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PROPELLER FLAP AS A WORKHORSE FOR DISTAL LEG RECONSTRUCTION IN A LIMITED RESOURCE SETTING: A CASE SERIES

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Summary

Objective. To report the experience of using propeller perforator flaps for reconstructing distal third leg and ankle defects at the National Orthopaedic Hospital, Enugu, between January and July 2025.

Case series. Six propeller perforator flaps were performed in five patients (aged 13-49 years). Flaps were based on the posterior tibial artery (n = 5) and the anterior tibial artery (n = 1). The perforator was identified using a handheld Doppler, skeletonized, and the flaps were rotated. All secondary donor defects were covered with split-thickness skin grafts. Indications included soft tissue loss from open tibiofibular fractures (n = 5) and post-traumatic ankle contracture (n = 1). Propeller flaps were chosen over reverse sural flaps due to traumatic or iatrogenic injury to the sural pedicle (n = 4) and as a primary option without any sural pedicle damage (n = 2).

Four flaps survived completely. One developed venous congestion and was managed with negative pressure wound therapy, debridement, and skin grafting. The flap survival rate was 66.67% (n = 4/6) and the salvage rate was 50% (n = 1/2). One anterior tibial artery flap was lost and replaced with a posterior tibial artery propeller flap, which healed successfully.

Conclusion. Propeller perforator flaps demonstrated favourable outcomes in distal third leg and ankle reconstructions, even serving as an effective salvage option after flap failure. They offer reliable coverage and should be considered as a primary option in the reconstructive armamentarium for lower limb defects in resource-limited settings.

Keywords: distal third leg defect, ankle defect, lower limb reconstruction, perforator flap, propeller flap

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INTRODUCTION

Reconstruction of soft tissue defects in the distal third of the leg and ankle presents a challenge owing to the scarcity of tissue and the precarious vascularization of these body regions, which restricts the options among

local flaps [1,2]. Free flaps are therefore the gold standard for reconstructing these defects. However, the time required to perform the procedure, the available theatre space, the need for re-exploration and the procedure costs associated with the surgeon's skills limit the use of free flaps in settings with limited resources. Propeller perforator flaps, which are island flaps rotated around a perforating vessel, can offer a viable alternative for reconstructing these tissue defects [3-6].

In various centres, even those with high volumes of microsurgery interventions, the use of propeller perforator flaps by plastic surgeons remains largely limited to small and medium-sized defects [7]. However, propeller perforator flaps have characteristics that make them suitable for addressing soft-tissue defects in the distal third of the leg and ankle: they offer a reliable vascular pedicle, are quick and easy to harvest, and allow short operation time. Furthermore, complications associated with propeller perforator flaps can be minimized through optimal patient selection, meticulous preoperative planning, and careful dissection techniques.[4,5].

There are a paucity of published experiences on propeller perforator flaps from plastic surgery departments in sub-Saharan African centres [8,9]. The aim of this study is to report the use and the outcomes of propeller perforator flaps for reconstructing distal leg and ankle defects at the Plastic Surgery Department of the National Orthopaedic Hospital in Enugu, Nigeria, between January and July 2025.

METHODS

This was a retrospective review of the use of propeller perforator flaps for the reconstruction of distal third leg and ankle defects at the National Orthopaedic Hospital, Enugu (Nigeria), between January and July 2025.

National Orthopaedic Hospital in Enugu is a regional specialised centre that serves the South-Eastern Region and parts of the North-Central and South-South regions of Nigeria. It is a 350-bed capacity hospital offering training and services in Plastic and Reconstructive Surgery, Orthopaedic and Traumatology, Neurosurgery, and rehabilitation.

The staff of the Plastic Surgery department consists of seven consultant plastic surgeons and usually 12-20 senior residents in training.

Patients' social and demographic characteristics, intraoperative findings, flap details, operative time, and postoperative complications were evaluated. The primary outcome was the flap survival rate, and the secondary outcomes were the degree of rotation of the flap, the time from presentation to surgery, the complications, the operative time, and the salvage rate. Cases were presented in narrative form, accompanied by figures and tables.

This case series was prepared in accordance with the PROCESS 2020 guidelines [10].

SURGICAL TECHNIQUE

Pre-operative perforator mapping was done on the wards using a handheld Doppler. All surgeries were performed under spinal anaesthesia and by the lead surgeon, a consultant plastic surgeon, in all cases. For the posterior tibial artery perforator, patients were positioned in the frog leg position; for the anterior tibial perforator, patients were in the supine position.

The perforator closest to the defect was located with the handheld Doppler on the operating table and marked on the leg. The perforator was used as the pivot point to design the flap. The distance between the defect and the most distal perforator was noted and transposed to the proximal leg, adding 1cm. The width of the primary defect was marked and used to measure the flap width, adding 0.5 cm [11-13]. A tourniquet was applied to the thigh. The flap was raised following the markings. An exploratory incision was first made at a side of the flap. The flap was raised in the sub-fascial plane, and the identified perforators were skeletonised. The most promising perforator (in terms of calibre and proximity to the defect) was identified and preserved while ligating other perforators. The dissection was then done from proximal to distal towards the selected perforator. All the flaps were pivoted on a single perforator. The flap was then rotated either clockwise or anticlockwise (depending on the direction of less tension to the pedicle) with angles between 130º and 180º, to close the primary defect. The tourniquet was released to allow haemostasis and to evaluate the flap viability before flap inset. A handheld Doppler was used to ascertain adequate flow into the flap. The secondary defect was immediately covered with a split-thickness skin graft.

CASE SERIES

Six propeller perforator flaps were performed in five patients aged 13-49 years (the mean age was 36.33, 12.63SD). The male-to-female ratio was 2:1. Indications for reconstruction included soft tissue loss from open tibiofibular fractures (five cases) and post-traumatic ankle contracture (one case).

Propeller flaps were selected over reverse sural flaps due to traumatic or iatrogenic injury to the sural pedicle (n = 4) and as a primary option without any sural pedicle damage (n = 2). Flaps were based on the posterior tibial artery

Table I. Socio-demographic characteristics, surgical indications, location and size of defect, time to surgery of the patients.

	Sex	Age	Comorbid conditions	Surgical indications	Location of the defect	Size of defect (cm x cm)	Time to surgery* (Days)
Case n. 1 (24 February 2025)	F	13	None	Ankle contracture	Anterior distal leg, anterior ankle and dorsum of the foot	12 x 6.5	N/A**
Case n. 2a (7 April 2025)	M	35	None	Distal leg gunshot wound	Anterior distal third of the leg	12 x 10	56
Case n. 2b (10 July 2025)	M	35	None	Loss of propeller perforator flap (case 2b)	Anterior distal third of the leg	8 x 5.5	150
Case n. 3 (16 June 2025)	M	43	None	Post traumatic distal leg defect	Medial malleolar region	8 x 5.5	48
Case n. 4 (23 June 2025)	M	49	None	Post traumatic distal leg defect	Medial malleolar region	8 x 5.5	19
Case n. 5 (24 July 2025)	F	43	Hypertension	Post traumatic distal leg defect	Medial malleolar region	8 x 5	22

Time to surgery*: time from presentation to the Emergency Department to the day of surgery

N/A**: Not applicable (elective case who presented through Clinics)

(n = 5) and the anterior tibial artery (n = 1). Table I summarizes the social and demographic characteristics, the surgical indications, the location and size of defect, and the time to surgery.

In the first case (Case n. 1), the propeller perforator flap was raised after a one-week delay of a distally based fascio-cutaneous flap (the reverse sural pedicle was injured). While elevating the flap for inset, a large posterior



Figure 1. Case n. 1: Case of venous congestion salvaged with Negative Pressure Wound Therapy (NPWT) and split thickness skin graft. (**A.** Complete flap congestion, **B.** Flap appearance after NPWT, **C.** Postoperative Day 5 picture after skin graft).

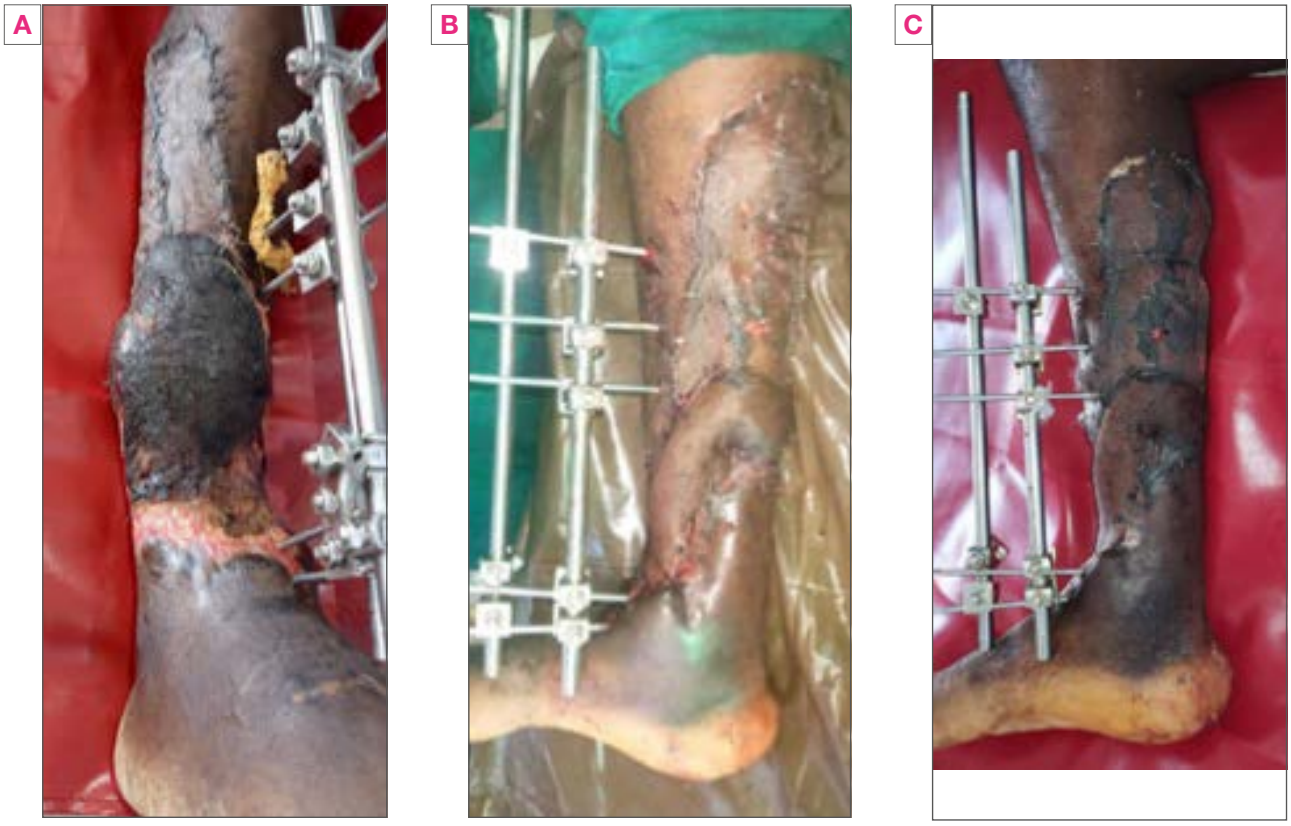


Figure 2. Salvage posterior tibial artery propeller perforator flap after first anterior tibial artery propeller perforator flap (Case n. 2a and Case n. 2b). (**A.** Case n. 2a. Complete flap loss, **B.** Case n. 2b. Intraoperative picture, **C.** Postoperative Day 5 picture with viable flap).

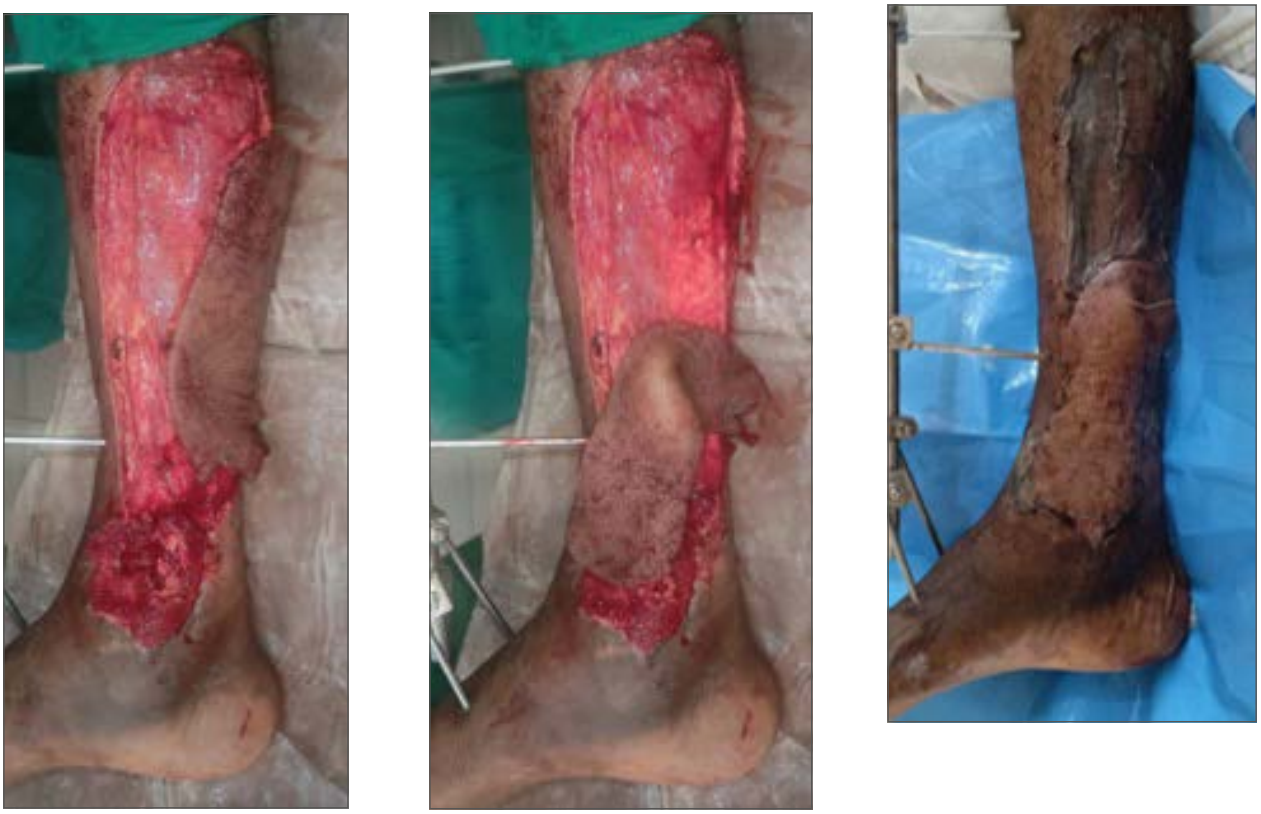


Figure 3. Case n. 3: Successful case of posterior tibial artery propeller perforator flap. (**A.** Flap dissection, (**B.** Flap rotation, (**C.** Flap and skin graft inspection at postoperative Day 5).



Figure 4. Case n. 5: Successful case of posterior tibial artery propeller perforator flap. (**A.** Defect, **B.** Flap rotation and fixation). **C.** Split thickness skin graft of secondary defect, **D.** Postoperative picture at Day 5.

Table II. Intra-operative characteristics, outcome and salvage procedures of propeller perforator flap at National Orthopaedic Hospital, Enugu.

	Status reverse sural pedicle	Perforator used	Flap dimensions (cm x cm)	Flap pre-conditioning	Degree of rotation	Operative time (min)	Outcome	Salvage procedure
Case n. 1 (24 February 2025)	Damaged	Posterior tibial artery	18 x 7	Yes (Delayed fascio-cutaneous flap)	130°	145	Venous congestion	NPWT* + STSG**
Case n. 2a (7 April 2025)	Damaged	Anterior tibial artery	13 x 10.5	No	175°	140	Complete flap loss	Propeller perforator flap
Case n. 2b (10 July 2025)	Damaged	Posterior tibial artery	12 x 6	No	145°	104	Total viability	N/A***
Case n. 3 (16 June 2025)	Damaged	Posterior tibial artery	14 x 6	No	170°	135	Total viability	N/A***
Case n. 4 (23 June 2025)	Intact	Posterior tibial artery	12 x 6	No	176°	168	Total viability	N/A***
Case n. 5 (24 July 2025)	Intact	Posterior tibial artery	13 x 6	No	160°	95	Total viability	N/A***

*NPWT: Negative pressure wound therapy, **STSG: split thickness skin graft, ***N/A: Not applicable.

tibial perforator was identified, and a propeller perforator flap was raised based on it. The flap developed venous congestion and was managed with Negative Pressure Wound Therapy (NPWT), debridement, and skin grafting (Fig. 1).

In Case n. 2, an anterior tibial artery propeller perforator flap cover was done with complete flap necrosis (Case n. 2a). Debridement and wound dressings were executed. Three months later, the defect was finally covered with a posterior tibial artery propeller flap (Case n. 2b), which healed successfully (Fig. 2).

The three other propeller perforator flaps (Case n. 3, Case n. 4, and Case n. 5) survived completely with no complications (Figs. 3-4). The flap survival rate was 66.67% (n = 4/6) and the complications rate 33.33% (n = 2/6). Of the two flaps with complications (compromised viability), one was salvaged with NPWT and skin graft while the other was completely lost. The salvage rate was 50% (n = 1/2).

The median time from admission in Accident and Emergency department to surgery was 48 days (IQR 22-56). The mean degree of rotation of the flaps was 159.33° [(SD = 18.46), range from 130° to 176°]. The mean operative time was 131.17 min [(SD = 27.14) range from 95 min to 168 min]. Intraoperative characteristics, outcomes, and salvage procedures were summarized in Table II. The mean follow-up time was 6.67 months (1.97 SD).

DISCUSSION

This case series highlights the progressive use of propeller perforator flaps for resurfacing distal leg and ankle defects at the National Orthopaedic Hospital, Enugu (Nigeria), between January and July 2025. Despite advances in microsurgery and the diffusion of free flaps, reconstructing distal leg and ankle defects remains a remarkable challenge.

In an attempt to answer the question of reconstructing complex defects of the lower extremity, in particular the lower third of the leg and ankle, AlMugaren FM et al. (2020) advised free flaps for large defects, propeller and reverse or distally based sural flaps for small to medium-size defects [11].

The ideal reconstruction option is still considered the procedure with the simplest technicality, the lowest donor-site morbidity, the best colour match with the recipient site, and the best aesthetic and functional outcomes. Unlike free flaps, propeller perforator flaps fulfil these criteria [5,13]. In fact, propeller perforator flaps have the advantages of reducing costs and operative time (not requiring a microsurgical anastomosis). Moreover, the propeller perforator flaps comply with the “replace like with like” principle [12]. In our cases, the surgeries were performed in less than three hours, with a satisfactory colour match.

Perforator flaps are versatile, allowing the surgeon considerable flexibility in selection and design. In the lower limbs, there are 93 perforators distributed across 21 distinct vascular territories [14].

The leg perforators are located on the medial, lateral, and posterior surfaces; on the medial side, three large branches from the posterior tibial artery pierce the deep fascia at the medial border of the tibia.

On the lateral side, there are four to five small branches from the anterior tibial artery at the anterior border of the compartment, and five small branches from the peroneal artery at the posterior border. The posterior surface of the leg has a large and constant branch from the popliteal artery located at the midline, 4 cm below the popliteal crease, which runs longitudinally along the lower quarter of the leg [15].

The design of the propeller perforator flaps enables axial rotation. When the pedicle is skeletonized, these flaps allow a rotation greater than 90°, up to 180°, if possible[16-18]. In our series, the degree of rotation ranged from 130° to 176° without kinking the pedicle.

The leg has a conus-shaped appearance with scarce tissue in the distal third. The design of the propeller perforator flap helps harvest available tissue from the mid and proximal third of the leg for reconstructing distal leg and ankle defects, where there is paucity of local tissue [13]. This is one advantage of propeller perforator flaps over keystone perforator flaps [6,16]. Furthermore, the propeller perforator flaps provide coverage options without creating morbidity in another region of the body, which aids nursing care, unlike free flaps or cross-leg flaps.

Propeller perforator flaps are not without complications. Complication rates reported in the literature varied from 14% to 28.6% [5,12,17]. In our series, we had one case of venous congestion and one case with a complete flap loss.

In patients with one or more comorbidities, Chaput B et al. (2017) delayed the propeller perforator flaps as the goal was not to increase arterial perforasome but to describe the venous perforasome, which allowed them to excise the necrotic part of the flap before flap rotation and inset [19]. The second surgery was done in 48 or 72 hours after the first to avoid difficulties of flap inset due to massive oedema and local inflammation. However, they had venous congestions in 6/20 cases, which did not progress to necrosis or flap loss [19]. In our cases, a standard delay was performed for a distally based fascio-cutaneous flap before identifying a large posterior tibial perforator intraoperatively (Case n. 1). The indication for the delay was due to the large size of the defect after excision of an anterior ankle contracture,

and the damage to the reverse sural pedicle during the trauma. In Case n. 1, there was a venous congestion, which was successfully managed with NPWT and split-thickness skin graft. Another complication in Case n. 2 was the complete flap loss with the anterior tibial artery perforator. In the same situation of complete loss of propeller flap, Gupta S et al. resorted to cross leg and reverse sural flap in the secondary procedure. However, we were able to use another perforator flap in our case (Case n. 5), similar to that performed by Chowdhury R et al. [5,17].

In our opinion, given the complications, especially the complete flap loss of propeller perforator flaps, the reverse sural island flap is still adopted as the workhorse of reconstruction of the distal third and ankle defects in our sub-region. In fact, in most sub-Saharan African centres including our hospital, the reverse sural island flap has been considered the first option for covering the defects of the distal leg and ankle for decades [20-22]. In addition, there is a learning curve for achieving good results with propeller perforator flaps, which further limit their use [5]. However, there is sometimes a traumatic or an iatrogenic damage to reverse the sural artery pedicle. Therefore, the plastic surgeon has to resort to further skills to resurface the defects with reasonably good results, such as propeller perforator flaps (like the first flaps of our series). Consequently, the propeller perforator flaps should be considered the first option, and the reverse sural flap the lifeboat, to improve the skills and experience of plastic surgeons, particularly in our sub-region.

Finally, based on the literature and our experience, the loss of the propeller perforator flaps can be reduced by following some recommendations. These recommendations include, but are not limited to, the need for an exploratory incision to confirm the location of the perforator, the complete dissection of the main perforator from all its attachments and branches, and the dissection of the perforator long enough below the fascia. The use of handheld Doppler preoperatively and intraoperatively is a good advantage, especially after releasing the tourniquet to assess the blood flow into the flap [11].

CONCLUSION

Propeller perforator flaps provided favourable outcomes for reconstructing the distal third leg and ankle at our hospital, even resulting in an optimal salvage option after flap failure.

Initially used for the damage of the reverse sural pedicle, the successful outcomes of the propeller perforator flaps made them the first option in the reconstruction of the distal leg and ankle, even with an intact reverse sural pedicle in our setting. They offer reliable coverage and should be considered a primary option in the reconstructive armamentarium for lower limb defects, particularly in resource-limited settings.

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Conflict of interest statement

The authors declare no conflict of interest.

Authors contribution

KKTE, OIS, OCP, UEO: conceptualization, design, and methodology. KKTE, OIS, OCP, UEO, OJN, ASO: data collection. KKTE, UEO, EO data analysis and interpretation of the results. KKTE, OJN, ASO, EO: writing. All the authors critically revised the manuscript and approved the final version to be submitted.

Ethical consideration

This study was approved by the Ethical Committee of the National Orthopaedic Hospital, Enugu (Nigeria).

The cases are reported according to the ethical rules about confidentiality and patients' personal data protection according to the Helsinki Declaration[23].

Artificial Intelligence

The authors did not use any generative artificial intelligence (AI) software in the writing process of the present manuscript, tables, and figures. The authors used AI-software for spelling and grammar check of the texts.

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