Journal of Bangladesh College of Physicians and Surgeons
Vol. 39, No. 2, April 2021

Use of Perforator Propeller Flaps for Coverage of Soft Tissue Defects Around The Distal Leg and Ankle

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Abstract:

Introduction: Perforator propeller flap is a suitable option to cover soft tissue defects in the distal leg and ankle which preserves the main vascular arteries of the lower extremity and muscle function. The aim of this study is to evaluate the use of perforator propeller flaps for coverage of soft tissue defects around the distal leg and ankle.

Methods: This prospective study was donebetween December 2018 to November 2019in the Department of Burn & Plastic Surgery of National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka. Total 32 patients with small to medium sized soft tissue defect over distal leg and ankle underwent reconstruction with perforator propeller flaps. Sixteen patients had defect over tendo achilles area, 6 had defect over lateral malleolus,7 over medial malleolus and medial aspect of distal third leg and only 3 had defect in front of ankle. Average Flap length and width were 12.72 (±4.19) & 5.63 (±1.78) cm respectively. Flap rotation was measured 180 degrees in 84.37% of the cases. The propeller flaps were based on a single perforator and it was observed from the posterior tibial artery in 62.5% and peroneal artery in 37.5% of the cases.

Results: 81.25% of the flaps completely survived. Total flap loss was observed in one case (3%) while partial flap loss occurred in 6.2% cases. Marginal flap necrosis and epidermolysis were observed in 6.2% and 3% cases respectively.

Conclusions: Propeller flapshavereliable vascular pedicle as well as greater freedom in design and arc of rotation that extend the possibility ofreconstructing difficult wounds with local tissues and minimal donor-site morbidity.

Key Words: perforator flap, propeller flap, distal leg

(J Bangladesh Coll Phys Surg 2021; 39: 87-93)
DOI: https://doi.org/10.3329/jbcps.v39i2.52388

Introduction

Reconstruction of the distal leg and ankle invariably need flap coverage because bones, tendons and neurovascular structures easily become exposed in trauma. Initially random pattern flaps were used which are unreliable in the distal leg and ankle because of their small dimensions to maintain length-to-width ratios and restrictions in mobility[1].

Advances in techniques of flap harvest gave birth to perforator flaps through the innovative work by Koshima and Kroll[2,3] in 1989. In the axial supply, cutaneous vessels run in the subcutaneous fat in a direction parallel to the skin. Perforator supply, on the other hand, arises from an underlying artery and courses to and through the fascia to supply the overlying tissue.

One subset of perforator flaps that has become increasingly popular is the perforator-based propeller flap. Such flaps are based on a single perforator and designed in a shape that resembles an airplane propeller and can be rotated up to180^0 on an acentric axis to cover adjacent, small to medium- sized soft tissue defects[4].

The final definition and terminology of propeller perforator flaps was defined by Advisory Panel of the First Tokyo Meeting on Perforator and Propeller Flaps in 2009[5], as a skin island with two paddles which can be of the same dimensions or with a larger and a smaller one, the demarcation limit between

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Received: 15 July, 2020 **Accepted:** 10 January, 2021

them being the perforator vessel and the flap has to rotate around the perforator vessel for at least 90 to 180 degrees[1].

An average of 93 perforators supply the integument of the lower extremity[1]. The series of perforators from the posterior tibial and the peroneal vessels has changed the pattern of flap use in distal leg. Perforator-based propeller flaps has several potential advantages. The main artery and underlying muscle are preserved.The need to perform amicrosurgical anastomosis is avoided, relatively fast dissection, provides benefit of "like with like" principle[6].

The main goal of the study was to justify the use of local perforator propeller flaps as a suitable option for the coverage of soft-tissue defects of small-medium size in the distal leg and ankle, with low morbidity of the donor site and low complications.

Methods

This prospective study was donebetween December 2018 to November 2019 in the Department of Burn & Plastic Surgery of National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka.Total 32 patients with small to medium sized soft tissue defect over distal leg and around ankle joint underwent reconstruction of defects with perforator propeller flaps. Out of the 32 patients, 27 were male and 5 were female. Their ages varied from 9 to 65 years.

All patients were counselled for surgery and informed written consent for surgery as well as pre-operative & post-operative photographs were taken. Findings of observation and interview with the patient and attendants were recorded in prescribed data collection sheet.

Wound selection

Small and medium sized defects were selected for coverage with perforator propeller flaps. As the definition of small and medium size is whimsical, to assess the size of the wound, the leg was circumferentially divided into three areas such as an anterolateral surface, an anteromedial surface and a posterior surface. Defects involving only one surface was considered as small while a medium defect was that involved two adjacent surfaces.

Preoperative workup

Selection of perforator was done preoperatively by searching of a perforator along the axial line for peroneal and posterior tibial vessels using a 8 MHz handheld Doppler. Perforators with good flowing sound closet to the defect were marked.

A provisional flap design was made with the perforator as the pivot point of the flap. 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, and 1 cm is added. This value forms the proximal limit of the flap. The width of the defect is measured. 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 no excessive sideways traction on the perforator during wound closure.

Operative technique

Patient in supine position with the leg slightly abducted and internally rotated (for posterior tibial perforator based flap) or adducted and externally rotated (for peroneal perforator based flap) under spinal anesthesia, a thigh tourniquet was used without exsanguination.

An incision was made along the posterior border of the predesigned flap and was extended down to the deep fascia, exposing the muscles of posterior compartment. The fascia was reflected anteriorly exposing the intramuscular septum where the exact location of the perforators could be verified. It was not necessary to expose the main trunk of posterior tibial and peroneal vessels or skeletonize the perforators. The design and size of the flaps were adjusted according to the size of the defect and the position of the good caliber perforator nearest to the defect. Flap harvesting completed by elevation of the flap at the subfascial level by incising through the anterior and superior margins.

Dissection proceeded from the proximal to distal through the depth of the intramuscular septum until the previously marked perforator was reached. In peroneal perforator based flaps, the superficial peroneal nerve was encountered in the lower part of the leg and it was preserved. The septum distal to the site of the perforator was also incised to facilitate transposition with 90°–180° rotation on a single perforator. The longer proximal limb was rotated into the defect, while the shorter distal limb was rotated proximally to decrease the size of the donor site, or allow for the primary closure, which was done in two cases. The tourniquet was released before completely islanding the flap. Long leg anterior/ posterior cast was applied in all casesaccording to flap location to immobilize the limb.

Postoperative care and follow up

Light dressing was applied to all flaps, with a window for flap monitoring.The skin paddle of the flap was observed starting at 6 hours postoperatively, then every 12 hourly for the first 48hoursand then once every dayfor any venous congestion or diminish arterial supply by checking colour,temperature, capillary refill, turgor and byhand held doppler. As first 72 hours are critical, hydration of the patient, leg elevation with maintenance of adequate blood pressure and temperature were ensured. Special precaution was taken to ensure that there was no pressure applied over the site of the pedicle.

Dressing was done on 4th postoperative day. Presence of infection, marginal necrosis, and flap loss also needed to monitor. Flap donor site was inspected for presence of infection and graft loss. Decision was taken in case of flap loss whether managed by conservative measures or excision and skin grafting will be sufficed or reconstruction by alternative flap required. For flap donor site and skin donor site, it was decided whether skin graft will require covering the wound. Patient was discharged on 7th postoperative day with removing the stapler pin in SSG site. Patient came for flap suture removal on 14th postoperative day. Partial weight bearing walking was allowed at the end of 3rd week and this was according to the presence of bone fractures and the method of bone fixation. On 30th day, all operative areas would be observed for assessment of outcome of the procedure.

Patients were followed up for a period of 4–12 weeks. The flaps were evaluated as regards achieving the preoperative goal of coverage of the soft-tissue defects and reconstructive outcome.At final follow up,outcome was measured as excellent (flap survived completely, donor area healed without complications), satisfactory(partial flap loss or marginal necrosis, infection in donor area managed conservatively), poor(complete flap loss, donor area needed secondary procedure).

Results

The mean patient age was 36.93 + 13.17 years (range: 9 to 65 years). Among 32 patients 27 were male and rest 5 were female. Common causes of defect were RTA(56.25%) and toilet pan injury(31.25%).

Most of the defects were located over the tendoachilles region (50%). Other defects were located over medial aspect of distal third leg including medial malleolus (21.87%), lateral aspect of distal third leg including lateral malleolus (18.75%), front of ankle (9.37%) (Figure1).

Figure: 1. Soft tissue defect over tendoachilles covered by posterior tibial artery perforator flap. (a). Soft tissue defect & flap design. (b). Flap harvest. (c). Final flap inset after rotation.(d). Postoperative view at 2 weeks.

Posterior tibial artey perforator based flaps were used in 62.5% cases to cover defect while peroneal artery perforator based flaps were used in 37.5% cases. The majority of peroneal artery perforator (PAP) flaps were used in defect over lateral malleolus and front of

ankle whereas the posterior tibial artery perforator (PTAP) flaps were commonly applied for coverage of defect over tendoachilles and medial malleolus (Figure 2).

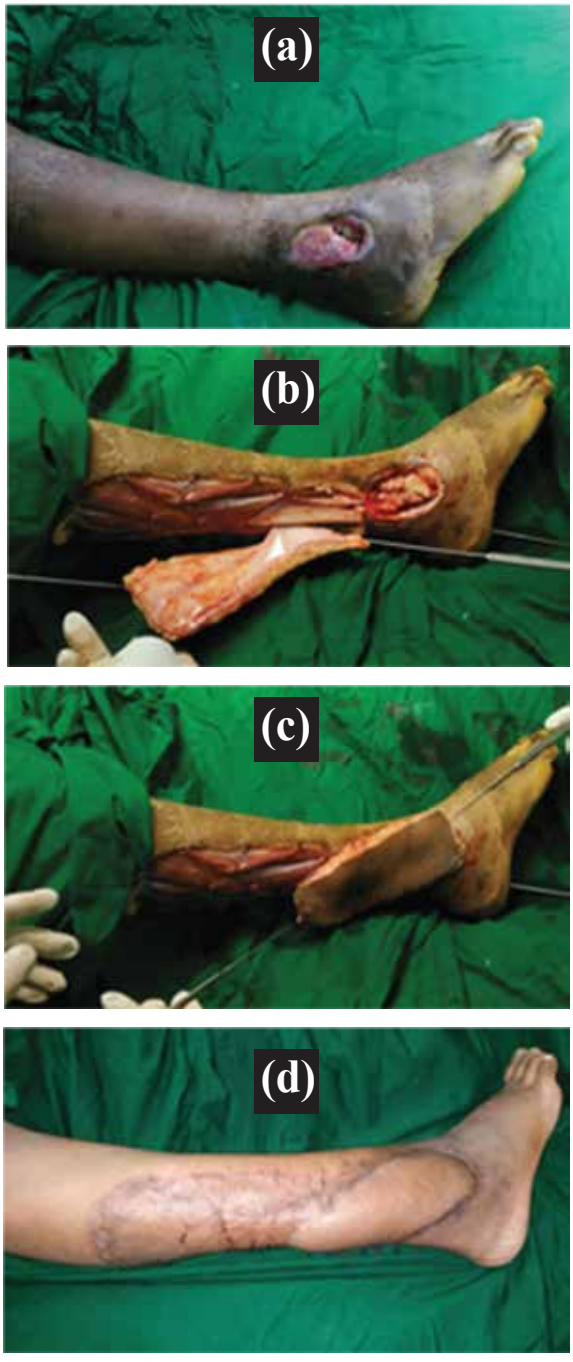

Figure: 2. Soft tissue defect over lateral malleolus covered by peroneal artery perforator flap. (a).Soft tissue defect with exposed bone. (b). Flap harvest. (c).Flap rotation to cover defect.(d). Postoperative view at 6 weeks.

Mean wound length was 7.3+2.18 cm. and mean width was 4.7+1.18 cm. Largest defect size was 12x6 cm^2 and smallest defect was 5 X 3 cm^2. Average flap length and width were 12.72 ± 4.19 cm and 5.63 ± 1.78 cm respectively. Largest flap was 21 X 8 cm^2 while smallest flap was 7 X 4 cm^2 in this study.

The arc of rotation of the propeller flap was 120^0-180^0 in 84.37% cases while in rest 15.63% cases the flaps were rotated 90^0-120^0. Mean distance of perforator closet to the wound was 2.83 ± 1.82 cm. The donor sites were partially covered by the flap and the rest is skin grafted (Table 1).

Table 1

Degree of rotation of flap

Degree of flap rotation	Number	Percentage (%)
90^0-120^0	5	15.63
120^0-180^0	27	84.37

Complete flap survival observed in 81.25% cases while in 3.12% cases there was total flap loss. Marginal flap necrosis (6.25%), partial flap loss (6.25%) and epidermolysis (3.12%) were other flap related complications. Venous congestion was found to be the most frequent cause of flap failure which was observed in first postoperative day (Table 2).

Table 2

Distribution of patients by survivability of flaps (n=32)

Flap survivability	Number	Percentage (%)
Completely survived	26	81.25
Epidermolysis	01	3.12
Marginal necrosis (< 10% flap loss)	02	6.25
Partial flap loss (10% -30% flap loss)	02	6.25
Complete flap loss (>30% flap loss)	01	3.12

Marginal flap necrosis and epidermolysis were managed by regular dressings change and secondary suturing. Partial flap loss and complete flap loss cases were managed by SSG coverage or coverage with another flap .

Discussion

Reconstruction of soft-tissue defects at the level of distal leg and ankle region remains a frequent and challenging problem for reconstructive surgeon[7,8]. Options for reconstruction of these defects includelocal flaps, distant flaps and free flaps.

Local flap includes random pattern flaps, fasciocutaneous flaps, reverse sural fasciocutaneous flap[9], and muscle flap. Distant flap includes cross leg flap, and free flaps. Failure rate in random pattern flaps are high while free flap is time consuming and costly with significant donor site morbidity. This demands microsurgery facility and expertise[10–12]. Fasciocutaneous flap from the ipsiateral leg is less preferred due to its morbidity as donor area always requires large area skin graft and bulky dog ear, which is unappealing. Distally based reverse flow sural artery island flap is a good alternative to reconstruct distal leg defects. The sural nerve is not important for vascularization of the distally based superficial sural artery flap and can be spared during flap elevation[13].Muscle flap has a limited role with disadvantage of sacrifice of function[14].

The concept of perforator flaps with improvement in understanding of flap perfusion is discussed in different studies of Taylor on angiosomes of the body. Perforator flaps are based on a reliablevascular pedicle and play an important role in reconstructing defects of different regions of the body.

Since the concept of perforator based propeller flaps was first applied by Hyakusoku and colleagues to release scar contracture, the flap has been widely applied to cover defects all over the body. Application of the propeller flap design permits greater flexibility and versatility in the coverage of difficult wounds[15].

It has recently become popular in the reconstruction of the lower extremities, because of advantages such as having a reliable blood supply while sparing the major blood vessel. In addition, its greater rotation arch makes it popular for distal lower-leg reconstruction [16]. Disadvantages of these propellers flap includes a limited role in large defects and variable location of the perforators.

In the current study, perforator propeller flaps have been used to cover defects in 32 cases around distal leg and ankle .Average flap length and width were 12.72 ± 4.19 cm and 5.63 ± 1.78 cm respectively in this study. Pierluigi et al.[17] used flap sizes ranging from 3 x 5 cm – 25 x 15 cm with a flap survival rate of 90%. Ariel et al.[18] in their case report and literature review reported flap dimensions varying from 15 cm^2 –135 cm^2.

In this study the source vessels in the leg are posterior tibial perforators in 62.5% cases and peroneal artery perforators in 37.5% cases. Similar results found in study done by Prasad, et al.[1](posterior tibial perforator in 60% cases, peroneal perforator in 40% cases). Posterior tibial perforators were mostly used due to its constancy in position and larger diameter of the perforators, than those of peroneal vessels.

The arc of rotation of the propeller flap was 120^0 -180^0 in 84.37% cases while in rest 15.63 % cases the flaps were rotated 90^0-120^0. In study done by Prasad et al.[1], the angle of rotation about the perforator varied from 90- 180 degrees. Nikhil et al[19]reported 180 degrees pedicle rotation in all the 25 cases in their series with a complete flap loss in 3 cases (25%) and partial flap loss in 7 cases (28%) .

Total 81.25% flaps survived completely without any compliations and only in 3.12% cases, the flap completely lost .The cause of flap necrosis was venous congestion in all cases. Pierluigi et al reported flap necrosis in 2 cases (9%) out of 22 cases. Durga Karki and Narayan[8]reported loss of 1 flap (5%) out of 20 patients due to venous congestion while Prasad, et al.[1]in their study showed a higher flap loss(30%).

The most common complication in our series is venous congestion of the flap in 6 cases (18.75%) that lead to flap necrosis in 3 cases(1 total and 2 partial). In the rest of the 3 cases the congestion settled with minimal complications (marginal necrosis and epidermolysis) by 3rd or 4th postoperative day. Measures taken to manage venous congestions were limb elevation, stitch removal in distal flap margin, drainage of blood by messaging the flap from periphery towards centerand intravenous administration of heparin as a continuous

infusion upto 5th postoperative day.The incidence of venous congestion in other series Ting Chen Lu[20]37.5%, Pignatti[5] 33.5% .

Superficial epidermolysis in 1 case (3.12%) managed by dressing and wound infection in 2 cases due to underlying osteomyelitis of the bone was managed by regular dressing and use of antibiotics according to culture and sensitivity.

Follow up in this study was up to 3 months as most of these patients are poor and coming to this study center (tertiary level hospital) from different district areas of our country.Outcome was assessed after final follow upbased on parameters set in methodology and it was found excellent in 83% cases, satisfactory in 11% cases and poor in 6% cases.

Conclusion

The perforator-based propeller flap is a good armamentarium of reconstructive surgeons for coverage of soft tissue defect around distal leg and ankle. Besides having a more reliable vascular pedicle than traditional flap, propeller flaps allow for greater freedom in design and arc of rotation that extend the possibility of reconstructing difficult wounds with local tissues . This flap avoids multiple surgical sites and the extra costs associated with free flaps and microsurgery.

Perforator based propeller flap is a one stage versatile technique with minimal donor site morbidity. It is ideal for reconstruction of small-to medium size defects of distal leg and ankle region with good cosmetic and functional outcome.

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