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Mohammed Awad Abdelrahiem Awad
Al-Azhar University Resident of Plastic and Reconstructive Surgery, at Nasser Institute Hospital, Awadmohammed07@gmail.com

Wael Mohamed Ayad
Professor of Plastic and ReconstructiveSurgery Faculty of Medicine for Boys, Al-Azhar University

Ayman Abdel-Moety Altramsy
Professor and Head of Department of Plastic and Reconstructive Surgery Faculty of Medicine for Girls, Al-Azhar University

Ahmed Mohamed Nafeh
Plastic and Reconstructive Surgery Faculty of Medicine, Helwan University

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ORIGINAL ARTICLE

Evaluation of Medial and Lateral Supramalleolar Flaps for Reconstruction of Soft Tissue Defects Around Ankle

Mohammed Awad Abdelrahiem Awad [a,*], Wael Mohamed Ayad [b], Ayman Abdel-Moety Altramsy [c], Ahmed Mohamed Nafeh [d]

[a] Department of Plastic and Reconstructive Surgery, Nasser Institute Hospital, Al-Azhar University, Cairo, Egypt
[b] Plastic and Reconstructive Surgery Department, Faculty of Medicine for Boys, Al-Azhar University, Egypt
[c] Department of Plastic and Reconstructive Surgery, Faculty of Medicine for Girls, Al-Azhar University, Egypt
[d] Plastic and Reconstructive Surgery, Faculty of Medicine, Helwan University, Helwan, Cairo, Egypt

Abstract

Background: **In patients with underlying vascular disease, which can affect circulation, and in patients with chronic wounds brought on by severe trauma, plastic surgeons continue to struggle with the reconstruction of ankle and heel deformities. Due to their capacity to cover soft tissue defects in the lower limb without the need for microsurgical procedures and with reduced donor site morbidity, perforator-based propeller flaps have grown in popularity. Perforator-based propeller flaps were one of the first options for covering lower limb soft tissue defects, due to the idea of replacing 'like with like' tissue.**

Aim: **This study aims to evaluate clinically the use of perforator propeller flaps (medial and lateral supramalleoular perforator flaps) for the reconstruction of soft tissue defects around the ankle.**

Patients and methods: **A retrospective study of 20 patients with soft-tissue defects involved acute trauma, chronic scar contracture, and chronic ulcers around the ankle. Reconstruction using medial and lateral supramalleolar perforator-based propeller flaps was conducted between January 2021 and December 2022.**

Results: **The soft tissue defects in our patients ranged from medium-sized to relatively large sized defects, and we were able to successfully use propeller-based perforator flaps to cover the defects with grafting of the donor site. The smallest defect in our study measured 7 × 6 cm, and the largest was 30 × 8 cm. The flap size in our study was measured as well. They ranged from 14 × 9 cm being the smallest to 30 × 10 cm being the largest. The outcome was divided into three types: satisfied, borderline, and unsatisfied. In all, 13 (65 %) patients were satisfied, six (30 %) patients were borderline, and one (5 %) patient was unsatisfied. In four patients who experienced venous congestion, complications were found.**

Conclusions: **Propeller flaps with perforator bases are a significant addition to the toolbox for soft tissue reconstruction. The procedure takes less time and has lower donor site morbidity. The method is perfect for treating small to medium-sized ankle defects.**

Keywords: Lateral supramalleolar, Medial supramalleolar, Propeller flap, Reconstruction around ankle, Soft tissue defects

1. Introduction

Reconstructing the lower extremity is thought to be the most difficult of all body parts, due to the risks of bone exposure and the scarcity of local tissues.[1] As a result, many surgeons have preferred free flaps for reconstructing lower limb defects. This perception is gradually changing as more surgeons become aware of the versatility, in particular, of perforator-pedicle propeller flaps, which can provide a like-with-like repair without affecting the leg's main vessels or the muscles beneath the skin.[2] Additionally, as with any perforator flap, there will be less donor-site morbidity; additionally, there is no requirement for microanastomoses, eliminating their inherent risks; additionally, the procedure

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* Corresponding author.
E-mail address: Awadmohammed07@gmail.com (M.A.A. Awad).

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requires less operating time than with a free flap, benefiting both the patient and the surgeon.[3]

Perforator flaps have the benefits of being secure, dependable, and having little donor site morbidity. Additionally, it has the benefit of a wide arc of mobilisation and rotation, which increases the reach of local flaps and their adaptability.[4]

The elderly and patients with multiple injuries and compromised systems can be managed quickly and effectively with this technique. The fasciocutaneous flap was initially referred to as the propeller flap by Hyakusoku and colleagues in 1991. This flap is rotated 90° to cover defects brought on by the release of postburn contracture in the cubital and axillary areas.[5]

Propeller perforator flap complications typically involve complete or partial flap loss caused by venous issues, similar to free flap complications. The ability to determine the safe vascular limits of a pedicled perforator flap is the primary means of reducing the rate of complications.[6]

When traditional flaps are not an option, propeller perforator flaps serve as an alternative to free flaps. They offer several benefits over conventional pedicled flaps, including the ability to reconstruct even complex wounds with local tissues and low donor-site morbidity. Their design flexibility enables the reconstruction of complex defects which typically necessitate multiple procedures in a single stage, speeding healing, reducing morbidity and discomfort for the patient, improving aesthetic results, and hiding scars.[7]

The medial supramalleolar propeller perforator flap (MSMPPF) is the counterpart of the lateral supramalleolar propeller perforator flap (LSMPPF). Both are fasciocutaneous flaps that are raised from the medial and lateral sides of the lower leg and used to reconstruct the lower leg and foot distally. The MSMPPF is supplied by the perforating branches of the posterior tibial artery. The perforating branches of the peroneal artery supply the LSMPPF.[8]

2. Patients and methodology

A retrospective study of 20 patients with soft-tissue defects involved acute trauma, chronic scar contracture, and a chronic ulcer around the ankle. Between January 2021 and December 2022, reconstruction was done using medial and lateral supramalleolar perforator-based propeller flaps.

Patients in this study were told about the goals of this surgery, common complications and their treatments, and the period of hospitalisation. Written consent was obtained from the patients.

All patients were subjected to full history taking, preoperative investigations, preoperative photography, laboratory investigations for each patient to evaluate fitness for anesthesia, and a plain radiography to exclude any foreign body, fractures, and osteomyelitis.

Handheld Doppler was used for identification and marking of perforators near the raw area, and the perforator most prominent and closest to the raw area was selected.

Surgical technique: Around the perforator, there is a marked flap. If more than one vessel was found, various options were considered. An alternative flap is always planned as a 'plan B'. An exploratory incision is planned without interfering with the alternative local flap(s) or such as to allow access to the recipient vessels when plan B is a free flap. If possible, the skin incision was placed along previous scars, giving us the idea that a propeller flap could be done in scarred skin, e.g., in cases of postburnt skin, as long as the perforator could be detected by hand-held Doppler.

Operative technique: the procedure was done under general or spinal anesthesia. Disinfection and toweling of the patient with povidone iodine were performed. A pneumatic tourniquet was used on the thigh to facilitate the dissection. Limb elevation above the level of the heart for 5 min of massage of the limb from distal to proximal without exsanguination Padding of the thigh, then elevation of the pressure of the tourniquet to 100° above systolic blood pressure.

To prepare the defect, the wound was cleaned up, and any necessary repairs were made to the other crucial structures. Normal skin edges are created by removing any tissue with questionable viability.

Harvesting the flap; exposure of the perforator; flap marking modification; flap dissection and isolation of the perforator vessel; tourniquet release.

Flap rotation and inset: The propeller flap was rotated in either the clockwise or anticlockwise direction, depending on what was necessary to cover the wound at the smallest angle while protecting the vascular pedicle. In order to prevent rotation or stretching of the vascular pedicle, the flap was then sutured and fixed. The angle formed between the proximal long axis of the flap and the defect determines the rotation's direction. In this study, the angle can be between 90 and 180°. It is not necessary to rotate it beyond 180°. Then we closed the donor site and dressed the flap. The operative time for all patients ranged from 90 min to 130 min.

Postoperatively: all patients were asked to come once weekly for the first two months. And all patients were photographed immediately postoperatively and after the fifth day postoperatively.

Outcome measurements: patients were evaluated both functionally and aesthetically Fig. 1.

3. Results

Our study was a retrospective study of 20 patients with soft-tissue defects involving acute trauma, chronic scar contracture, and chronic ulcers around the ankle. All patients underwent reconstructive procedures using medial and lateral supra-malleoular perforator propeller flaps. Age distribution: patients' ages ranged from 4 to 48 years old (mean of 22.5). Sex Distribution: The study included 4 (20 %) females and 16 (80 %) males.

Etiology of the defect: 10 (50 %) patients were presented with defects due to trauma, all of them due to road traffic accidents. Four (20 %) patients presented with postburn contractures, two (10 %) patients presented with tumours, and four (20 %) patients presented with chronic leg ulcers on top of an unstable scar Fig. 2.

Site of the defect: Seven (35 %) patients had a soft tissue defect in the lateral malleolus, another five (25 %) patients had a soft tissue defect in the anterior ankle, four (20 %) patients had a soft tissue defect in the medial malleolus, and two (10 %) patients had a soft tissue defect in the heel. Two (10 %) patients had a soft tissue defect in the posterior ankle, as shown in Table 1.

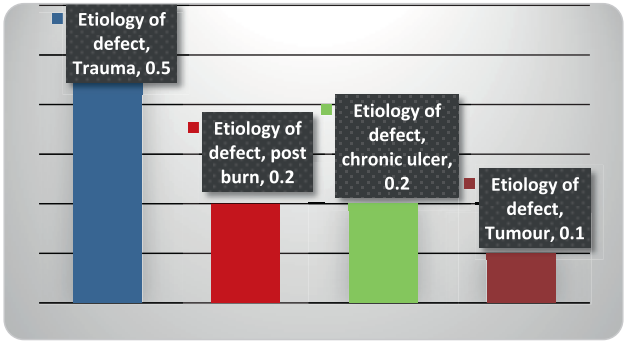

Fig. 2. Showing distribution of etiology.

Table 1. Showing site of defect.

Site of the defect	Number of patients (Percentage)
Lateral malleolus	7 (35 %)
Anterior ankle	5 (25 %)
Medial malleolus	4 (20 %)
Heel	2 (10 %)
Posterior ankle	2 (10 %)

Fig. 1. (A) Showing a pre-operative photo, (B) showing preoperative marking, (C, D, and E) showing intraoperative steps, and (F and G) showing postoperative outcomes.

Size of flap: The measurement was performed for both the size of the flap and the size of the defect to be covered. Concerning the size of the defect, it ranged from relatively small defects measuring 7 × 6 cm to large defects measuring 30 × 8 cm. On the other hand, the sizes of flap ranged in measurements from 14 × 9 cm being the smallest and 30 × 10 being the largest. It is noted that the size of the flap was a bit larger than the size of the relative defect.

Type of flap: regarding type of flap, 10 (50 %) flaps were based on perforator from posterior tibial artery (medial supramalleolar propeller perforator flaps) and 10 (50 %) flaps were based on a perforator from peroneal artery (lateral supramalleolar propeller perforator flaps) Table 2.

Closure of the donor site: all donor sites were closed by split-thickness skin grafts, except for one case closed directly. Arc of rotation: the arc of rotation was 180° in 12 (60 %) patients, 160° in three (15 %) patients, 120° in three (15 %) patients, and 90° in two (10 %) patients.

Postoperative complications: venous congestion led to partial loss of the flap in 15 % of our patients and complete necrosis in 5 % of our flaps. Nevertheless, the flap fulfilled its role by preserving granulation tissue to cover up the essential structures underlying the flap. Both of these complications were treated by grafting.

Outcomes: the outcomes are divided into aesthetic and functional outcomes. Regarding the functional outcomes, they were evaluated according to suture removal and the requirement for dressing. Sutures were kept for two weeks on the flap. Removal of the dressing and splinting of the donor site were performed after three weeks. Eighteen patients had regained their normal functions and daily activities by the third week.

Two of the patients had complications; the complications were either partial or complete loss of the flap. Both patients continued on dressings for a month, which comprised chemical debridement ointment (Iruxol, Kahira Pharmaceuticals). A secondary intervention was later performed in the form of split-thickness grafting.

Aesthetically, the outcome was divided into three types: satisfied, borderline, and unsatisfied.

Table 2. Showing Arc of rotation.

Arc of rotation	Number of patients (%)
180°	12 (60 %)
160°	3 (15 %)
120°	3 (15 %)
90°	2 (10 %)

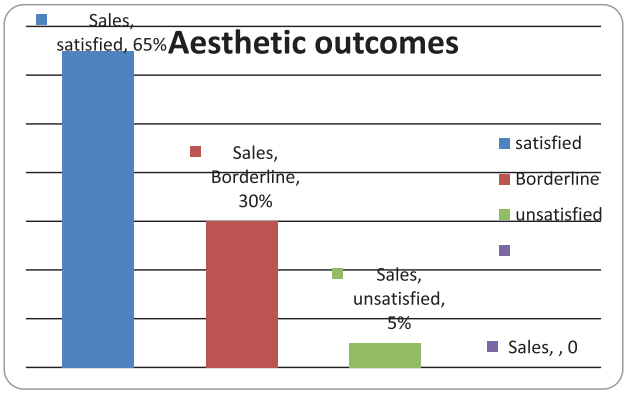

Fig. 3. Showing Aesthetic outcomes.

Thirteen (65 %) patients were satisfied, six (30 %) patients were borderline, and one (5 %) patient was unsatisfied Fig. 3.

Out of the 13 satisfied patients, 6 cases were trauma; 3 cases suffered from chronic ulcers on top of an unstable scar; 3 cases suffered from postburn; and 1 case suffered from a tumour.

Of the six patients that were borderline, four suffered from trauma, one suffered from postburn, and one suffered from a chronic ulcer.

The unsatisfied patient suffered from a skin tumour. The unsatisfactory patient results were due to the site of the donor site, which was adjacent to the site of the flap, and the patient saw that the graft placed on the donor site was disfiguring.

4. Discussion

The term 'perforator-based flap' was first used by Kroll and Rosenfield, and Hyakusoku et al. introduced the idea of propeller flaps in 1991. A definition for propeller flap was first laid out in 2009 during the First Tokyo Meeting. An island pedicled flap with a rotation arc greater than 90° is what it is referred to as.[9]

Both the surgeon and the patient now have higher expectations as a result of the evolution of various treatment plans. The treatment of soft tissue defects in the lower limb has greatly improved with the development of microsurgical techniques. Fascioscuatenous flaps have replaced muscle-free flaps in surgical procedures. Due to a decline in donor site morbidities, perforator flaps have recently taken the place of muscular flaps.[10]

Pedicle based propeller flaps have gained wide popularity among surgeons due to their tremendous advantages, which include a simpler technique that does not require microsurgical techniques, which take a lot of time and pressure on the surgeon, preservation of the main arterial trunk and muscles. For

good functional and aesthetic results, use 'like-with-like' tissue with minimal donor site morbidity.[11]

In our study, we performed MSM and LSM perforator-based propeller flaps on 20 cases. The causes of soft tissue defects around the ankle in this study were variable, ranging from post-traumatic loss of tissue to post-burn contracture to chronic ulcers and skin tumours. Post-traumatic stress disorder was the most typical case in our study, which represented 50 % of the cases. It should also be noted that all the traumatic cases involved males.

Similar to our study, Sananpanich et al. published a case series of 25 cases, 56 % of these cases were post-traumatic.[12] In addition, Karki and Narayanhad operated on 20 cases in their studies, of which 95 % were post-traumatic.[4] Chang et al. published a case series of 12 patients, 66.6 % of whom were post-traumatic.[13]

The rotational degrees in our study ranged from 90 to 180° without creating tension on the flap. The most common rotational degree in our study was 180° (12 patients), while the least common degree of rotation used in our study was 90° (two patients). In 50 % of our cases, we relied on perforators from the posterior tibial, 40 % on peroneal arteries, and 10 % on the anterior tibial. We used the anterior tibial artery in 2 cases, the peroneal artery in 8 cases, and the posterior tibial artery in 10 cases.

Tos et al. worked on 22 cases, with most of their cases having an arc of rotation of 180° at 50 %.[14] Karki and Narayan worked in their study on 20 cases, with all of them having an arc of rotation of 180°.[4]

These studies show that a degree of rotation of 180 can be achieved without any major complications or loss of the flap in many of the cases, which gives propeller perforator flaps a great advantage.

The soft tissue defects in our patients ranged from medium-sized to relatively large sized defects, and we were able to successfully use propeller-based perforator flaps to cover the defects with grafting of the donor site. The smallest defect in our study measured 7 × 6 cm, and the largest was 30 × 8 cm. The flap size in our study was measured as well. They ranged from 14 × 9 cm being the smallest to 30 × 10 cm being the largest.

Karki and Narayan covered relatively smaller defects than ours, ranging from 4 × 3.5 cm to 7 × 5 cm.[4] Sananpanich and colleagues also covered flaps of small sizes in their studies.[15]

On the other hand, Tos and colleagues covered defect sizes closer to those that we worked with in our studies. The largest defect in their study was 14 × 20 cm.[14] Chang and colleagues also repaired using relatively larger flap sizes, like our study.[16]

Since the defects in our study and donor site sizes were relatively larger, we closed the donor site by split-thickness skin grafting in all of our 20 cases. It is indeed more aesthetic to close the donor site by primary intention when possible, but split-thickness skin grafts could be considered a price that all our patients were willing to pay for coverage of defects by simpler procedures than the more complex free flaps.

In our series, we used a handheld Doppler to locate the perforators pre-operatively, and the best perforator was used intraoperatively. Preoperative Doppler investigations are essential to map out the perforators present in the area to be used as a flap.[13] HiguerasSuée et al. recommend the use of a pre-operative angioscanner to map the vascular anatomy of the lower limb before reconstruction, especially in traumatic patients or patients suffering from vascular diseases.[17]

Venous congestion is one of the most common complications in propeller flaps, especially in distal-based perforator flaps. Venous congestion led to partial loss of the flap in 15 % of our patients and complete necrosis in 5 % of our flaps. Nevertheless, the flap fulfilled its role by preserving granulation tissue to cover up the essential structures underlying the flap. Both of these complications were treated by grafting.

Karki and Narayan had 10 % of their patients suffer from venous congestion, with partial flap necrosis in one of their patients.[4] Tos and colleagues had (13.6 %) of their patients suffer from venous congestion, and one of their patients suffered from partial flap necrosis.[14]

There are multiple types of flaps that could be used in the lower limb, but the only two types used in our study were the posterior tibial artery MSMP, which presented 50 % of our cases, and the peroneal artery LSMP which presented 50 % of our cases.

Our findings were supported by numerous additional studies, the majority of which used the posterior tibial artery. Tos et al. used the PTA in 63.6 % of their cases.[14] Karki and Narayan used the PTA on 70 % of their cases.[4]

Finally, Robotti et al. used the PTA in all of their 24 cases.[18] On the other hand, Sananpanich and colleagues had 25 cases in their series, of which 84 % were performed using the peroneal artery.[18]

In our study, we discovered that 13 (65 %) patients of the cases were satisfied, six (30 %) of them were borderline, and one (5 %) patient was unsatisfied. Aesthetics are a fundamental component of reconstructive surgery, and using a propeller flap to reconstruct a defect in the lower limb can produce a

very good result due to the replacement of like-for-like tissue.

Teo et al. also mentioned in their study that the flap in the propeller, compared with some free flaps and other locoregional flaps, may be less bulky and allow for a better fit with the surrounding skin.[19]

We believe that with the suitable characteristics of a defect, perforator-based propeller flaps are a great tool in the arsenal of the reconstructive surgeon to cover the defect with minimal morbidities, less surgery time, a shorter hospital stay, and no microsurgical technique requirements.

4.1. Conclusions

Propeller flaps with perforator bases are a significant addition to the toolbox for soft tissue reconstruction. The procedure takes less time and has lower donor site morbidity. The method is perfect for treating small to medium-sized ankle defects.

Conflicts of interest

None declared.

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