ORIGINAL RESEARCH PAPER

Volume-8 | Issue-2 | February-2019 | PRINT ISSN No 2277 - 8179

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

PERFORATOR MAPPING OF MAIN VASCULAR AXES OF LOWER LIMB AND ITS CLINICAL APPLICATION IN RESURFACING MIDDLE AND LOWER THIRD LEG DEFECTS – A PROSPECTIVE STUDY.

Plastic Surgery

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ABSTRACT

CONTEXT- With the concept of perforators and angiosomes, locoregional tissues can be transferred, based on a reliable perforator, the flaps being islanded or propelled into the defect in the middle and lower third defects of the lower limb.

AIM– We aimed to study the location and number of perforators of the 3 vascular axes of the lower limb preoperatively with hand held doppler, assess intraoperative confirmation and design flaps accordingly to resurface middle and lower third defects of lower limb.

METHODOLOGY- 30 patients with soft tissue defects of the middle and/or lower third of lower limbs were resurfaced with perforator flaps during which the perforators were mapped, the flaps designed and executed noting the complications at Medical College, Kolkata, India over 2 years.

RESULTS - 66.67% flaps were of islanded propeller types. The maximum flap size was 15X9 cm. 41% peroneal perforators were located in 13-18 cm interval, 30% posterior tibial perforators in 21-26 cm interval and 33% anterior tibial perforators in 4-9 cm interval, distance being measured from inter-malleolar line. 8.33% flap loss due to congestion occurred. Complications decreased as perforators placed more distant to the defect were taken.

CONCLUSION- Soft tissue defects in middle and lower third of small to moderate size in lower limb can be safely resurfaced with perforator flaps with the selection of a reliable perforator.

KEYWORDS

perforator, perforator flap

INTRODUCTION

Soft-tissue coverage of the lower leg is a formidable challenge due to minimal laxity of the cylindrical skin envelope of the leg. Local skin flaps in the leg even with a delay have been notoriously inadequate for coverage and distant flaps like cross leg flap may cause prolonged morbidity and patient discomfort. The classical approach for repair of proximal defects has been via the transposition of the soleus or gastrocnemius muscles for middle and upper third respectively. If the zone of injury has included these muscles or if it involves the distal third of the leg, any substantial skin loss may require the microsurgical transfer of tissue in order to obtain wound healing.

With the development of perforator flaps, newer and more reliable flaps have become available for lower limb reconstruction. Referring to Taylor and Palmer's concept of angiosomes1, almost all the tissues of an angiosome can be harvested on one adequate perforator vessel. The perforator pedicles of these flaps originate from one of the main vessels of the lower extremity, course through one or more muscles or one of the intermuscular septum up to the fascia, and ramify at a suprafascial level. Hyakusokuet al.2 in 1991 described an adipocutaneous flap designed as a propeller, blood supplied through a random subcutaneous pedicle and rotated 90 degrees.

The term 'propeller flap' was first time used by Hallock3 and the definition was provided by an Advisory Panel of the First Tokyo Meeting on Perforator and Propeller Flaps in 20094.

Our study aims to study the number and locations of the reliable lower leg perforators (perforator mapping) and its use to design flaps to cover mid and lower third leg defects.

SUBJECTS AND METHODS

We conducted this prospective interventional study in our institute. The duration was two years from October 2016 to September 2018. The study population comprised of the patients admitted to our department or referred from other departments in our hospital. We included all consecutive patients with soft tissue defects indicated for flap coverage who consented for the surgery (convenience sampling method).

We excluded patients less than five years and more than 80 years and those with comorbidities like uncontrolled diabetes mellitus and diagnosed vascular disease to minimize confounding by other variables. Patients unfit for surgery and anesthesia and those who did not give consent were also excluded.

Patients with middle and lower third soft tissue defects of the lower limb were assessed by hand held doppler (8 mHz probe) for number and location of perforators of vascular axes. Their distances from intermalleolar line (line joining lateral and medial malleolus) were measured as in fig.1

Fig.1: Posterior tibial artery perforators dopplered and flap marked for exposed tibia lower 3rd leg

Flaps were designed based on location of perforators, size and location of the defects. Intraoperative confirmation of perforators' location was done as in fig.2.

Fig. 2: Intra-operative marking of posterior tibial artery perforators

We used three 5-cm intervals- 4-9cm, 13-18cm and 21-26 cm from the intermalleolar line as a fixed bony reference point. For simplification, we defined the perforator flaps as fasciocutaneous flaps, islanded on an isolated perforator vessel. It could be a septocutaneous, a musculocutaneous or a direct cutaneous perforator. We named the flap on the axial source vessel that the perforator arose from.

RESULTS

We studied a total of thirty patients in the age group ranging from 14years to 70 years, of which there were twenty four males and six females. The mean age of the patients was 39.9 years with male:female ratio of 4:1. Vehicular accidents were the aetiological cause in all patients. Fifteen patients(50%) had flaps on peroneal axis, thirteen patients(43.3%) had posterior tibial perforator flaps and two(6.7%) anterior tibial flaps were used. There were six complications. One was due to donor site graft loss. Five complications were related to flap necrosis, which ranged from flap tip necrosis to whole flap loss. All these 5 cases needed addition operative intervention- wound debridement, skin grafting or another flap. Flap complication rate in our study is 16.67 % out of which 10% were islanded propeller types and 6.67% perforator plus peninsular (Table 1).

Table 1: Data of patients included in the study

S.no	Age/Sex	Defect location & size (cms)	Vessel	No. of perforators	Location of perforator (distance from Intermalleolar line in cms)	Flap based on (cms from IML)	Flap size (cms)	Intra operative confirmation of flap perforator	Distance of perforator from defect margin (cms)	Flap type	Flap complications
1	40/M	Lower 3rd 6x5	Post. tibial	5	9,13,17,22,26	9	15x8	Not present	5	Islanded propeller	Nil
2	34/M	Lower 3rd 5x4	Peroneal	4	6,13,17,31	9	12x6	Present, extra at 9 cm	4	Islanded propeller	Nil
3	46/M	Lower 3rd 7x5	Peroneal	4	5,14,18,21	5	14x9	Present	4	Islanded propeller	Flap tip necrosis
4	21/M	Lower 3rd 5x3	Peroneal	5	5,14,17,24,30	5	11x5	Present	5	Islanded propeller	Nil
5	68/M	Lower 3rd 4x5	Peroneal	3	6,12,18	12	13x7	Present	6	Islanded propeller	Nil
6	37/M	Middle 3rd (7x5)	Peroneal	4	5,13,18,24	13	10x7	Present	4	Islanded propeller	Nil
7	32/M	Lower 3rd 6x4	Post. tibial	4	4,9,14,26	14	13x8	Present	5	Islanded propeller	Distal 3 cm necrosis
8	17/M	Middle 3rd (5x4)	Post. tibial	5	8,15,18,21,26	15	10x7	Present	4	Perforator plus	Nil
9	14/ F	Lower 3rd (7x5)	Peroneal	4	6,12,17,22	6	12x8	Present	3	Perforator plus	Distal half necrosis
10	45/M	Lower 3rd (6x4)	Post. tibial	6	6,9,16,21,24, 30	6	12x6	Present	5	Islanded propeller	Nil
11	51/M	Lower 3rd (5x4)	Ant. tibial	9	4,6,8,13,19,2 1,24,29,34	6	8x5	Present	3	Islanded propeller	Nil
12	28/ F	Lower 3rd (7x5)	Post. tibial	5	7,14,18,22,24	7	13x7	Present	5	Perforator plus	Nil
13	60/M	Middle 3rd (6x5)	Peroneal	4	5,13,15,26	15	12x6	Not Present	5	Islanded propeller	Nil
14	56/M	Lower 3rd (5x4)	Peroneal	5	4,6,14,18,22	6	10x6	Present	4	Islanded propeller	Nil
15	33/M	Middle 3rd (9x7)	Post. tibial	5	8,15,17,22,34	15	14x9	Present	3	Perforator plus	Flap tip necrosis
16	59/ F	Lat. Malleolus (4x3)	Peroneal	3	5,13,16	5	8x6	Present	3	Islanded propeller	Nil
17	22/M	Middle 3rd (7x6)	Post. tibial	5	9,13,16,20,23	16	12x8	Present	6	Perforator plus	Nil
18	40/ F	Med. Malleolus (5x4)	Post. tibial	5	6,14,19,24,31	6	10x8	Present	4	Islanded propeller	Nil
19	26/M	Lower 3rd (6x4)	Peroneal	5	6,14,17,22,26	14	14x8	Present	6	Islanded propeller	Skin graft loss at donor site
20	33/M	Lower 3rd (7x5)	Post. tibial	4	9,13,15,24	9	12x7	Present	4	Islanded propeller	Nil
21	60/M	Middle 3rd (7x6)	Peroneal	4	7,15,18,30	15	13x8	Present	5	Perforator plus	Nil
22	19/ F	Middle 3rd(10x5)	Post. tibial	5	9,14,20,22,26	20	14x8	Present	5	Perforator plus	Nil

23	50/M	Middle 3rd(6x4)	Peroneal	5	8,13,15,23,28	13	12x7	Present	6	Islanded propeller	Nil
24	44/M	Lower 3rd (8x5)	Post. tibial	5	11,21,24,30,34	11	12x8	Present	4	Perforator plus	Nil
25	67/M	Lower 3rd (5x3)	Ant. tibial	9	4,6,8,14,21,22,24,28,32	4	8x5	Present	4	Islanded propeller	Nil
26	20/M	Lower 3rd (10x6)	Post. tibial	5	9,13,19,23,31	6	14x9	Present, extra at 6cm	5	Perforator plus	Nil
27	29/M	Lower 3rd (5x4)	Peroneal	5	5,11,13,20,28	5	8x6	Present	4	Islanded propeller	Total flap necrosis
28	31/F	Lower 3rd (6x3)	Peroneal	4	5,12,18,26	12	8x6	Present	5	Islanded propeller	Nil
29	70/M	Lower 3rd (9x5)	Peroneal	4	6,14,17,27	6	13x8	Present	5	Perforator plus	Nil
30	44/M	Lower 3rd (7x4)	Post. tibial	5	8,13,19,24,31	13	10x7	Present	5	Islanded propeller	Nil

Peroneal artery perforators

Total no. of patients studied with peroneal artery perforators = 15
Sum total no. of peroneal artery perforators = 63
Average no. of peroneal artery perforators = 4.2 ≈ 4.

Perforators clustered in three 5-cm intervals from intermalleolar line -
Perforators in 4-9 cm interval = 16 (25%)
Perforators in 13-18 cm interval = 26 (41%)
Perforators in 21-26 cm interval = 10 (16%)
Most of the perforators (41%) were present in middle 13-18 cm interval and there was almost a constant perforator 5 to 6 cm from intermalleolar line. Total 82% of perforators were present in these three 5-cm intervals.

Posterior tibial artery perforators

Total no. of patients for whom posterior tibial artery perforators used = 13
Sum total no. of posterior tibial artery perforators = 64
Average no. of posterior tibial artery perforators = 4.9 ≈ 5

Perforators clustered in three 5-cm intervals from intermalleolar line -
Perforators in 4-9 cm interval = 14 (22%)
Perforators in 13-18 cm interval = 18 (28%)
Perforators in 21-26 cm interval = 19 (30%)
Perforators of posterior tibial artery were more or less evenly distributed in all three intervals. Total 80% of perforators were present in three 5-cm intervals.

Anterior tibial artery perforators

Total no. of patients studied with anterior tibial artery perforators = 2
Sum total no. of anterior tibial artery perforators = 18
Average no. of anterior tibial artery perforators = 9

Perforators clustered in three 5-cm intervals from intermalleolar line –
Perforators in 4-9 cm interval = 6 (33%)
Perforators in 13-18 cm interval = 2 (11%)
Perforators in 21-26 cm interval = 5 (28%)
Perforators of anterior tibial artery were mainly clustered in 4-9 cm and 21-26 cm interval

Sensitivity of hand-held doppler in detecting perforators

True positives were flap perforators correctly identified by hand held doppler, while false negatives were those perforators which are missed by hand held doppler.

Out of 30 patients, hand held doppler correctly identified location of flap perforators in 28 cases and missed perforators in 2 cases.
So sensitivity of hand held doppler with 8 MHz probe in detecting perforators was 93.33% (greater than 90%)

2 types of flaps were done –

1. Islanded propeller – Flap completely islanded on a single perforator and rotated into the defect like a propeller, angle of rotation was from 0-180 degree: 20 cases (66.67%)

2. Perforator plus peninsular – In this flap a skin bridge was retained at the base of the flap : 10 cases (33.33%)

We didn't use V-Y advancement for any flap.

Flap size – We used perforator flaps to cover small to medium size defects. Defects in our series ranged from 4x3 cm to 9x6 cm (maximum 10x6 cm). The flap size ranged from 8x5 cm to 15x9 cm (maximum length of flap- 15 cm, maximum width of flap- 9 cm).

Distance of perforator from defect margin – We also measured distance of perforator from margin of defect, on which flap was based. We didn't base any flap on perforator which was within less than 3 cm from defect margin.

Number of flaps based on perforator at 3 cm from defect margin = 04 (13.33%)

Number of flaps based on perforator at 4 cm from defect margin = 10 (33.33%)

Number of flaps based on perforator at 5 cm from defect margin = 12 (40%)

Number of flaps based on perforator at 6 cm from defect margin = 04 (13.33%)

In all our flaps distance of perforator from defect was in range of 3-6 cm. Most of the flaps were based on perforators which were either 4 or 5 cm from defect margin.

Relationship of complication to flap type, flap size and distance of perforator from defect –

Flap type- Out of 20 islanded propeller flaps, flap complications occurred in 3 cases (15%), partial necrosis in 2 patients and total necrosis in 1 patient, requiring secondary procedures of debridement, dressing, vacuum assisted closure and skin grafts or other local fasciocutaneous flaps.

Out of 10 perforator plus peninsular flaps, marginal necrosis occurred in 2 cases (20%).

Flap size – The flap size ranged from 8x5 to 15x9 cms. We didn't find any relation between flap size and flap complications.

Distance of perforator from defect – We maintained a minimum distance of 3 cm from defect margin to perforator to avoid the zone of trauma.

Number of flaps based on perforator at 3 cm from defect margin = 4
Complications occurred in 2 cases (50%)

Number of flaps based on perforator at 4 cm from defect margin = 10
Complications occurred in 2 cases (20%)

Number of flaps based on perforator at 5 cm from defect margin = 12
Complication occurred in 1 case only (8%)

Number of flaps based on perforator at 6 cm from defect margin = 4

No complication occurred in any of the cases (0%)

DISCUSSION

We ensured the reliability of the perforator by the caliber of the perforator being at least 1 mm5 and observing pulsations on release of tourniquet later on.

Several studies6-8 demonstrated that reliable perforators of posterior tibial artery range from 2 to 8 in number being located in the middle third of the leg (range 8 - 24 cm from the medial malleolus). In our study the posterior tibial artery perforators were more widely distributed throughout the leg 4 to 34 cm from the intermalleolar line.

As per our study the peroneal artery perforators predominate in the 13- to 18-cm interval, supporting other studies9,10 of their predominance in the middle third of the fibula. We also found a constant perforator of peroneal artery at 5 or 6 cm from the lateral malleolus.

Similar to Carriquiry's study8 average number of anterior tibial perforators in our study is 9. They are mainly in proximal 21-26 cm cluster or distal 4-9cm cluster.

We found that as selected perforator moves away from defect, complication rate decreases.

This may be due to fact that lesser the distance between defect and perforator, chances to injury to perforator is more (zone of trauma).
But disadvantages of remote perforators include shifting of the pivot point and difficult execution of flap and requirement of larger flaps. Peninsular flaps did not have major flap loss and this is likely due to the fact that the retained skin bridge contains superficial vein for better drainage of flap.

CONCLUSION

Average number of peroneal artery perforators was found to be 4 mostly (41%) present in the middle 13-18 cm interval with a constant perforator 5 or 6 cm from intermalleolar line.

Average number of posterior tibial artery perforators was 5 distributed in all three intervals (4-9, 13-18, 21-26 cm).

Average number of anterior tibial artery perforators was 9 mainly clustered in the 4-9 cm and 21-26 cm interval.

Sensitivity of hand held Doppler with 8 MHz probe in detecting perforators was 93%.

Defects of small to moderate sizes over mid and lower third of leg can be resurfaced with a perforator flap if planned properly, perforator selected away from zone of trauma with good results. The perforator flaps have the advantage of preservation of muscle and its function, sparing of main vascular trunk, better aesthetic result of donor site by avoiding dog ears or bulges as in fig.3.

Fig3: Defect in lower third leg resurfaced with peroneal artery perforator flap and its long term result

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