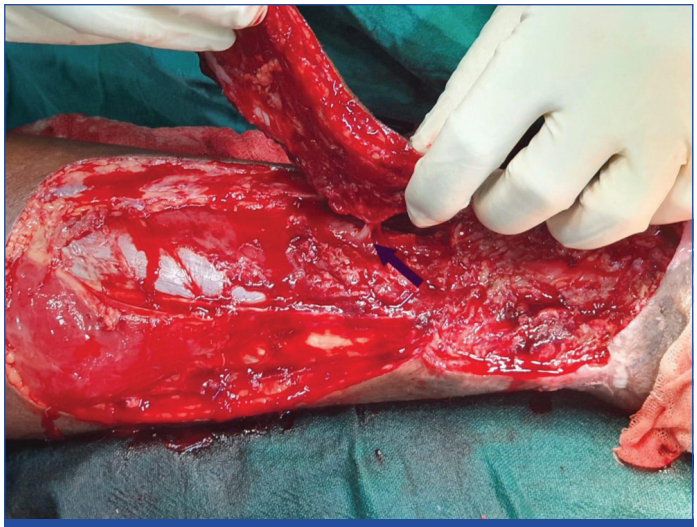
[Table/Fig-7]: Picture showing lateral supramalleolar artery flap. The tip of the artery forceps points to the perforator.

[Table/Fig-8]: Lateral supramalleolar artery perforator flap seven days postoperatively.

Categories (a) and (b) were considered successful, as the flaps effectively resurfaced the defect without the need for further surgical intervention. In cases categorised as (c), another flap was required, and the original flap was not considered successful in these instances. By this criterion, peroneal artery-based perforator flaps were useful in 90% of cases [Table/Fig-10].

DISCUSSION

In the present study of 49 patients, 40 (81.63%) were male, and 9 (18.37%) were female, which is consistent with the majority of



[Table/Fig-9]: Posterior tibial perforator flap. The arrow-head points to the perforator.

Flap	Total number	Fully survived and completely covered the defect (a)	Minor necrosis, no surgical procedure needed (b)	Major necrosis or complete loss, required another surgical procedure (c)
PAPF	20	14 (70%)	4 (20%)	2 (10%)
PTAPF	5	2 (40%)	2 (40%)	1 (20%)
LSF	15	9 (60%)	4 (26.7%)	2 (13.3%)
MPA	6	4 (66.7%)	1 (16.7%)	1 (16.7%)
LCF	3	2 (66.7%)	0 (0.0%)	1 (33.3%)
Total	49	31 (63.2%)	11 (22.4%)	7 (14.3%)

[Table/Fig-10]: Table showing outcome of different flap coverage in terms of efficacy of Resurfacing the Peri-ankle defects.

trauma cases (69.3%) attributed to outdoor work [5]. Trauma, particularly from RTAs, was the primary cause of defects in the present study (73.52%). Laitonjam M et al., and Mukherjee MK et al., have also found a high incidence of trauma in their studies on soft-tissue defects around the ankle (56% and 70%, respectively) [6,7].

Among the 49 patients in the present study, 31 (63.2%) flaps survived completely, 11 (22.4%) had minor necrosis but did not require further surgery, and seven flaps necrosed completely, necessitating the use of another flap. Mukherjee MK et al., found a lower failure rate in their study using perforator flaps (5%), but they utilised a combination of free and pedicled flaps [7].

In the current study, 90% of cases benefited from PAPF, which had the highest success rate among all the flaps employed. Shen L et al., reported postoperative complications with peroneal perforator-based propeller flaps, including venous congestion, but most flaps survived [8]. Ahn DK et al., also endorsed the use of PAPFs for ankle and heel reconstruction. In their study, all PAPFs survived without any major complications [9]. Terzić Z and Djordjević B; emphasised the clinical benefits of peroneal perforator-based reverse flaps [10].

PAPFs are particularly useful for ankle and heel defects due to their anatomical characteristics, which allow for flexibility and reduced donor-site morbidity. Lu TC et al., found the flap useful for covering defects in various areas of the lower extremity. They encountered minor wound dehiscence in only two out of 12 cases, which responded well to conservative treatment [11].

The PTAPF was successful in 80% of cases, as no further surgical intervention was required in four out of five cases. Other studies also found this flap effective in leg and foot defect reconstruction [12-14]. Kerfant N et al., reported a success rate of 85%. Carabelli G et al., had one case of complete flap failure and one case of partial failure in a total of 12 patients. Meanwhile, Akhtar M et al., had only one case of complete flap loss out of 42 patients [12-14].

Lateral supramalleolar artery flaps were found to be successful in 86.7% of cases for resurfacing soft-tissue defects around the ankle,

consistent with findings from other researchers [15,16]. This flap is valued for its thinness and reduced aesthetic sequelae. Medial plantar artery flaps proved effective in resurfacing defects around the ankle in 83.3% of cases. These flaps provide sensate and glabrous skin cover, and the absence of muscle in the flap enhances heel stability [17].

Lateral calcaneal artery flaps were successful in 66.6% of cases, although they can lead to donor-site grafting and sensory disturbances in the dorsum of the foot [18]. However, this flap was used in only a small number of cases in the present study.

It is important to note that the present study primarily focused on the effectiveness of local and locoregional perforator flaps for defect coverage, without addressing aspects such as donor site morbidity, aesthetic outcomes, or sensation restoration. Nevertheless, it was observed that most flaps regained protective sensory function, regardless of nerve repair [19]. Perforator-based flaps offer the advantage of being less invasive and preserving important structures during harvesting, making them valuable in achieving minimal donor site morbidity and optimal aesthetic outcomes in lower extremity reconstruction [20,21].

Limitation(s)

Firstly, the current study is based on a single center, which may limit the generalizability of the findings to the entire population. Secondly, certain flaps, such as the LCF, were performed in a smaller number of cases. Thirdly, the study did not assess donor site morbidity, aesthetic outcomes, sensation restoration, or other functional outcomes. Lastly, the follow-up period was short.

CONCLUSION(S)

Perforator-based flaps present a valuable solution for reconstructing ankle and surrounding area defects of small to medium size. Males have been found to be more commonly affected than females, and RTAs are the most common aetiology. The choice of different flaps depends on the location of defects and the suitability of available perforators.

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