

Outcome of Perforator-Based Flap for Reconstruction of the Soft Tissue Defects of the Leg: A Hospital Based Prospective Study

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Abstract

Background: Soft tissue reconstruction of the lower limb is challenging as there are chances of poor wound healing and also scarcity of tissue for local flap coverage. Due to limited mobility and paucity of overlying skin, even small soft tissue defects of the lower limb generally need flap coverage. So, present study, was conducted to assess the outcome of perforator-based flap for reconstruction of the soft tissue defects of the leg.

Methods: This prospective study was conducted between September 2020 to November 2021 among patients admitted in Department of Plastic and Reconstructive surgery with soft tissue defects over lower limb. Patient's socio-demographic characteristics and various pre-operative, intra-operative and post-operative variables were obtained using a predesigned and pretested questionnaire. For statistical analysis data was entered into a Microsoft excel spreadsheet and then analysed by SPSS. P -value ≤ 0.05 was considered for statistically significant.

Results: In present study a total of 117 study subjects were enrolled. The mean age of patients was 33.91 ± 12.50 years. In our study, nearly three fourth of the patients (74.4%) were males. In our study we performed procedure for 32 (27.4%) lateral supramalleolar flap, 2 (1.7%) lateral calcaneal, 1 (0.9%) lateral sural artery perforator flap, 14 (12.0%) medial plantar artery perforator flap, 23 (19.6%) medial sural artery perforator flap, 1 (0.9%) medialis pedis flap, 16 (13.6%) peroneal artery perforator flap and 28 (23.9%) posterior tibial artery perforator flap. In our study, 2 (1.7%) flaps had infection, 8 (6.8%) flaps had marginal necrosis and 12 (10.3%) flaps had partial necrosis. We found that out of 117 flaps, 95 (81.2%) flaps had no complications and the overall flap survival rate was 89.7%.

Conclusion: The overall survival rate, functional and cosmetic outcome of perforator-based flaps for lower limb soft tissue reconstruction is acceptable. Therefore, whenever possible it should be considered as a reconstructive option for coverage of soft tissue defects of lower limb.

Keywords: Perforator based flap, soft tissue, Lower limb, prospective study, complications

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Introduction

Soft tissue reconstruction of the lower limb is challenging as there are chances of poor wound healing and also scarcity of tissue for local flap coverage. Due to limited mobility and paucity of overlying skin, even small soft tissue defects of the lower limb generally need flap coverage.[1,2]

The flap design that usually works well elsewhere on the body, commonly fail when applied to soft tissue defects on the leg, especially when these defects are a result of trauma or chronic osteomyelitis. Initially it was advised to avoid local flaps below knee unless the defect was small or the special techniques such as delay incisions were used. Reconstructive surgeons relied on cross-leg flaps a lot and also the flaps that were transferred from a distance using the tube pedicle technique. Ger introduced the use of transposed muscle flaps for reconstruction of the leg.[3] The lower one third of the leg is the least well served area by muscle flap. The fasciocutaneous flap reported by Ponten showed that long narrow flaps could be safely raised below the knee as long as the deep fascia was included.[4] Ponten's flaps could not be islanded as they were not based on any specific perforators.

Following widespread use, it was realized that Ponten's flap was unsuitable for the management of difficult soft tissue defects in the lower third of the leg. Chatre and Quaba reviewed the results of 100 fasciocutaneous flaps used for lower leg reconstruction between 1981 and 1986. They reported an overall necrosis rate of 8% but the necrosis rate for flaps raised to cover defects in the lower third of the leg was an unacceptable 25%.[5]

Before the introduction of microsurgery, there were few reconstructive options for lower limb defects, such as local flaps like random skin flaps, muscular or musculocutaneous flaps and performed cross-leg flaps, thus immobilizing the

limbs for weeks. A random pattern flap has an indistinct perfusion pattern and is limited in size and mobility.[6] Musculocutaneous flaps and muscle flaps with skin grafts such as from the gastrocnemius, soleus, and tibialis anterior can be used in the proximal and middle thirds of a pretibial defect.[7] Unfortunately, the area least well served by these muscle flaps is the lower third of the leg.[8]

With the development of perforator flaps newer and more reliable flaps have become available for lower limb reconstruction.[9] According to the Gent consensus, perforator flaps are composed of skin and subcutaneous fat nourished by perforators arising from deep vascular systems, which reach the surface by passing mostly through muscle and intermuscular septa.[10,11]

The advent of fasciocutaneous flaps stimulated great interest in the cutaneous circulation of the lower extremities. Of particular significance was the description of the septocutaneous vessels of the leg[12] and the extension of the concepts of reverse flow and distally based flaps to the leg.[13] Rather than sacrificing the whole vascular axis in the process of transferring a flap, it was soon appreciated that flaps could be based on a single septocutaneous perforator of the tibial or peroneal vessels.[14] The circulation in a perforator based flap remains more physiological compared with a distally based axial vessel type flap.

In the present study, the goal was to study the reconstructive, functional and the aesthetic outcome of perforator-based flap for reconstruction of the soft tissue defects of the leg including related complications and donor site morbidity.

Material and Methods

Study setting

This hospital based observational prospective study was started after getting clearance from the ethics Committee, in the Department of Plastic and Reconstructive surgery, IPGME&R SSKM Hospital, a tertiary care hospital in Kolkata. The study was conducted from 1st September 2020 to 30th November 2021.

Study subjects

The study included patients admitted in Department of Plastic and Reconstructive surgery with soft tissue defects over lower limb (with exposed tendon, bone, muscle) and who underwent soft tissue reconstruction by consecutive sampling technique. Patients with peripheral vascular disease, patients with extensive tissue defect where any reconstruction is not feasible, patients with injuries where the viability of the leg is doubtful and subjects lost during follow up, were excluded from the study.

Data Collection method and tool

After explaining the purpose of the study, written informed consent in the local language (Bengali or Hindi) was obtained from every subject. Patient's socio-demographic characteristics and various pre-operative, intra-operative and post-operative variables were obtained using a pre-designed and pretested questionnaire.

Surgical procedure

The process of selecting the vascular axis of the leg (anterior tibial artery, peroneal or posterior tibial artery), on which to base the perforating vessel of the flap, was done by preoperative auscultation with a handheld Doppler with 8-Mhz probe, with an angulation of the probe of approximately 45 degrees to the skin surface, according to the location of the defect to be covered. A provisional flap design can be drawn as follows, with the perforator as the pivot point of the flap, as

has been described previously.¹⁵ First, the distance between the perforator and the distal edge of the defect is measured. This value is then transposed proximally along the axis of the main source vessel, again measured from the perforator, and 1 cm is added. This value forms the proximal limit of the flap. Next, the width of the proximal flap needed to cover the defect is determined by measuring the width of the defect. This value is then used to determine the proximal flap width, adding 0.5 cm to allow for flap contraction and to facilitate its inset without tension. The lateral dimensions are equidistant to ensure that when the flap is eventually rotated around to fill the defect, there is no excessive sideways traction on the perforator during wound closure.

We performed a first longitudinal skin incision on one of the margins of the flap to observe the perforator localized preoperative with the handheld Doppler. The distance of the perforator from the proximal edge of the defect determined the length of the minor paddle used to cover or partially cover the donor site. If direct closure of the donor site was not achievable, a skin graft was used to close the residual defect.

The elevation of the flap was performed with the patient in supine position, without performing exsanguination of the extremity with an elastic bandage, and at the thigh a controlled tourniquet was placed with a continuous pressure of 250 mm Hg. The flap is dissected, under 2.5× magnification, subfascially or suprafascially, with an axial orientation with respect to the affected limb, always releasing the perforating vessels of all the muscular branches and adhesions, with dissection of the pedicle at least 2 cm as it has been recommended (Figure 1).¹⁶ Once the pedicle has been dissected, the ischemia is released to assess the irrigation of the flap and before its transposition, it is

left in its native orientation for 10 minutes to then corroborate the adequate capillary filling of the borders of the flap. In case of finding more than 1 vessel, a microclamp is placed on 1 of the vessels to base the flap in only 1 perforator to allow a rotation of up to 180 degrees.

Statistical Analysis

For statistical analysis data was entered into a Microsoft excel spreadsheet and then analyzed by SPSS (version 27.0;

SPSS Inc., Chicago, IL, USA). Data has been summarized as mean and standard deviation for numerical variables; and count and percentages for categorical variables. Two-sample t-tests for a difference in mean involved independent samples or unpaired samples. Paired t-tests were a form of blocking and had greater power than unpaired tests. The chi-square analysis was used to test the significant difference of proportions. P-value ≤ 0.05 was considered for statistically significant.



Figure 1: Surgical procedure showing raised variety of raised flap (Medial sural artery perforator flap, Medial plantar artery perforator flap, Posterior tibial artery perforator flap and Peroneal artery perforator-based flap)

Results

In present study a total of 117 study subjects were enrolled using consecutive sampling technique. In our study, 33.3% of patients belonged to 21-30 years of age,

followed by 23.1% patients were in the 41-50 years of age. The mean age of patients was 33.91 ± 12.50 years. In our study,

nearly three fourth of the patients (74.4%) were males (Table 1).

Table 1: baseline characteristics of the study subjects.

Variables	Frequency/Mean	Percent/SD
Age Group (in years)		
≤20	16	13.7%
21-30	39	33.3%
31-40	23	19.7%
41-50	27	23.1%
≥51	12	10.3%
Age (in years)	33.91	12.50
Gender		
Female	30	25.6%
Male	87	74.4%

In the present study, in 60 (51.3%) patients left lower limb was affected and in 57 (48.7%) patients right lower limb was affected. In the present study, 24 (20.5%) patients had defect over lower one third

leg, followed by defect on dorsum of foot (12.8%), on heel (12.8%) and over middle one third leg (12.8%). In our study, most of patients (89.7%) had trauma as etiology of the defect (Table 2).

Table 2: Injury characteristics of the study subjects.

Injury characteristics	Frequency	Percent
Side affected		
Left	60	51.3%
Right	57	48.7%
Site of defect		
Anterior ankle	12	10.3%
Dorsum foot	15	12.8%
Heel	15	12.8%
Knee	11	9.4%
Lateral ankle	3	2.6%
Lower one third leg	24	20.5%
Medial ankle	5	4.3%
Middle one third leg	15	12.8%
Posterior ankle	9	7.7%
Upper one third leg	8	6.8%
Etiology		
Trauma	105	89.7%
Burn	5	4.3%
Non healing ulcer	5	4.3%
Malignancy	2	1.7%

In our study we performed procedure for 32 (27.4%) lateral supramalleolar flap, 2 (1.7%) lateral calcaneal, 1 (0.9%) lateral sural artery perforator flap, 14 (12.0%) medial plantar artery perforator flap, 23

(19.6%) medial sural artery perforator flap, 1 (0.9%) medialis pedis flap, 16 (13.6%) peroneal artery perforator flap and 28 (23.9%) posterior tibial artery perforator flap. In our study, 103 (88.0%) flaps were

based on 1 perforator and 14 (12.0%) flaps were based on 2 perforators. In our study, most of flaps moved by rotation (65.0%) and least flaps were moved by advancement (4.3%). In our study, for nearly all (97.4%) donor site skin grafting (STSG) was done (Table 3). The mean duration of surgery was 146.23 ± 20.24 minutes. In present study, the average size

of defect that was reconstructed by various perforator-based flap was 6.4×3.8 cm. The largest defect measured was 9×4 cm and the smallest defect measured was 4×3 cm. The average size of the perforator-based flap was 8.2×4.9 cm. The largest flap measured was 11×5 cm and the smallest flap measured was 6×4 cm.

Table 3: Surgical procedure characteristics among study subjects.

Procedure characteristics	Frequency/Mean	Percent/SD
Flap		
Lateral calcaneal artery flap	2	1.7%
Lateral supramalleolar flap	32	27.4%
Lateral sural artery perforator flap	1	0.9%
Medial plantar artery perforator flap	14	12.0%
Medial sural artery perforator flap	23	19.6%
Medialis pedis flap	1	0.9%
Peroneal artery perforator flap	16	13.6%
Posterior tibial artery perforator flap	28	23.9%
Number of Perforators		
1	103	88.0%
2	14	12.0%
Type of movement of flap		
Rotation	76	65.0%
Transposition	28	23.9%
Propeller	8	6.8%
Advancement	5	4.3%
Donor site		
Primary closure	3	2.6%
STSG	114	97.4%
Duration of surgery (minute)	146.23	20.24

In our study, 2 (1.7%) flaps had infection, 8 (6.8%) flaps had marginal necrosis and 12 (10.3%) flaps had partial necrosis. There were no complications in 81% of the flaps. In the present study, 12(10.3%) flaps could not survive for which secondary procedures like flap/skin grafting was done

(Table 4). In our study, 89 (76.0%) patients were hospitalised for <2 weeks and 28 (23.9%) patients were hospitalised for >2 weeks. In our study, majority of the patients (93.2%) had acceptable aesthetic outcome.

Table 4: Outcome of the surgical procedure among study subjects.

Outcome	Frequency	Percent
Complications		
Infection	2	1.7%
Marginal necrosis	8	6.8%
Partial necrosis	12	10.3%
Nil	95	81.2%
Secondary flap/ graft required		
No	105	89.7%
Yes	12	10.3%
Days of hospital stay		
<2 weeks	89	76.0%
>2 weeks	28	23.9%
Aesthetic outcome		
Excellent	81	69.2%
Good	28	23.9%
Poor	8	6.8%

Out of 32 LSF (lateral supramalleolar flaps), 6 flaps had complications of which 2 flaps survived despite complications and 4 flaps failed. Out of 14 MPAF (medial plantar artery perforator flaps), 2 flaps had complications of which 1 flap required secondary procedure. Out of 2 lateral calcaneal artery flaps, 1 flap had complication, and no flap required secondary procedure. Out of 1 lateral sural artery perforator flap, 0 flaps had complications no flap required secondary procedure. Out of 23 medial sural artery perforator flaps, 4 flaps had complications of which 2 flap required secondary

procedure. 1 medialis pedis flap that was performed had no complications. Out of 16 peroneal artery perforator flaps, 5 flaps had complications of which 2 flaps required secondary procedure. Out of 28 posterior tibial artery perforator flaps, 4 flaps had complications of which 3 flaps required secondary procedure. We found that out of 117 flaps, 95 (81.2%) flaps had no complications. Out of 22 flaps with complications, 10 flaps survived despite complications and remaining 12 flaps required second procedure like flap or skin grafting. In present study, the overall flap survival rate was 89.7% (Table 5).

Table 5: Distribution of survival of various flaps among study subjects.

Flaps (n=117)	Flaps survived	Number of complications	Flaps survived despite complications	Flaps failed (required flap/ skin graft)	Flaps survival rate
PTAPF (n=28)	25	4	1	3	89.3%
PAPF (n=16)	14	5	3	2	87.5%
LSF (n=32)	28	6	2	4	87.50%
MPAF (n=14)	13	2	1	1	92.80%
MPF (n=1)	1	0	0	0	100%
LCAF (n=2)	2	1	1	0	100%
MSAPF (n=23)	21	4	2	2	91.3%
LSAPF (n=1)	1	0	0	0	100%
Overall	105	22	10	12	89.7%

Discussion

In present study, patients with soft tissue defect over leg with exposed tendon, bone, muscle were included. The mean age of patients was 33.91 ± 12.50 years. The mean age of the patients included was 35.3 years in the study by Hamed ML et al., and 36.93 ± 13.17 years in the study done Sarker A et al.[17,18] In our study, nearly three fourth of the patients (74.4%) were males. Similarly, in majority of subjects were males in studies done by Prasad K et al., (90%), Ramesha KT et al., (73.3%) and Sarker A et al., (84.4%).[18,19,20]

In the present study, in 60 (51.3%) patients left lower limb was affected and in 57 (48.7%) patients right lower limb was affected. Yasir M et al., found that left lower limb was affected in 56.5% patients and in 43.50% patients right lower limb was affected. In our study, most of patients (89.7%) had trauma as etiology of the defect.[21] Yasir M et al., showed that etiology for lower limb defect was trauma in 35% of patients, burn in 13%, malignancy in 4.3%, ulcer in 8.6%, rest were cellulitis, osteomyelitis, and exposed hardware.[21]

In the present study, 24 (20.5%) patients had defect over lower one third leg, followed by defect on dorsum of foot (12.8%), on heel (12.8%) and over middle one third leg (12.8%). In a study by Sarker A et al., 50% of patients had defect over tendoachilles area, 21.8% had defect over medial malleolus and medial aspect of distal third leg and only 9.3% of patients had defect in front of ankle.[18] Prasad K et al., found that 65% of defects were on lower one third leg, 35% defects on middle one third leg and 5% defects were on upper one third of leg.¹⁹

In the present study the average length of the defect was 6.4 cm and width were 3.8 cm. The largest defect measured was 9x4 cm and the smallest defect measured was

4x3 cm. Sarker A et al., found that the average length of the defect was 7.3 cm and width was 4.7 cm.¹⁸ The largest defect size was 12x6 cm and the smallest defect was 5x3 cm. Prasad K et al., documented that the largest defect size was 8x2 cm and the smallest defect size was 3x2 cm.¹⁹ In the present study the largest flap measured was 11x5cm and the smallest flap measured was 6x4cm. In study by Sarker A et al., the largest flap size was 21x8 cm and the smallest flap was 7x4 cm.[18] Prasad K et al., documented that the largest flap size was 12x6 cm and the smallest flap size was 5x3 cm.[19]

In the present study, 103 (88.0%) flaps were based on 1 perforator and 14 (12.0%) flaps were based on 2 perforators. In a study by Yasir M et al., 78.3% of flaps were based on 1 perforator and 21.7% of flaps were based on 2 perforators.²¹ In the present study majority of the flaps moved by rotation (65.0%), 28 (23.9%) flaps had transposition movement, 5 (4.3%) flaps had advancement, 8 (6.8%) flaps had propeller movement. Yasir M et al., reported that 52.2% were propeller flaps, 21.7% of flaps moved by rotation, 17.4% by transposition and 8.7% by advancement.[21]

In our study, 2 (1.7%) flaps had infection, 8 (6.8%) flaps had marginal necrosis and 12 (10.3%) flaps had partial necrosis. There were no complications in 81% of the flaps. Yasir M et al., found that 17.3% of patients had minor complications which included infection, wound dehiscence and congestion of flap.[21] Sananpanich K et al., reported complications in 6.7% of flaps.[22] Ramesha KT et al., reported partial flap necrosis in 13.3% of flaps.²⁰ Sarker A et al., documented partial flap necrosis in 6.25%, marginal flap necrosis in 6.25%, complete flap loss in 3.12%. [18] In present study, 13.7% of patients with complications required secondary procedure like flap/grafting. Yasir M et al.,

found that 13% of patients with complications required grafting later on.[21]

Overall flap survival rate was 89.7% in present study. Prasad K et al., documented the flap survival rate of 70%.[19] Sarker A et al., documented the flap survival rate of 81.25%.¹⁸ In the present study the mean duration of surgery of patients was 146.23 ± 20.24 minutes. Yasir M et al., documented that the average duration of surgery was 150 minutes.[21] In the present study 69.2% patients reported outcome as excellent, 23.9% as good and 6.8% as poor. In a study by Shahabuddin SF et al., among most of cases, the aesthetic result was acceptable and patients were completely satisfied.[23,24] In the present study there was no donor site morbidity. Sarker A et al., reported that there was minimal donor site morbidity.[18]

Limitations

Few limitations of the present are that the study has been done in a single centre, the study was carried out in a tertiary care hospital, so hospital bias cannot be ruled out and last one is that ongoing COVID 19 pandemic and lockdown has further hampered the study.

Conclusion

Perforator based flaps provide a valuable option for the reconstruction of small to medium size lower limb defects. Careful selection of the perforator and optimal designing of the flap result in favourable outcomes with the use of local perforator flaps for reconstruction in extremities. It is a simple, relatively easy, with reduced donor site morbidity and a safe alternative to the more complex and time-consuming microsurgical reconstructions in the areas where other local reconstruction options are not possible. The overall cosmetic outcome of perforator-based flaps for lower limb soft tissue reconstruction is

acceptable. Therefore, whenever possible it should be considered as a reconstructive option for coverage of soft tissue defects of lower limb.

References

1. Gillies HD, Millard DR. The principles and art of plastic surgery. Boston: Little and Brown; 1957.
2. Godina M. Early microsurgical reconstruction of complex trauma of the extremities. *Plast Reconstr Surg.* 1986; 78:285–92.
3. Ger R. The technique of muscle transposition in the operative treatment of traumatic and ulcerative lesions of the leg. *J Trauma.* 1971; 11:502–510.
4. Ponten B. The fasciocutaneous flap: its use in soft tissue defects of the lower leg. *Br J Plast Surg.* 1981; 34:215–220.
5. Chatre MG, Quaba AA. Fasciocutaneous flaps in lower leg reconstructions: experience with 100 flaps. Edinburgh, Scotland: Presented at the British Association of Plastic Surgeons, Summer Meeting; July 2, 1987.
6. Quaba O, Quaba A. Pedicled perforator flaps for the lower limb. *Semin Plast Surg.* 2006; 20:103–11. [Google Scholar]
7. Fayman MS, Orak F, Hugo B, et al. The distally based split soleus muscle flap. *Br J Plast Surg.* 1987; 40:20–6.
8. Tanaka K, Matsumura H, Miyaki T. An anatomic study of the intermuscular septum of the lower leg; branches from the posterior tibial artery and potential for reconstruction of the lower leg and the heel. *J Plast Reconstr Aesthet Surg.* 2006; 59:835–8.
9. Hallock GG. Lower extremity muscle perforator flaps for lower extremity reconstruction. *Plast Reconstr Surg.* 2004; 114:1123–30.
10. Schaverien M, Saint-Cyr M. Perforators of the lower leg: analysis

- of perforator locations and clinical application for pedicled perforator flaps. *Plast Reconstr Surg.* 2008; 122:161–70.
11. Georgescu AV, Matei I, Ardelean F, Capota I. Microsurgical nonmicrovascular flaps in forearm and hand reconstruction. *Microsurgery.* 2007; 27:1–7.
 12. Carriquiry C, Costa M A, Vasconez L O. An anatomic study of the septocutaneous vessels of the leg. *Plast Reconstr Surg.* 1985; 76:354–363.
 13. Song R, Gao Y, Song Y, Yu Y, Song Y. The forearm flap. *Clin Plast Surg.* 1982; 9:21–26.
 14. Mzezewa, S. Z., Setati, M., Netshiongolwe, T., & Sinoamadi, V. Prevalence of breast cancer in reduction mammoplasty specimens, in women of African origin: preliminary histology results at Mankweng and Polokwane hospitals: Clinical Case Series. *Journal of Medical Research and Health Sciences,* 2020:3(10), 1109–1113.
 15. Quaba A A. In: Court-Brown CM, McQueen MM, Quaba AA, editor. *Management of Open Fractures.* London: Martin Dunitz Publishers; 1996. Local flaps. pp. 195–209.
 16. Teo TC. Reconstrucción de la extremidad inferior con colgajos de perforantes locales. *Cir Plas Iberolatinoam.* 2006; 32:15–16.
 17. Lecours C, Saint-Cyr M, Wong C, et al. Freestyle pedicle perforator flaps: clinical results and vascular anatomy. *Plast Reconstr Surg.* 2010; 126:1589–1603.
 18. Hamed ML, Elbarbary AS, Sayed AE, Salam AM, Galal DM. The Assessment of Postoperative Patency and Flow Pattern of Twisted Vascular Pedicle in Propeller Perforator Flaps in Lower Extremities Reconstruction. *QJM: An International Journal of Medicine.* 2021 Oct;114(Supplement _1):hcab105-012.
 19. Sarker A, Begum KN, Faruquee SR, Ali MA, Chowdhury MA, Manzur RM. Use of Perforator Propeller Flaps for Coverage of Soft issue Defects Around the Distal Leg and Ankle. *Journal of Bangladesh College of Physicians and Surgeons.* 2021 Mar 9;39(2):87-93.
 20. Prasad K et al. A study of propeller flaps for the reconstruction of soft tissue defects of lower limbs. *Int. J. of Contemporary Medical Research* 2019, 6(1) 1-7.
 21. Ramesha KT, Vijay J, Shankarappa M. Propeller flaps and its outcomes-a prospective study of 15 cases over two-years. *Journal of Clinical and Diagnostic Research: JCDR.* 2014 Jan;8(1):87.
 22. Yasir M, Wani AH, Zargar HR. Perforator flaps for reconstruction of lower limb defects. *World journal of plastic surgery.* 2017 Jan;6(1):74.
 23. Sananpanich K, Tu YK, Kraissarin J, Chalidapong P. Reconstruction of limb soft-tissue defects: using pedicle perforator flaps with preservation of major vessels, a report of 45 cases. *Injury.* 2008 Oct 1; 39:55-66.
 24. Shahabuddin SF, Khurram MF. A study of clinical applications of perforator-based propeller flaps in leg reconstructive surgery: a single-center experience of 40 cases. *The international journal of lower extremity wounds.* Mar 2020;19(1):70-7.