

Long-Term Patency of Twisted Vascular Pedicles in Perforator-Based Propeller Flaps

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Background: Propeller flaps require torsion of the vascular pedicle of up to 180 degrees. Contrary to free flaps, where the relevance of an intact vascular pedicle has been documented, little is known regarding twisted pedicles of propeller flaps. As secondary surgeries requiring undermining of the flap are common in the extremities, knowledge regarding the necessity to protect the pedicle is relevant. The aim of this study was a long-term evaluation of the patency of vascular pedicle of propeller flaps.

Methods: In a retrospective clinical study, 22 patients who underwent soft-tissue reconstruction with a propeller flap were evaluated after 43 months. A Doppler probe was used to locate and evaluate the patency of the vascular pedicle of the flap.

Results: The flaps were used in the lower extremity in 19 cases, on the trunk in 3 cases. All flaps had healed. In all patients, an intact vascular pedicle could be found. Flap size, source vessel, or infection could therefore not be linked to an increased risk of pedicle loss.

Conclusions: The vascular pedicle of propeller flaps remains patent in the long term. This allows reelevation and undermining of the flap. We therefore recommend protecting the pedicle in all secondary cases to prevent later flap loss. (*Plast Reconstr Surg Glob Open* 2017;6:e1544; doi: 10.1097/GOX.0000000000001544; Published online 25 October 2017.)

INTRODUCTION

Survival of transferred, vascularized tissue depends on the patency of the vascular pedicle in the immediate post-operative period. After neovascularization, occlusion of the vascular pedicle may not cause subsequent tissue loss. Complete tissue survival despite loss of the vascular pedicle 6–9 days after tissue transfer has been reported.^{1–3} Contrary to this flap loss after transection of the vascular pedicle as late as 8 years after tissue transfer has also been documented.^{4,5} The relevance of a patent vascular pedicle varies according to flap type and recipient site. Generally, the vascular pedicle of microsurgically transferred tissue remains patent and

continues to contribute to the majority of blood supply.^{6,7} Little is known about the long-term patency rate of twisted vascular pedicles as used in perforator-based rotational advancement flaps also called propeller flaps. Although no microvascular anastomosis is performed, twisting of the vascular pedicle may induce remodeling and thickening of the vessel wall leading to gradual occlusion of the vascular pedicle. In second-stage cases requiring extensive undermining, complete tissue loss may occur. The aim of this study was the evaluation of the long-term patency of the vascular pedicle of propeller flaps. As these have become common clinical practice for soft-tissue reconstruction of complex distal lower extremity wounds, secondary bone grafting or tendon transfer frequently necessitates reelevation of these flaps and might jeopardize flap perfusion.^{8,9}

MATERIAL AND METHODS

Patients who underwent soft-tissue reconstruction with a perforator-based propeller flap between 2008 and 2013 were identified. Only patients older than 18 years of age with a minimum follow-up of 18 months were included.

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Patients were scheduled for a clinical examination after giving informed consent. Patient records were analyzed with regard to age, gender and comorbidities, bacterial contamination or infection, and mechanism of trauma. Flap size, source vessel identified during the dissection of the perforator, arc of rotation, and donor site closure were also analyzed. During follow-up examinations scarring, presence of fistula formation and appearance of the flap were evaluated. Two-point discrimination was tested using the Semmes-Weinstein Method. A handheld Doppler device (Dopplex SD2, Huntleigh Healthcare, Cardiff, United Kingdom) with an 8 MHz Probe (VP 8XS High sensitivity 8MHz Probe, Huntleigh Healthcare) was used to localize the vascular pedicle and evaluate its patency by an experienced senior plastic surgeon. This study was approved by the institutional ethic committee.

RESULTS

Fifty-two patients were identified who underwent a perforator-based propeller flap soft-tissue reconstruction between 2008 and 2013. Twenty-two were available for follow-up and agreed to participate in this study. There were 20 male and 2 female patients with an average age of 51.6 years. Soft-tissue defects were located in the trunk in 3 cases, 19 patients presented with defects in the lower extremities. Before reconstruction, negative-pressure wound therapy was used in 82%; in 9 cases, bacterial contamination was present at the time of reconstruction. The average time-to-reconstruction was 48.5 days in 19 patients, in the remaining 3 patients this time exceeded 1 year. Five patients were treated for osteomyelitis. The average flap size was 108 cm² ranging from 2 to 364 cm². The arc of rotation was 180° in 19 cases in the lower extremity, 90° in 3 cases. Source vessel in the lower extremity were the posterior tibial artery in 10 cases, the peroneal artery in 5 cases, the femoral artery in 3 cases, and the anterior tibial artery in 1 case. In the trunk, the source vessel was the superior gluteal artery in 2 cases, the thoracodorsal artery in 1 case. The donor site was closed primarily in 9 patients, 13 required a skin graft. No complete flap loss occurred. Superficial tip necrosis was seen in 3 patients, all of whom received a skin graft. Six patients developed a fistula, which closed by secondary intention in 5. The average time to follow-up was 43 months ranging from 18 to 98 months. At the time of follow-up, all patients had healed. One patient returned with recurrent osteomyelitis 8 years postoperatively with a completely healed soft-tissue envelope. The location of the perforator was anticipated to be at the midpoint between the proximal border of the donor site and the distal tip of the flap. A biphasic Doppler signal over the original vascular pedicle was detected in all patients. No other audible Doppler signals could be detected in the flap. The sensibility of the transferred tissue was reduced to a 2-point discrimination of 8 mm (range, 3–18 mm).

DISCUSSION

The relevance of a patent vascular pedicle immediately after microvascular tissue transfer is well known. If rapid neovascularization secures perfusion of the transferred tissue, occlusion of the vascular pedicle as early as 6 days

postoperatively may not lead to tissue loss.^{1,2} When no immediate pedicle loss occurs, it can be expected to remain patent. Krag et al.⁶ reported angiographic patency of the vascular pedicle in 32 of 33 patients 12 months after free-tissue transfer. Machens et al.⁷ demonstrated the reliance of transferred tissue on its vascular pedicle after up to 10 years using the hydrogen clearance method. Thus, the alteration of the vessel by performing a microsurgical anastomosis does not induce architectural changes in the vessel wall causing a gradual obliteration, which might not be clinically apparent due to competent collaterals. Krag et al.⁶ estimated that 70% of the perfusion of the transferred tissue is received from the pedicle. Transection of the pedicle during undermining of the flap would most likely cause tissue loss. As propeller flaps are also transferred only on the vascular pedicle, the same concepts may apply.⁹ We found a similar patency rate of twisted vascular pedicles used in propeller flaps. In all patients, an audible Doppler signal could be detected over the vascular pedicle (Figs. 1–3). Both the microsurgical dissection of the perforator and twisting did not predispose the vascular pedicle for later occlusion. Neither source vessel nor size of the flap seemed to influence patency rates of twisted pedicles. Delayed wound healing or fistula formation was encountered in 9 cases, of which 8 healed. Despite infection being a noted risk factor for loss of the vascular pedicle, all pedicles remained patent. The small size of the study may have influenced this finding. In flaps that underwent a partial tip necrosis also, no late loss of the vascular pedicle could be demonstrated (Figs. 4, 5). Thus, partial flap loss seems to represent an inadequate perforator connection rather than a hemorrhagic infarction due to increased venous pressure in the flap after torsion of the pedicle.¹⁰



Fig. 1. Propeller flap based on peroneal artery perforator.



Fig. 2. Three days postoperatively.



Fig. 3. Patent vascular pedicle 24 months postoperatively. The pedicle is located halfway between proximal donor site and the distal tip of the flap.



Fig. 4. Superficial epidermolysis postoperatively.



Fig. 5. Patent vascular pedicle 57 months postoperatively.

Studies evaluating the vascular patency after tissue transfer utilized invasive methods. Krag et al.⁶ studied vascular patency of free musculocutaneous LD flaps angiographically; Machens et al.⁷ applied the hydrogen clearance method. We did not consider angiography due to its invasive nature. Although the information obtained through the handheld Doppler device is not comparable with angiography, computed tomography angiography, or magnetic resonance angiography, it is the clinically preferred and reliable preoperative tool to localize perforators.¹⁰ The handheld Doppler device is adequate to detect a biphasic flow in small lower extremity perforators when using an 8–10 MHz probe.¹¹ Before secondary operations involving undermining of the flap, the information gained from this simple examination may not

only demonstrate a functioning vascular pedicle but also marks its location. However, the mere presence of a patent vascular pedicle does not demonstrate inadequate autonomization of the transferred tissue.^{12,13} Neovascularization from the wound bed and skin margins may ensure flap perfusion even after transection of the pedicle.^{12–14} Even more sensitive ultrasound Doppler devices cannot detect newly formed vessels smaller than 0.5 mm in diameter.¹² No conclusion whether or not propeller flaps have autonomized can thus be derived from our study. Measuring autonomization is clinically difficult as transection of the vascular pedicle is ethically unacceptable.^{7,14} Machens et al.⁷ used the invasive hydrogen clearance method during compression of the vascular pedicle to demonstrate reliance of transferred tissue on its original blood supply as long as 10 years after tissue transfer. Mücke et al.¹⁴ evaluated free flaps in the oral cavity with laser spectrophotometry. In both studies, a significant reduction of flap perfusion could be demonstrated during compression of the pedicle of muscle flaps. More rapid autonomization was found in fasciocutaneous flaps. Another significant variable was the recipient site.¹⁴ These results may apply to propeller flaps. In cutaneous flaps, the skin component may enhance neovascularization at the level of the subdermal plexus, where it may be more reliable than vascularization from the deep wound bed.¹⁴ Unfortunately, this study cannot answer the question if fasciocutaneous perforator flaps in the lower extremity behave similarly, which is the subject of a current study.

CONCLUSION

We recommend to limit undermining of the flap to only 1 side of the long axis, leaving as much of the base undisturbed as possible.

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REFERENCES

1. Wise SR, Harsha WJ, Kim N, et al. Free flap survival despite early loss of the vascular pedicle. *Head Neck*. 2011;33:1068–1071.
2. Yoon AP, Jones NF. Critical time for neovascularization/angiogenesis to allow free flap survival after delayed postoperative anastomotic compromise without surgical intervention: A review of the literature. *Microsurgery*. 2016;36:604–612.
3. Granzow J, Li AI, Caton A, et al. Free flap survival following failure of the vascular pedicle. *Ann Plast Surg*. 2015;75:44–48.
4. Sadove RC, Kanter MJ. Absent neovascularization in a lower extremity free flap: a case report. *J Reconstr Microsurg*. 1993;9:5–9.
5. Salgado CJ, Smith A, Kim S, et al. Effects of late loss of arterial inflow on free flap survival. *J Reconstr Microsurg*. 2002;18:579–584.
6. Krag C, Lavendt E. Late patency of clinical microvascular anastomoses to free composite tissue transplants. I. Angiographical aspects. *Scand J Plast Reconstr Surg*. 1985;19:65–72.
7. Machens HG, Pallua N, Pasel J, et al. Persistence of pedicle blood flow up to 10 years after free musculocutaneous tissue transfer. *Plast Reconstr Surg*. 1998;101:719–726.

8. Teo TC. The propeller flap concept. *Clin Plast Surg*. 2010;37:615–26, vi.
9. Jakubietz RG, Jakubietz DF, Gruenert JG, et al. Reconstruction of soft tissue defects of the Achilles tendon with rotation flaps, pedicled propeller flaps and free perforator flaps. *Microsurgery*. 2010;30:608–613.
10. Lazzeri D, Huemer GM, Nicoli F, et al. Indications, outcomes, and complications of pedicled propeller perforator flaps for upper body defects: a systematic review. *Arch Plast Surg*. 2013;40:44–50.
11. Khan UD, Miller JG. Reliability of handheld Doppler in planning local perforator-based flaps for extremities. *Aesthetic Plast Surg*. 2007;31:521–525.
12. Arnez ZM. Free flap neovascularization: fact or fiction? *Eur J Plast Surg* 2003; 26:3–4
13. Tadros A, Kumar K, Jaffe W, London N, Varma S. Free flap neovascularization: fact or fiction? *Eur J Plast Surg* 2003; 26:1–2
14. Mücke T, Wolff KD, Rau A, et al. Autonomization of free flaps in the oral cavity: A prospective clinical study. *Microsurgery*. 2012;32:201–206.