Original Article

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Is Pedicle Perforator Flap Safe and Reliable for Lower Limb Reconstruction?

Surgery Section

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ABSTRACT

Introduction: Soft tissue defect in lower limb remains a challenge for reconstructive surgeon. Plastic surgery is a battle between blood supply and defect dimension. Anatomic studies have documented the role of perforator in the blood supply of cutaneous tissues in various areas of the body.

Aim: To present experience with perforator flaps for reconstruction of soft tissue defects in the lower limb.

Materials and Methods: A retrospective study was conducted in 24 patients between July 2016 and November 2019 who had undergone pedicle perforator flap in lower limb. Defect location, size of defect, type of flap used and complications were recorded. All flaps were raised after preoperative localisation of perforator by hand held Doppler. Safety of the flap was determined in terms of flap necrosis and flap failure. Statistical analysis was conducted in terms of numbers and percentages.

Results: Posterior tibial artery perforator flap was used in six cases. Peroneal perforator flap was used in 18 cases. The flaps were used for proximal third defect (n=5), middle third defect (n=2), and third defect (n=17). The most common size of the defect was between 30-90 cm^2 (n=13), <30 cm^2 (n=8) and >90 cm^2 (n=3). Minor complication occurred in 33.48%. There was no case of total flap necrosis. No patient had any functional deficit.

Conclusion: Since pedicle perforator flap is without total flap failure and donor site defect or functional, it can be used for reconstruction of defects of proximal, middle and distal third of leg.

Keywords: Perforator plus flap, Peroneal perforator flap, Posterior tibial perforator flap, Propeller flap

INTRODUCTION

Reconstruction of lower limb and particularly lower third of leg poses a challenge to reconstructive surgeon. Various flaps with its anatomic components have been described. Distally based fasciocutaneous flap from sural region based on perforators along intermusclar septum described by Donski PK et al., has been used since many days [1]. Masquelet AC et al., described his flap which became a workhorse flap for lower third leg [2]. Amarante J et al., described distally based fasciocutaneous flap based on posterior tibial artery perforator [3]. Fasciocutaneous flaps described by Ponten B rely on deep fascia for blood supply. One of the limitations of the pedicled fasciocutaneous flap is that they cannot be islanded [4]. They have limited mobility and decrease distal reach. Musculocutaneous flaps and muscle flaps with skin grafts were used in the past for proximal and middle third defects of leg [5-7]. Muscle dissection resulted in increased donor site morbidity and caused functional deficit. Free tissue transfer requires surgical expertise, skilled assistance, and postoperative monitoring, microsurgical facility and is a time consuming procedure. Anatomical studies on blood supply of cutaneous and subcutaneous tissues have helped in harvesting different types of perforator flaps [8]. Perforator flaps are composed of skin and subcutaneous fat and supplied by perforators arising from main axial vessels of leg namely anterior tibial, posterior tibial, and peroneal arteries in the lower leg within intermusclar septa [9]. Flaps raised on perforator have increased mobility. Perforator propeller flaps [10,11] based on peroneal perforator has been initially described as an alternative to free flap for small and medium size defects. However, venous congestion remains a problem in perforator propeller flap [12]. This problem was addressed by perforator plus [13,14] flaps. Perforator plus flaps maintain arterial supply through perforator and preservation of a skin at base provides additional venous drainage. Another advantage of perforator plus flap is that it can be an alternative to free flap for large defects and distal defects [15]. Perforator propeller flap and perforator plus flap have gained popularity for lower third defects of lower limb. Very few have reported its use in upper third pretibial defect or middle third tibial defect [16]. We present our experience of perforator based flaps (both peroneal artery and posterior tibial artery) for small, medium and large defects in upper third, middle third and lower third of lower limb.

MATERIALS AND METHODS

A retrospective study was conducted in 24 patients between July 2016 to November 2019 who underwent reconstruction of upper third, middle third and lower third of lower limb using perforator flap of posterior tibial, peroneal artery. Apart of routine investigation in all patients peroneal artery perforator or posterior tibial artery perforator was marked by 8 Hz hand held Doppler. In no case colour Doppler USG or CT angiography was done.

Inclusion Criteria

Exposed bone, tendon, implant, unstable scar, post cancer defect, postinfective raw area in upper third, middle third and lower third of the limb were included in the study.

Exclusion Criteria

Patients with recent MI (60 days) or unstable angina, decompensated heart failure, high-grade arrhythmias, or haemodynamically important valvular heart disease (aortic stenosis in particular); Peripheral arterial disease; Acute infection; Uncontrolled diabetes mellitus; Heavy smokers (>25 cigarettes per day).

Choices of flaps were detected by location, site, and size of the defect. Both posterior tibial artery perforator flap and peroneal artery perforator flap were used. When posterior tibial perforator flaps was harvested patient was operated in supine position. When peroneal perforator flap was raised for heel defect, patient was kept in prone position. When peroneal perforator based flaps were used for lateral malleolar, lateral ankle defects patient was kept in lateral decubitus position. Preoperatively perforator was identified by hand held Doppler. Peroneal perforator flap was used preferentially when soft tissue loss was found to be in lateral portion of the limb. Posterior tibial artery flap was selected for smaller defect on medial side. All defects in upper third or middle third of leg were resurfaced with proximally based perforator plus flap.

Flaps were divided into two groups. Peroneal Artery Perforator Based Flap (PAPF) and Posterior Tibial Perforator Based Flap (PTPF). Many different modifications were done based on flap pedicle and flap components [Table/Fig-1] [10,13,14,17].

Based on location of perforator
1. Lowermost septo cutaneous perforator- 5cm above lateral malleolar
2. Middle third septo cutaneous perforator- 7 to 10 cm above lateral malleolus
3. Upper third peroneal perforator

Pedicle component
Subcutaneous pedicle
Skeletosed Perforator (known as propeller perforator flap) [10]
Fasciocutaneous pedicle (known as perforator plus flap) [13.14]
Adipofascial pedicle [17]

[Table/Fig-1]: Flap variation [10,13,14,17].

Surgical complications like partial necrosis, total necrosis, limb oedema, infection, superficial epidermolysis, and minor venous congestion were noted.

Operative Technique

Initially, debridement and saline gauze dressing removes necrotic tissue and prepares the wound for soft tissue coverage. Preoperative localisation of perforator was done with 8 Hz hand held Doppler [18]. Tourniquet was applied after limb elevation. Exploratory incision was given on one side of flap. Incision was deepened below deep fascia. The flap was raised till suitable perforator is identified. Distance from the perforator to the distal end of defect was calculated (x). About 1 cm was added to the length of the flap (x+1) [10]. Tourniquet was released after perforator identification. If perforator size was more than 0.5 mm and was found to have visible pulsation propeller flap was designed. All fascial strands around the perforator were divided. Papaverine or 2% xylocaine was applied over perforator after flap harvest and flap was allowed to perfuse for 15 minutes. Drain was given. Flap insetting was done with 3-0 polyamide. If any doubt arises regarding the pulsation of the perforator then perforator plus design was chosen. Flap was raised from distal to proximal. Intermuscular septum was released till perforator was visible. No venous supercharging was done in any case. Postoperatively, limb was elevated for two weeks. All cases donor site was skin grafted. For foot and calcaneal defects supportive plaster of paris or splint was used postoperatively for immobilisation for two weeks.

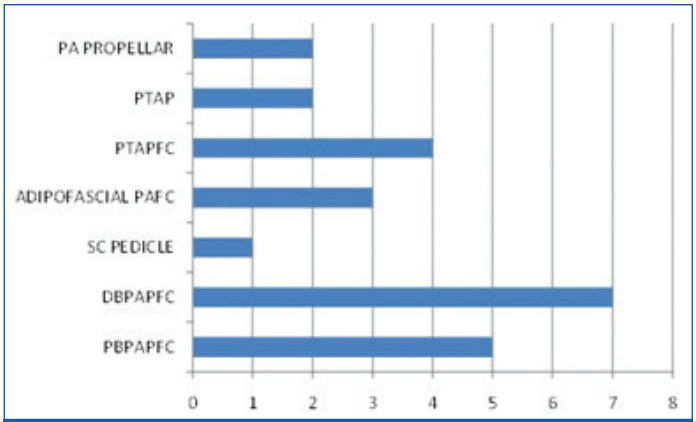
RESULTS

The age of the patients ranged from 8 years to 52 years with mean age 30.66±11.40 years. Common age group was between 20-40 years. Male to female ratio was 3.8:1 (M=19, F=5). The most common size of the defect was between 30-90 cm^2 (n=13), <30 cm^2 (n=8) and >90 cm^2 (n=3). Peroneal perforator flap was the most commonly performed flap for upper third (n=5), middle third (n=2) and lower third defects (n=11) with a total of 18 cases. Posterior tibial artery perforator was used in 6 cases and all were in lower third of leg. Trauma was the most common indication for flap coverage (n=14, 58.33% cases) [Table/Fig-2]. Adipofascial pedicle was done in three cases. Subcutaneous pedicle flap was done in one case. All the posterior tibial perforator flap were distally based while peroneal perforator flap was distally based in lower third defects and proximally based in upper third defects [Table/Fig-3].

Oedema was the most common complication occurring in five cases (21%) which subsided after limb elevation. Epidermolysis was found in one (4.16%) patient which healed completely. Partial flap loss occurred in one patient (4.16%) which healed with regular dressing. Venous congestion occurred in one patient (4.16%) which

Case	Age/sex	Cause	Location	Flap type	Comorbidity	Flap size (cm^2)	Originating artery	Complications	Follow-up (month)
1	15/M	Trauma	Upper third	PBPAPFC	-	8x6	PA/PBPAPFC	Oedema	3
2	13/M	Malignacy	Upper third	PBPAPFC	-	7x6	PA	-	5
3	20/F	Infection	Upper third	PBPAPFC	-	8x7	PA	-	7
4	45/M	Trauma	Upper third	PBPAPFC	-	7x5	PA	-	2
5	8/M	Trauma	Upper third	PBPAPFC	-	8x7	PA	-	4
6	27/M	Trauma	Middle third	DBPAPFC	-	12x6	PA	Oedema	3
7	25/F	Burn	Middle third	SUBCUTANEOUS PEDICLED PROPELLAR FLAP	-	6x3	PA	-	4
8	30/M	Leprotic ulcer	Lower third	DBPAPFC	-	13x10	PA	Superficial epidermolysis	8
9	38/F	Trauma	Lower third	DBPAPFC	-	21x12	PA	Oedema	4
10	24/M	Trauma	Lower third	DBPAPFC	-	10x6	PA	-	6
11	41/F	Infective	Lower third	DBPAPFC	DM	6x4	PA	-	3
12	43/M	Trauma	Lower third	ADIPOFASCIAL PAFC	HPTN	12x10	PA	Oedema	4
13	52/M	Trauma	Lower third	ADIPOFASCIAL PAFC	DM	10x8	PA	Partial flap loss	5
14	39/M	Burn	Lower third	ADIPOFASCIAL PAFC	-	9x8	PA	-	2
15	40/M	Trauma	Lower third	DBPAPFC	-	10x8	PA	Venous congestion	8
16	26/M	Trauma	Lower third	PTAPFC	-	7x4	PTA	-	4
17	22/F	Trauma	Lower third	PTAPFC	-	5x4	PTA	-	3
18	24/M	Trauma	Lower third	PA propeller flap	-	6x5	PA	Oedema	2
19	46/M	Trauma	Lower third	PTAPFC	HPTN	5x3	PTA	-	6
20	42/M	Trauma	Lower third	PTAP	-	4x4	PTA	-	4
21	34/M	Infection	Lower third	PTAPFC	DM	6x6	PTA	-	5
22	32/M	Infection	Lower third	PTAP	-	7x5	PTA	-	9
23	24/M	Scar	Lower third	DBPAPFC	-	6x4	PA	-	4
24	26/M	Scar	Lower third	PA propeller flap	-	4x3	PA	-	6

[Table/Fig-2]: Findings of the present cases.
PBPAPFC: Proximal based peroneal artery perforator plus fasciocutaneous flap; DBPAPFC: Distally based peroneal artery perforator plus fasciocutaneous flap; PAFC: Peroneal artery perforator plus fasciocutaneous flap; PTAFC: Posterior tibial artery plus fasciocutaneous flap; PTAPFC: Posterior tibial artery based perforator plus fasciocutaneous flap; PTAP: Posterior tibial artery propellar flap; DM: Diabetes mellitus; PA: Peroneal artery; PTA: Posterior tibial artery



[Table/Fig-3]: Chart presentation of various flaps.
PA PROPELLAR: Perneal artery propeller flap; PTAP: Posterior tibial artery propeller flap; PTAPFC: Posterior tibial artery based perforator plus fasciocutaneous flap; ADIPFASCIAL PAFC: Adipofascial perneal artery perforator plus fasciocutaneous flap; SC PEDICLE: Subcutaneus pedicle propeller flap; DBPAPFC: Distally based peroneal artery perforator plus fasciocutaneous flap; PBPAPFC: Proximal based peroneal artery perforator plus fasciocutaneous flap

was relieved by removal of distal sutures. There was no case of total flap failure. The congestion subsided within days without any necrosis. All flaps healed well without any major complication. No patient had any functional deficit. All donor sites healed well.

[Table/Fig-4]: a) Defect on the dorsum of foot; b) Postoperative result of the flap on the dorsum of foot; c) Postoperative results with well settled flap.

Post-traumatic defect on the dorsum of the foot with exposed implant of size 21 x12 cm. Distally based peroneal artery perforator plus flap was planned. Perforator was identified about 7 cm above lateral malleolus by hand held Doppler. Proximal end of the flap was 3 cm below the knee joint. Donor site was skin grafted. Flap insetting done [Table/Fig-4a-c].

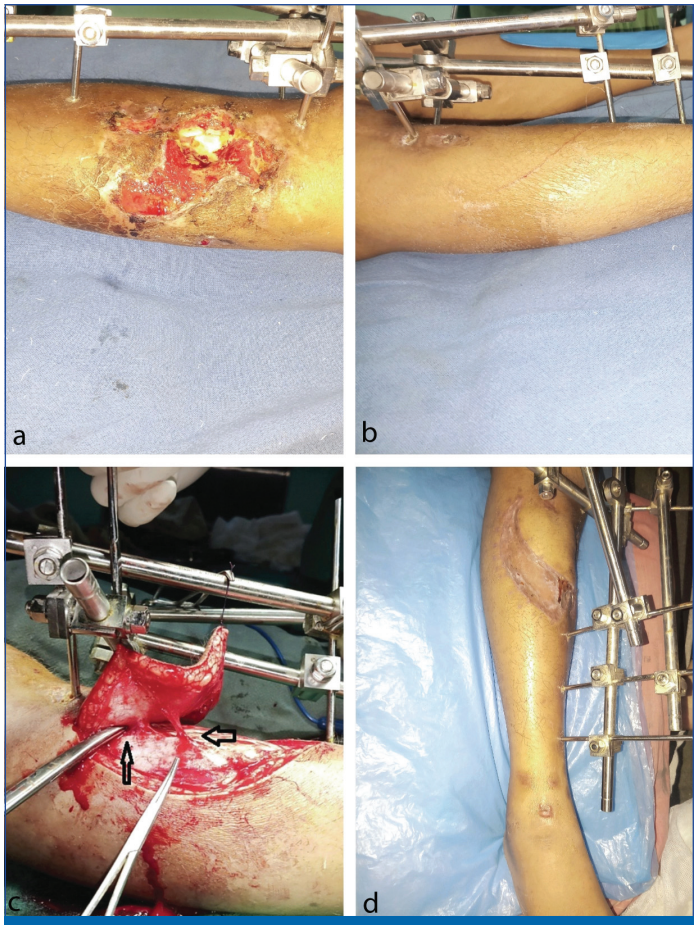
Post-traumatic defect on the proximal third of tibia. Peroneal perforator was identified preoperatively. On exploration, two perforators was identified. Both perforators were preserved. Flap was transposed. Donor site was skin grafted. The entire flap survived [Table/Fig-5a-d].

Post-traumatic exposed tibia on the lower third of leg of size 6 cm x 5 cm. Peroneal perforator was identified by Doppler. A sizable perforator was found intraoperatively. Perforator was skeletonised. Perforator propeller flap was rotated by 90º. Donor site was skin grafted. Entire flap survived [Table/Fig-6a-c].

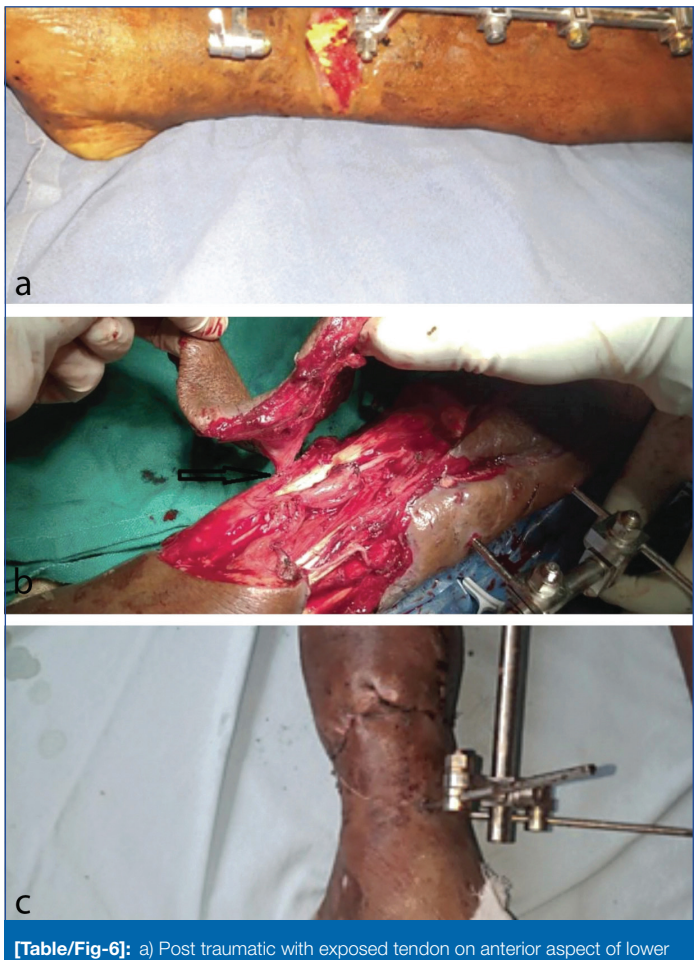
Postinfective skin defect in lower third of leg with skin defect of 7 cm x 5 cm. Posterior tibial perforator was identified preoperatively. Perforator was identified and skeletonised. Flap was rotated by 120º. Entire flap survived [Table/Fig-7a-c].

DISCUSSION

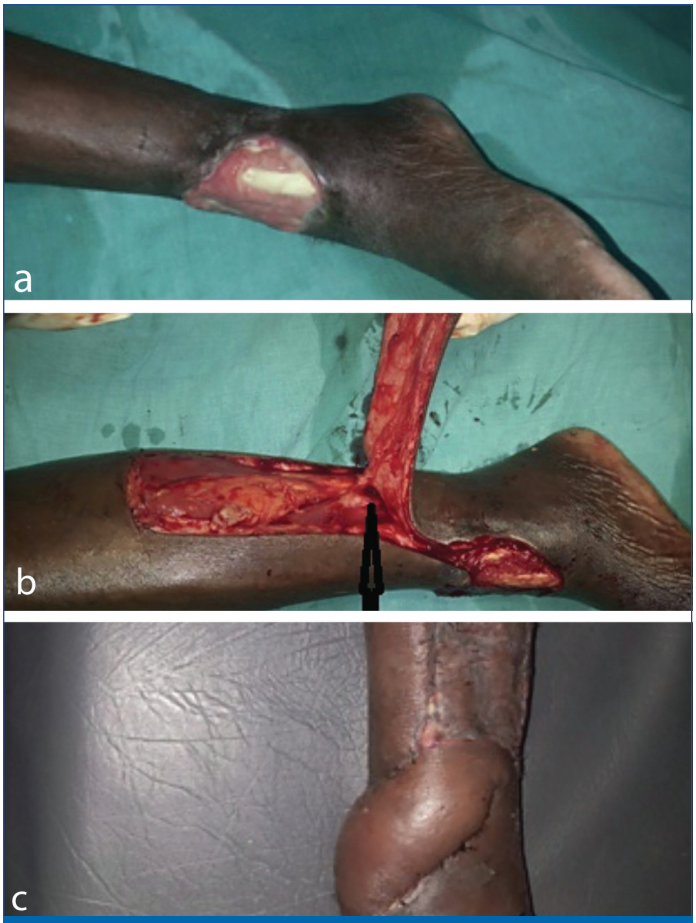
The Gent consensus has classified perforator into five types [19]. Perforator propeller flap [10] has many advantages: 1) Decreases donor site morbidity; 2) Replaces like with like; 3) Preserves axial vessels; 4) Preserves muscle and their function; 5) Better cosmetic result; 6) no sensory deficit; 7) Versatile design; 8) Freedom of insetting. Major disadvantage of propeller flap is venous congestion [12,16] which can be avoided by perforator plus design. In most of the series flap have been described for lower third defect [20-22]. Very few studies has described perforator flap utility for upper third and middle third defects [16,23]. In our series, flaps have been used in proximal third, middle third and distal third of leg.



[Table/Fig-5]: a) Defect on the upper third of leg with degloving injury on the medial side of leg; b) Anterolateral aspect of the skin is not damaged and outside zone of injury; c) Flap raised with two peroneal perforator. Arrow head points towards the perforator; d) Well healed flap after 1 month.



[Table/Fig-6]: a) Post traumatic with exposed tendon on anterior aspect of lower third of leg; b) Posterior tibial artery perforator identified in arrow head and preserved; c) Well settled flap. Donor site covered with skin graft.



[Table/Fig-7]: a): Defect on lower third leg with exposed tibia; Peroneal perforator identified and skeletonised (propeller flap); c): Well settled flap.

there was a minor complication rate of 29.32% in our study which was higher than Gir P et al., who had minor complication rate of 25.8% [20] and lower than Shin IS et al., (complication rate of 37.5%) and Innocenti M et al., (complication rate of 44%) [16,22]. Partial flap necrosis occurred in 4.16% which was lower than previous studies which showed 11.3%, 5.5%, and 25%, respectively [20-22]. Total flap failure rate was 0% which was similar to Lu TC et al., [21] but less than previous studies 1.1% [20], 2% [21] and 9.09% [24].

Koshima I et al., reported, use of posterior tibial artery perforator flap [25]. Dimension of largest flap based on posterior tibial artery perforator was 28 x 13 cm while largest dimension of the flap based on peroneal perforator artery was of size 15 x 9 cm [26]. In our series, the largest flap was of size 21 x 12 cm. Presence of multiple axial communication between perforators allow to raise such large flaps based on single perforator. Opening of choke vessels between the perferosome allows to raise flap beyond the anatomically defined perferosome [27]. Peroneal perforator based flaps can be designed as propeller flap, perforator plus flap with skin paddle, adipofascial pedicle, V Y advancement, proximally based or distally based [22]. Venous drainage is augmented with preservation of an adipofascial tissue around perforator [17]. In our series, we have used adipofascial pedicle in three cases. V Y advancement was not done in any case.

Reported incidence of total necrosis of distally based perforator flap [15] is 0% as compared to 3.8% to 36.0% in the distally based sural artery flap [28,29], and 16.7% to 24.0% in the distally based saphenous fasciocutaneous flap [30,31] In our series, no case has complete necrosis of flap which was comparable to the study by Loua Z et al., [15]. The partial necrosis rates of the peroneal perforator and posterior tibial perforator flaps have been reported to be 15.3% and 19.5% [15]. In our series we have only one case of partial necrosis of peroneal perforator flap (5.5%) and no necrosis of posterior tibial group. This may be because of the fact that comparatively smaller size flap were harvested in posterior tibial group group. More number of peroneal artery flaps were harvested than posterior tibial artery flap because distally based PAPF is superior to distally based posterior tibial artery perforator flap for distal defect due to more number of intercommunicating perforator [32] and less donor site morbidity [15].

Limitation(s)

Sample size in both groups is not same. Size of the flaps raised in both groups is not of equal size. Peroneal artery perforator flaps are used in large number and large size based on our experience with harvest of fibular osteo cutaneous flap and reverse sural flap.

CONCLUSION(S)

Peroneal artery perforator flaps are useful for resurfacing proximal, middle and lower third soft tissue defects of leg. Distally based peroneal artery perforator flaps are preferred to distally based posterior tibial artery perforator flap for lower leg, ankle, and foot due to less complications and less donor-site morbidities.

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