International Surgery Journal
Das AK et al. Int Surg J. 2026 Aug;13(8):1295-1301
https://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20262446

Original Research Article

Outcome of dorsal metatarsal artery perforator flap for coverage of soft tissue defect of dorsal distal foot and toes

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Received: 02 May 2026
Revised: 09 June 2026
Accepted: 02 July 2026

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ABSTRACT

Background: Resurfacing soft tissue defects in the distal foot remains challenging. Traditional options include amputation, cross-leg flaps, free tissue transfer, and skin grafts, each with limitations. The dorsal metatarsal artery perforator flap offers a safe, reliable alternative with minimal donor site morbidity, particularly suited for small to moderate defects. The aim of the study was to evaluate outcomes of the dorsal metatarsal artery perforator flap for reconstruction of distal dorsal foot and toe defects.
Methods: This prospective observational study was conducted in the Department of Plastic Surgery, Dhaka Medical College Hospital, involving 30 patients selected by purposive sampling. All patients were followed for 30 days postoperatively.
Results: Mean defect dimensions were 3.52±0.95 cm (length) and 2.52±0.56 cm (width), with a mean area of 9.07±3.83 cm². Mean flap dimensions were 5.6±1.33 cm (length) and 3.15±0.56 cm (width), mean area 17.89±6.07 cm². The first dorsal metatarsal artery perforator was used in 73.3% of patients, the second and third in 13.3% each. Marginal flap necrosis occurred in 46.7%, significant flap loss in 13.3%, and no necrosis in 20%. Venous congestion was seen in 53.3% and wound infection in 23.3%. No donor site morbidity was observed in 83.3%. Outcomes were satisfactory in 63.3%, good in 16.7%, and poor in 20% of cases.
Conclusions: The dorsal metatarsal artery perforator flap provides satisfactory, durable coverage for soft tissue defects of the distal dorsal foot and toes with low donor site morbidity.

Keywords: Dorsal metatarsal artery, Perforator flap, Soft tissue defect, Dorsal distal foot, Toes, Coverage, Outcome

INTRODUCTION

The distal foot, as a weight-bearing region, poses a significant challenge for soft-tissue reconstruction, particularly around the toes, in plastic surgery.[1] Defects in this area can result from several causes, including trauma, tumor excision, diabetes mellitus, burns, or frostbite.[2] Even small defects in this region are often complicated by exposed tendons or bones, making skin grafts an unsuitable option for coverage.[3] The preferred flap should offer a reliable blood supply, ensure both functional and aesthetic satisfaction, and reduce complications at donor site. Additionally, soft tissue reconstruction of the distal foot must provide a slim and flexible contour to allow for comfortable shoe wearing.[4] Traumatic soft-tissue defects on the dorsal great toe, especially when involving exposed tendon, joint, or bone, present a challenging reconstructive problem.[5] Several techniques have been outlined,

including toe amputation with fillet flap, cross-leg flap, reverse anterior tibial artery flap, and free tissue transfer. However, each of these methods comes with significant limitations. The fillet flap prevents toe salvage, while the cross-leg flap requires two stages, causing patient discomfort and joint stiffness. The reverse anterior tibial artery flap often results in overabundant tissue mass for tiny wounds of the great toe. Free tissue transfers, though effective, are time-consuming and associated with higher failure and re-operation rates, particularly in patients with comorbidities like diabetes or advanced age.[6] Perforator-based propeller flaps have become increasingly favored in plastic surgery over the past few years, primarily because of their significant advantages in minimizing donor site complications in comparison to traditional flaps.[7] These flaps are island-shaped, with an axis that encompasses the perforators, allowing them to rotate around this axis. Their key benefits include safety, reliability, negligible donor site complications, and the ability to rotate up to 180°. This capability to transfer skin from one vertical axis to another has made perforator-based propeller flaps particularly valuable in limb reconstruction, especially for the lower limbs.[8] The islanded, distally-based dorsal foot flap, based on the first metatarsal artery perforator (MAP), was first described by Earley and Milner in 1989 and later popularised by Quaba and colleagues in 1997 for the reconstruction of defects following the release of hyperextension contractures of the toes.[9] MAP-based propeller flaps have four main advantages: they do not necessitate the sacrifice of a large artery or operational muscle, formation of a lean and flexible flap with a good contour that avoids volume reduction procedures or special shoes, they do not require microsurgical anastomosis, and reducing operative time, hospitalization and recovery.[8] Recent systematic reviews and meta-analyses have further validated the safety and efficacy of perforator-based propeller flaps for distal lower-extremity reconstruction, demonstrating comparable complication rates to free flaps.[10,11] The major drawbacks of this flap includes donor site wound healing issues.[12] The elevation of these flaps is a laborious method which needs a precise and meticulous microsurgical technique like that required for the dissection of any perforator flap, without any assurance of adequate skin perfusion after flap elevation. Inadequate release of fascial bands around the communicating perforator after rotation may impede venous flow, which may lead to flap congestion.[13] Venous congestion remains a frequently encountered complication, particularly with reverse-flow variants, and several strategies have been reported to prevent and manage this challenge.[14] In this study, the outcomes of the dorsal metatarsal artery perforator flap will be assessed, considering both its advantages and disadvantages, even though there are occasional reports appeared in literatures.

Objectives

General objective was to evaluate the outcome of dorsal metatarsal artery perforator flap following reconstruction of dorsal distal foot and toe defect.

Specific objectives were to assess the dimension of the wound, to measure the dimension of the flap, to see the viability of the flap (marginal, partial, significant or complete flap necrosis), to find out flap related complications (venous congestion, infection, wound dehiscence), and to assess the donor site morbidity (wound infection, graft loss).

METHODS

This prospective observational study was conducted in the Department of Burn and Plastic Surgery, Dhaka Medical College Hospital, Dhaka, from 01 January 2023 to 31 August 2024. Patients with soft tissue defects over the dorsum of the distal foot and toes requiring flap coverage were enrolled using purposive sampling based on predefined criteria. A total of 30 patients were included. Eligible patients underwent thorough preoperative assessment, including history, examination, lab investigations, and optimization of general and nutritional status. Handheld Doppler ultrasonography identified and marked dorsal metatarsal artery (DMtA) perforators. Patients provided written consent after counseling, and preoperative photos were taken. Surgeries were performed under regional or general anesthesia. Flaps were harvested and inset according to described techniques. Donor sites were covered with split-thickness skin grafts. Postoperative care involved limb immobilization, elevation, and monitoring flap viability and complications on days 1, 5, 14, and 30. Follow-ups assessed wound size, flap viability, complications (infection, congestion, dehiscence), and donor site morbidity. Digital photos were taken at each visit. Data were compiled, checked, and analyzed using statistical package for the social sciences (SPSS) version 26, with assistance from experts when needed. The study protocol was approved by the Research Review Committee and Ethical Review Committee of Dhaka Medical College and registered with BSMMU. Participants were informed thoroughly about the study and gave written consent. Privacy and safety protocols were followed, and all study-related complications were treated free of cost.

Inclusion criteria

Patients with small to moderate-sized wounds (≤2 cm in length and breadth for small; >2 cm to 8 cm in length and >2 cm to 4 cm in breadth for moderate) located on the dorsum of the distal foot, toes, or web spaces, with exposed vital structures (tendons, bone, or neurovascular bundles) necessitating flap coverage; wounds resulting from trauma, electric burn, post-burn contracture release, or tumor excision that required flap coverage; and presence of a perforator vessel confirmed by preoperative handheld Doppler evaluation were included.

Exclusion criteria

Patients with previous trauma or surgery at the potential donor site that could compromise the pedicle; significant

comorbid medical conditions, including uncontrolled diabetes mellitus or peripheral vascular disease; major psychiatric disorders that would interfere with informed consent or postoperative care; and polytrauma or other life-threatening injuries requiring priority management were excluded.

Surgical procedure

Preoperative marking

Using a handheld Doppler probe, perforators located proximal to the defect in the dorsal metatarsal area were identified and marked on the skin.

Anesthesia and positioning

Spinal or general anesthesia was administered. The patient was placed in the supine position. A thigh tourniquet was applied without exsanguination of the limb.

Wound preparation

The wound was debrided, and the size and shape of the defect were recorded.

Flap design

A fasciocutaneous flap was designed adjacent to the defect, centered over the previously identified perforator. The flap dimensions (length and width in cm) were measured from the pivot point (2 cm proximal to the web edge) to the flap tip.

Dissection

Under 3.5× loupe magnification, a skin incision was made from the proximal side of the flap to expose the dorsalis pedis artery. Dissection proceeded distally to expose the deep plantar branch and the dorsal metatarsal artery (DMA). Care was taken to preserve the communicating branch between the DMA and the plantar artery, as well as any perforators coursing to the overlying skin. The loose, vascularized areolar tissue over the extensor tendons was preserved to serve as a recipient bed for skin grafting.

Flap rotation and inset

Fibrous constraints of the distal communicating branch perforator were released to permit clockwise or counterclockwise flap rotation into the defect. Flap elevation was limited to achieving sufficient rotation. After tourniquet release, hemostasis was secured, and flap viability checked.

The flap was transposed to the defect. Donor sites <2 cm were closed primarily; those ≥2 cm received split-thickness skin grafts. Light dressings prevented pressure, and the leg was immobilized with a short leg splint.

Postoperative care

The limb was elevated. Flap monitoring continued until postoperative day 5. Limited ambulation was allowed from day 5. Donor site staples were removed on day 7, and sutures were removed on day 14. Full activity was permitted after 4 weeks.

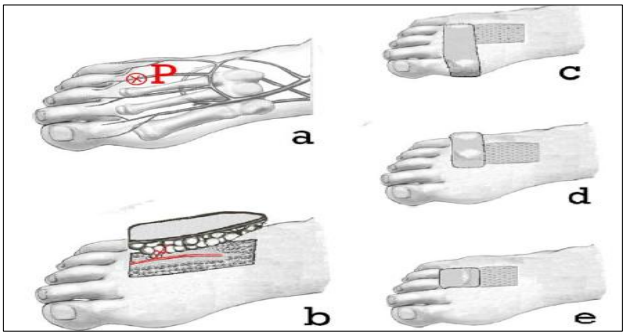

Figure 1: The schema presenting the design of the third MAP based propeller flap, (a) the pivot point, (b) territories supplied by third metatarsal artery, and (c–e) the arc of rotation of third MAP based propeller flaps.

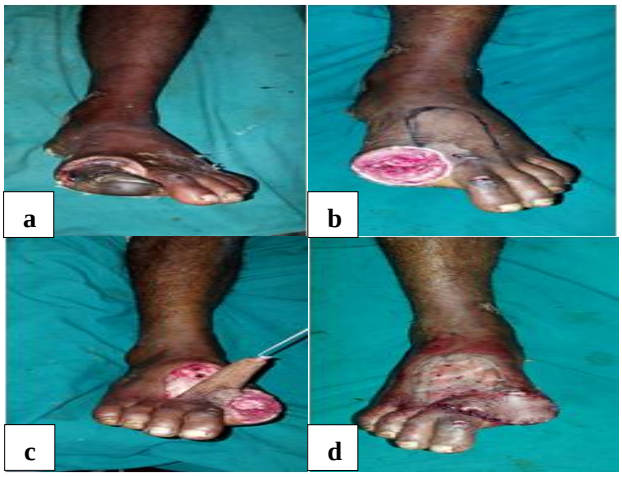

Figure 2: Sequential operative stages of fillet toe flap reconstruction showing (a) preoperative picture, (b) flap design, (c) flap elevation, and (d) flap inset.

RESULTS

This prospective study at Dhaka Medical College Hospital's Plastic Surgery department included 30 patients who underwent dorsal metatarsal artery perforator flaps for dorsal distal foot and toe defects. The goal was to evaluate early clinical outcomes. Data were gathered using a structured questionnaire.

Table 1 presents the age distribution of the study patients. Over a third (36.7%) were aged 31-40 years, 8 patients (26.7%) were 41-50 years old, 6 (19.9%) fell within 51-60 years, and 5 patients (16.6%) were 21-30 years old. The average age was 41.13±10.60 years, ranging from 21 to 60

years. The table also details the gender distribution, showing that most patients (83.3%) were male, while 5 (16.7%) were female.

Table 1: Distributions of the study patients by age and gender (n=30).

Age in years	Number	Percentage
21-30	5	16.6
31-40	11	36.7
41-50	8	26.7
51-60	6	20
Mean±SD	41.13±10.60	
Ranged (min-max)	21-60	
Gender		
Male	25	83.3
Female	5	16.7

Table 2 shows the mean length of defect was 3.52±0.95 cm with the ranged from 2 to 6 cm. The mean width of defect was 2.52±0.56 cm with the ranged from 1 to 3.5 cm. The mean dimension of defect was 9.07±3.83 cm^2 with the ranged from 2 to 21 cm^2. Then the mean length of the flap was 5.6±1.33 cm, with a range of 4 to 8 cm. The mean width of the flap was 3.15±0.56 cm, with a range of 2 to 4 cm. The mean dimension of the flap was 17.89±6.07 cm^2 with the ranged from 10 to 32 cm^2.

Table 2: Distributions of the study patients by defect (n=30).

Parameter		Mean±SD	Ranged (min-max)
Defect	Length (cm)	3.52±0.95	2-6
	Width (cm)	2.52±0.56	1-3.5
	Dimension (cm^2)	9.07±3.83	2-21
Flap	Length (cm)	5.6±1.33	4-8
	Width (cm)	3.15±0.56	2-4
	Dimension (cm^2)	17.89±6.07	10-32

Table 3 shows the distribution of study patients by DMtA perforator used. It was observed that almost three-fourths (73.3%) of patients had used the 1st DMtA perforator, 4 (13.3%) the 2nd, and 4 (13.3%) the 3rd. Regarding flap morbidity, it was observed that almost half (46.7%) of patients had marginal flap loss, 4 (13.3%) had significant flap loss, 2 (6.67%) had complete flap loss, and another 4 (13.3%) had partial flap loss. 6 (20%) patients had no flap necrosis.

Table 4 shows the distributions of the study patients by flap-related complication. It was observed that more than half (53.3%) of patients had flap-related complications: venous congestion, 7 (23.3%) had wound infection, and 2 (6.7%) had wound dehiscence. No flap-related complications were seen in 5 cases (16.7%). Regarding the donor site morbidity. It was observed that three (10%) patients had wound infection at the donor site and 2 (6.7%) patients had partial graft loss. No donor-site morbidity was observed in 25 cases (83.3%).

Table 3: Distributions of the study patients by DMtA perforator used and flap morbidity (n=30).

Parameter		Number	Percentage
DMtA perforator used	1st	22	73.3
	2nd	4	13.3
	3rd	4	13.3
Flap morbidity (% of flap loss)	Complete flap necrosis	2	6.67
	Marginal flap necrosis	14	46.7
	Partial flap necrosis	4	13.3
	Significant flap necrosis	4	13.3

Table 4: Distributions of the study patients by flap-related complication and donor site morbidity (n=30).

Parameters		Number	Percentage
Flap related complication	Venous congestion	16	53.3
	Wound infection	7	23.3
	Wound dehiscence	2	6.7
Donor site morbidity	Wound infection	3	10
	Partial graft loss	2	6.7

Table 5 shows the distributions of study patients by flap outcome. It was observed that almost two-thirds (63.3%) of patients' outcomes of flap were satisfactory, 6(20.0%) had poor outcomes, and 5 (16.7%) cases had good outcomes.

Table 5: Distributions of the study patients by outcome of flap (n=30).

Outcome of flap	Number	Percentage
Satisfactory	19	63.3
Poor	6	20
Good	5	16.7

DISCUSSION

The dorsal metatarsal artery perforator flap is an effective reconstructive technique for dorsal foot and toe soft-tissue defects. Studies highlight its versatility, reliability, and high survival rate, with manageable complications.[15-17] It is a valuable option for digital and toe reconstructions, offering good functional outcomes, adaptability to various defect sizes, and minimal donor site issues. Careful patient selection and surgical technique are key to its success,

making it a reliable tool in modern plastic surgery. This study evaluated the dorsal metatarsal artery perforator flap for covering soft tissue defects in the dorsal distal foot and toes. It examined wound coverage, flap viability, complications like infection, dehiscence, venous congestion, and donor site morbidity. Conducted on 30 patients at Dhaka Medical College Hospital from January 2023 to August 2024, with a 30-day follow-up.

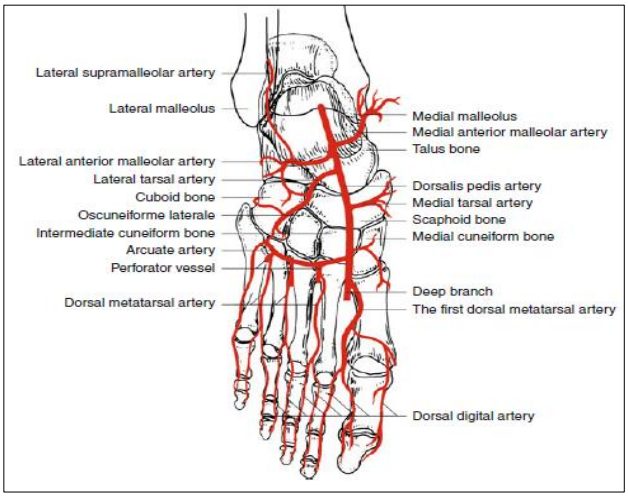

Figure 3: Vascular anatomy of the dorsum of foot.[16]

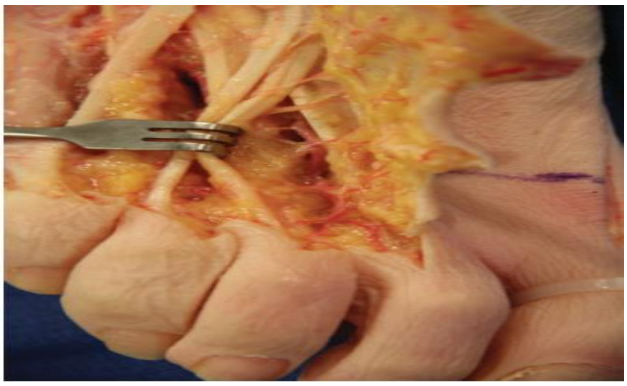

Figure 4: Latex injection and dissection showing cluster of cutaneous perforators arising from the distal half of this second dorsal metatarsal artery.[17]

Most patients undergoing dorsal metatarsal artery perforator flap procedures for foot soft tissue defects are aged 31-40 years (36.7%), followed by 41-50 years (19.9%), 51-60 years (16.6%), and 21-30 years (16.6%). The average age was 41.13 years. Wang et al reported a similar average age of 39.2 years, indicating a demographic prone to dorsal foot defects.[18] Shen et al highlighted this age group's importance in soft tissue reconstruction, with a range of 18- 62 years and a mean of 36.8 years, noting the flap's suitability for active, younger individuals at higher injury risk.[19] Li et al found a predominance of middle-aged patients, with older patients experiencing more variability and complications.[20]

This study found a clear male predominance in gender distribution, with 83.3% male and 16.7% female patients, aligning with other research on foot and toe soft tissue defects. Attinger et al also noted men are more exposed to occupational hazards.[21] Conversely, Koshima et al found a more balanced gender distribution, indicating regional or occupational differences.[22] Overall, findings highlight occupational risks, especially in male-dominated fields, as significant contributors to soft tissue defects.

This study found mean defect sizes of 3.52±0.95 cm in length, 2.52±0.56 cm in width, and an average area of 9.07±3.83 cm², highlighting the versatility of dorsal metatarsal artery perforator flaps. Teo et al, who showed that perforator flaps can handle a broad range of defects.[23] Together, these studies confirm perforator flaps effectively cover challenging distal foot defects.

The study reported mean flap length of 5.6±1.33 cm, width of 3.15±0.56 cm, and an area of 17.89±6.07 cm², illustrating the dorsal metatarsal artery perforator flap's versatility in managing various distal foot defects. Supporting studies, like Zhang et al. showed similar wide applicability, especially in younger patients, validating this technique's effectiveness.[24] Khan et al showed the size of the flap to roughly 2×4 cm depending on the location of the DMtAP.[25] Yeo et al reported successful coverage of smaller, localized toe defects using flaps ranging from 4×2 cm to 8×4 cm, further confirming the flap's adaptability for small to moderate soft tissue reconstructions.[26]

This study suggests that the dorsal metatarsal artery perforator flap effectively manages dorsal distal foot soft tissue defects. The first dorsal metatarsal artery perforator was used in 73.3% of cases, with the second and third in 13.3% each. Yeo et al found the first dorsal artery is the most consistent and largest, making it the preferred pedicle.[26] In 16 cadaveric feet, the first artery was in all specimens, while the second to fourth showed increasing absence. Knowing these vessels' anatomy is crucial for ensuring proper blood flow to the transferred tissue.

Scaglioni et al identified donor site morbidity as a potential disadvantage of perforator flaps, noting complications such as poor skin graft take and donor site pain.[15] However, in this study, donor site morbidity was low, with only 10% experiencing wound infection, and 83.3% reporting no complications, highlighting the minimal impact. D'Arpa et al emphasized preserving the paratenon of exposed tendons on the dorsum of the foot to reduce morbidity when elevating the flap.[27] In our cases, no donor site complications like ulceration, edema, or neuroma occurred.

Complications related to flap viability were notable, with 46.7% of patients experiencing marginal flap loss and 6.67% complete flap loss. These rates align with other studies reporting flap loss due to venous congestion, which affected 53.3% of patients and was the most common complication.[10] Despite challenges, the dorsal metatarsal

artery perforator flap remains a reliable option for defect coverage, with low donor-site morbidity and versatility for different defect sizes.[12]

The study shows that 63.3% of patients had satisfactory outcomes with the dorsal metatarsal artery perforator flap, while 16.7% had good outcomes and 16.7% had poor outcomes. This indicates the flap's success in covering distal foot soft tissue defects.[28] However, issues like venous congestion and flap loss affect success. Close postoperative monitoring can reduce complications. Advances like supercharging flaps are also improving good-outcome rates.[29]

Limitations

This study has limitations, including a 30-day follow-up, which prevented assessment of long-term flap durability and functional outcomes such as gait and shoe-wear tolerance. No objective measures were used, and the small sample size (n=30) was from a single center without a control group. Purposive sampling may have introduced bias, and outcome assessment was subjective, lacking patient-reported measures. Perforator mapping relied solely on handheld Doppler without advanced imaging like CT angiography.

CONCLUSION

This study concludes that the dorsal metatarsal artery perforator flap is a satisfactory option for covering soft tissue defects of the dorsal distal foot and toes. This flap can successfully cover small to medium sized soft tissue defects of the dorsal distal foot and toes. Donor sites of flap had minimum morbidity. Although some flap-related complications occurred, including venous congestion and marginal flap loss, overall the flap was durable, thus making it a viable option for dorsal distal foot and toe reconstruction.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Das AK, M. Alam T, Nahar URMM, Haider T, Sultana M, Rony NS. Outcome of dorsal metatarsal artery perforator flap for coverage of soft tissue defect of dorsal distal foot and toes. Int Surg J 2026;13:1295-301.