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A Comprehensive Study of Perforator Based Flap in Reconstruction of Soft Tissue Defects of Lower Extremity

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Abstract **Original Research Article**

This prospective study was carried out with the purpose of utility of local perforator based flaps for reconstruction of soft tissue defects of lower extremity. It is a relatively safe, simple alternative to more complex and time consuming microvascular reconstruction. The versatility of the perforator flap makes it ideal for the reconstruction of lower extremity.
Keywords: Prospective, carried, reconstruction, extremity.

INTRODUCTION

Tissue defects in distal third of the lower leg and foot is still a challenge for plastic surgeons. Over time many types of flaps were used (free, random, axial, perforator flaps) in order to repair the defects. The use of local perforator-based flaps for reconstruction of soft tissue defects of the lower extremity is a simple and safe alternative to the more complex and time-consuming microsurgical reconstructions [1]. The increasing success is also attributable to an improvement of the knowledge of vascular anatomy and perfusion of the soft tissue [2-5]. This paper describes the evolution, vascular anatomy, technical design, harvesting technique and clinical application of perforator based flaps in reconstruction of leg defects.

PATIENTS AND METHODS

This prospective study was conducted during July 2016 to March 2019 on patients admitted through Plastic Surgery OPD, General Surgery OPD, and Casualty or transferred from Orthopaedics in Netaji Subhash Chandra Bose Subharti Medical College, Meerut, India after taking permission from the institutional ethical committee and taking informed concent from patient. The present work is based on study of 15 patients who underwent reconstruction of lower limb using perforator based flaps. This prospective study was conducted on patients admitted through Plastic Surgery OPD, General Surgery OPD, and Casualty or transferred from Orthopaedics in Netaji Subhash Chandra Bose Subharti Medical College, Meerut. The study was carefully and meticuosly performed and an attempt made to cover all possible aspects. Flap selection was done regarding site, size, shape of the defect, status of surrounding tissue, presence of external fixator, patient comfort. The cases included belonged to different age groups and both sexes.

The inclusion criteria

- Soft tissue defect with or without exposed bone, joint, tendon or implant either due to trauma, infection or surgery admitted directly in Department of Surgery or Referred from Orthopedics
- Patients having Triphasic flow on Arterial Doppler.

The exclusion criteria

- Patients with history of vaso-spastic or vascular diseases/ Atherosclerosis / Buerger's disease
- Patients not having Triphasic flow on Arterial Doppler
- Patients in who repair of vascular injury have been done.

The patients are to be studied under following headings

- Particulars of the patient: this includes name, age, sex, date of admission.
- History: Careful history is taken to determine etiology of defect, injury and its duration. Patients with peripheral vascular diseases, other chronic disease affecting the vessels, vascular insufficiency in the leg are excluded.
- Clinical Examination:

- General Examination: pulse, blood pressure, respiratory rate, temperature, pallor, icterus and lymphadenopathy
- Systemic Examination: This is done to exclude any systemic disorder especially arterial disease affecting the vessels and to assess patient's fitness for anaesthesia and surgery.
- Local Examination: Detailed local examination of the wound is done and following are noted:
- Site and size of defect
- Condition of wound – for infection , pus discharge and necrotic tissue.
- Exposure of deeper structures such as bone, muscle and tendon
- Type of associated fracture of bone and presence of any orthopaedic implant such as external fixator, plates and screw.
- Vascular status of limb: Presence of vascular pulsation of anterior tibial, posterior tibial and dorsalis pedis arteries.
- Condition of surrounding skin for any scar, external fixator pins and their location.
- Functional statuses of the limb and movements of knee and ankle joints

- **Investigations**
- Blood- hemogram, blood sugar, blood urea, serum creatinine
- Urine- Routine and microscopic examination
- Pus: culture and sensitivity
- X-rays- leg and foot (A.P and Lateral views)
- ECG and Chest X-Ray – in elderly patients
- Colour Doppler (Arterial)- whether Triphasic flow present or not in Anterior Tibial, Posterior Tibial Arteries.
- Pre-operative evaluation of perforator with hand held Doppler device (8MHz Probe) – We consider preoperative Doppler as routine standard operating procedure for performing a perforator flap. The Doppler study was made with a hand held Doppler with an 8 Hz frequency probe around the axis of the major vessel adjoining the defect. The perforator with a consistent, audibly loud and high pitched Doppler signal was marked.

- **Operative detail**
- Anaesthesia –General or Spinal anaesthesia and under tourniquet control, the primary defect was debrided and prepared. With the help of lint piece, flap was marked and then transposed or rotated to the defect, based on the nearest perforator.

Incision

A non-committal generous exploratory incision was made. Incision was made in such a fashion that if need arises, tissue on both sides of the incision could be used for harvesting a flap. Due care was taken to make maximum use of the available tissue on both sides of the incision. Due care was also taken while making the incision so that, if appropriate perforator is not identified or if found to be in trauma zone, the same incision can be used to delay a fasciocutaneous flap or harvest a regional axial flap or as a gateway to dissect the recipient vessel for microanastomosis. Skin incision was given at most distal part of the flap fascia.

Flap planning and designing

After a non-committal exploratory incision was made, the perforators were identified. The perforator which is close to the edge of the wound is used. Perforator which is too far from the defect was also not chosen as it increases the length of the flap unnecessarily.

After an appropriate, reliable perforator was identified, the distance of the perforator to the distal edge of the defect was measured. Planning was made in reverse, considering the degree of rotation involved, and distal edge of the flap was marked along the long axis of the extremity. Due care was taken to add 1-1.5 cms to the long axis of the flap. The width of the defect was noted and marked on either side of the perforator. The flap was then harvested, and if possible islanded on the perforator and the perforator was skeletonised to prevent its kinking. Under loupe magnification the flap was raised proximal to the distal direction in the subfascial plane. Fascia was stitched to the skin to prevent shearing forces and impairment of fascial blood circulation. All the fibrous strands were dissected to prevent compression on the perforator after rotation. Throughout the procedure, a lignocaine soaked small piece of gauze was kept over the perforator. The perforator/ gauze were irrigated by lignocaine solution to prevent drying and spasm of the perforator.

After raising/ harvesting the flap was permitted to perfuse for a while before rotation. Whenever possible, a subcutaneous vein was kept at the base of the flap. It is possible to anastomose this vein to a local vein to augment the venous outflow if a venous compromise is anticipated. Cautery was used judiciously as and when needed, away from the perforator to achieve absolute hemostasis. The flap was then placed over the defect. The flap was turned from the side which causes the least degree of torsion on the perforator. This was decided on visual inspection. The initial sutures were taken along the sides of the perforator to prevent traction to the perforator. Due care was taken to inset the flap without any tension.

The secondary defect was closed by split skin grafting. Aseptic dressing was done

Post-operative management: Affected leg was to be kept in rest in elevated position and the flap was assessed clinically in post-operative period at 6 hours, 24 hours, 48 hours, 5th day, 10^{th} day. Stitches were removed on 14-21 post-operative day. The flap was assessed clinically after discharge from hospital with regard to colour, temperature, edema and discharge.

Any complication i.e. ischemic changes leading to necrosis was recorded and length to width ratio of surviving flap was recorded.

Follow-up - after 15days, 1 month, 3months, 6months and then every 1 year

Informed consent

Informed consent was obtained from all the patients included in the study.

RESULTS

The most common age group involved was 21-25 years (40%).Males constituted 87% of this study (13 patients) and females constituted only 13% (2 patients). Most common cause of lower limb defect in our study was Road traffic accidents constituting 87% (13 patients) of the patients followed by Post infective chronic ulcer constituting 13% (2 patients) of the patients.

Table-1: Cause of defect

S. No.	Cause of Defect	No. of patients	Percentage
1.	Road traffic accident	13	87
2.	Post infective chronic Ulcer	2	13

Most common site of defect in the lower limb was lower one-third and foot constituting 73% (11 patients) of the patients followed by middle one-third of leg in 27% (4 patients) of the patients. 53% (8 patients) underwent previous surgery in the form of External fixator application in 40% (6 patients) of cases and internal fixator application in 13% (2 patients) of cases. No fixation was done in 47% (7 patients) of cases. Most common time of presentation after injury in our study was within 1 week of injury constituting 47% (7 patients) of cases.

Table-2: Artery on which the Perforator Flap was based

Artery on which Flap was based	No. of patients	Percentage
Posterior Tibial	7	47
Peroneal	8	53

In this study most common artery on which Perforator flap was based was peroneal artery in 53% (8 patients) of cases followed by posterior tibial artery in 47% (7 patients) of cases. Most common type of flap used in our study was pedicled flap seen in 8(53%) patients followed by island flap in 7(47%) patients. In 7 patients (47%) flaps were based on Perforators of Posterior tibial artery out of which in 5(34%) patients perforator was located proximal to the defect and in 2(13%) patients perforator was located distal to the defect. In this study in 8 patients (53%) flaps were based on Perforators of Peroneal artery out of which in 6(40%) patients perforator was located proximal to the defect and in 2 patients (13%) perforator was located central to the defect. Most common location of the perforator to the defect was proximal to the defect in 74% (11patients) of cases. Mean defect size was 6.4x 3.8 cm in our study. Mean flap size was 9.9x 4.6 cm in our study. Mean operating time in our study was 130 minutes. In 20 perforators true localization was found in 90% cases and false localization in 10% cases. The maximum distance of the perforator in posterior tibial artery perforator flaps from the defect was 17cm and minimum was 5cm. The maximum distance of the perforator in peroneal artery perforator flaps from the defect was 10cm and minimum distance was 5cm. Most common problem at recipient site or defect site in our study was found out to be non-healing ulcer in 47% (7 patients) of cases followed by exposed bone with fracture tibia in 40% (6 patients) of cases.

Table-3: Post-Operative complications

Complications	No. of patients	Percentage
Venous Congestion	4	27
Marginal flap necrosis	2	13
Bulky Flap	2	13
Donor Graft Site infection	2	13

In our study most common early post-operative complication was venous congestion in 27% (4 patients) of cases. 2 out of 4 patients (50%) in whom flap was islanded developed venous congestion whereas 2 out of 11 patients (18%) in pedicled flap developed venous congestion. Late post-operative complications occurred in the form of marginal flap necrosis in 13% (2 patients) of cases (one where flap was islanded and another occurred in one flap which was pedicled). Bulky flap was seen in 13% (2 patients) of cases (one where flap was islanded and another occurred in one flap which was pedicled). Donor graft site infection occurred in 13% (2 patients) of cases. Maximum size of defect was 9x5 cm2 and minimum size of defect was 3x3 cm2. Maximum size of the flap was 12x5 cm2 and minimal size was 8x5 cm2. Most common range of degree of rotation of flap was 135-180 degrees seen in 9(60%) patients. 12(80%) patients turned up for

subsequent follow up in OPD. Secondary defects in all the patients in our study were managed by split skin grafting.

a

b

c

Fig-1: a, b, c, Case showing Posterior Tibial Artery Perforator Flap a) Pre-operative b) Intraoperative (showing perforator) c) Post-operative

a)

b)

c)

Fig-2: a,b,c, Case showing Peroneal Artery Perforator Flap a) Pre-operative b) Intraoperative (showing perforator) c) Post-operative

DISCUSSION

In the present study of 15 patients time of presentation of injury was less than 1 week in 61(61%) and 7(47%) patients in study conducted by Schaverien MV *et al*. [6] and the author. In a study conducted by Schaverien *et al*. [6] and the author time of presentation of injury was more than 1 week in 39(39%) and 8(53%) patients respectively. In our study the mean defect size was 6.4x3.8 cm. It is similar to studies conducted by T.-C. Lu *et al.* [7], Chang SM *et al*. [8], and Kerfant N *et al.* [9] where mean defect size was 5.8x4.6cm, 6.4x4cm and 5.5x4.1 cm respectively.

Table-4: According to Mean Flap Size

	Parrett BM *et al*. [10] (n=6)	Tos P *et al*. [13] (n=22)	Cheng L *et al.* [11] (n=55)	Author (n=15)
Mean Flap Size (in cm)	8x5.5	10x9.7	9.2x4.5	9.9x4.6

In our study mean flap size was 9.9x4.6cm. It is similar to studies conducted by Parrett BM *et al*. [10] and Cheng L *et al.* [11] where mean flap size was 8x5.5 cm and 9.2x4.5 cm respectively.

Flaps were based on perforators of Posterior tibial artery in 3(38%), 13(59%),7(58%), 4(57%), 8(67%) and 7(47%) patients in studies conducted by Jakubietz RG *et al*. [12] , Tos P *et al.* [13] , Chang SM *et al*. [8] , Ozalp B *et al.* [14], El-Sabbagh AH *et al*. [15] and the author.

Flaps were based on perforators of Peroneal artery in 5(62%), 6(27%), 5(42%), 4(33%) and 8(53%) patients in studies conducted by Jakubietz RG *et al*. [12], Tos P *et al*. [13], Chang SM *et al*. [8], El-Sabbagh AH *et al*. [15] and the author.

Table-5: According to Perforator localization with Hand-held Doppler

	Khan UD *et al*. [16](n=14)	Lethaus B *et al*. [17](n=45)	Author (n=15)
True Localization (True Positive)	40(82%)	86(74%)	18(90%)
False Localization (False Positive)	3(6%)	21(18%)	2(10%)
False Negative	6(12%)	9(8%)	

In our study of 15 patients true localization (True Positive) of perforator was found in 18(90%) perforators and false localization (False Positive) was present in 2(10%) of the perforators. It is similar to study conducted by Khan UD *et al.* [16] who studied 14 patients in which 15 patients true localization (True Positive) of perforator was found in 40(82%) perforators , false localization (False Positive) was present in 3(6%) of the perforators and false negative result occurred in 6(12%) perforators. Lethaus B *et al.* [17] studied 45 patients in which true localization (True Positive) of perforator was found in 86(74%) perforators, false localization (False Positive) was present in 21(18%) of the perforators and false negative result occurred in 9(8%) perforators.

In our study the range of angle of rotation of flap was 60-180 degrees. It is similar to study conducted by Lecours C *et al*. [18] and Bekara F *et al*. [19] where the the range of angle of rotation of flap was 70-180 and 60-180 degrees respectively. In studies conducted by Tos P *et al.* [13], Hafeez *et al.* [20] and Ozalp B *et al*. [14] the range of angle of rotation of flap was found out to be 90-180, 120-180 and 90-180 degrees respectively.

Bekara F *et al*. [19] in his study showed 4(0.9%) patients with 60-70 degree, 24(5.6%) patients with 80-90 degree, 10(2.4%)patients with 100-110 degree, 3(0.7%) patients with 120-130 degree, 4(0.9%) patients with 140-150 degree, 10(2.4%) patients with 160-170 degree, 147(34.3%) patients with 180 degree of angle of rotation and not recorded in 226 (52.8%) patients.

The author studied 15 patients in which all 15(100%) patients were managed by split skinbgrafting for secondary defects. The result was similar to studies conducted by Hafeez *et al.* [20], Ozalp B *et al.* [14], Kerfant N *et al*. [9] where split skin grafting was done for secondary defects in 22(92%), 7(100%) and 12(92%) patients.

In study conducted by Hafeez K *et al*. [20] and Kerfant N *et al*. [9] primary closure was done in 2(8%) and 1(8%) patients. In our study the mean operating time was 130 minutes. Parrett BM *et al*. [10], Ozalp B *et al*. [14], Cheng *et al*. [14] conducted studies in which the mean operating time was 103, 106 and 132 minutes respectively. A longer mean operating time was due to a learning curve and because operations were done by 3 plastic surgeons.

In studies conducted by Parrett *et al*. [10], Schaverien MV *et al*. [6], T.-C. Lu *et al*. [7], Hafeez *et al*. [20] and Cheng *et al*. [14] the outcome were 100%, 91%, 100%, 96%, 100% respectively. Outcome in our study was 87%. It is attributed to a learning curve and as 3 plastic surgeons was involved in our study.

Conclusion

The perforator flap is a good alternative for the reconstruction of lower limb defects providing low postoperative morbidity, good daily functions, and relatively satisfactory cosmetic results.

The pedicled perforator flaps have several advantages over those of distant free flaps. Because microvascular anastomosis is not required, the flap is less time consuming and has a lower risk of vascular thrombosis compared with other complex techniques. Use of perforator flaps also spares the major vessels and muscles. It can also be done without the need of general anaethesia causing less morbidity and mortality. Stable coverage with good contour, colour match and less operative time makes it a good choice for reconstruction of lower limb defects. It is also a single stage procedure and avoids the complications of free tissue transfer and is cost effective. It can be done under loupe magnification and the use of hand held Doppler increases its efficacy. Replacing like with like and limiting the donor-site to the same area and possibility of complete or partial primary closure are other advantages of these flaps.

A limitation of this study is our small size of study and there are anatomic variations in the localization and caliber of the perforators. Use of perforator based flaps is also limited because of its inability to cover large defects. Flap size is greater than the size of the defect in perforator flaps. There is a learning curve associated with identification of the perforators. Such flaps have limited use in cases of avulsion injuries and if the perforator is involved in the zone of trauma. Other limiting factors are difficulty in determining the extent of perfusion of flap based on a single perforator and availability of local tissue around the defect.

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