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Posterior tibial artery perforator flaps for coverage of Achilles region defects

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ABSTRACT

Background: Defects of the Achilles tendon region still represent a tricky issue in lower limb surgery. Among the several reconstructive possibilities, local propeller perforator flaps have gained popularity in the last decade.
Materials and methods: We report our experience with eight patients affected by small-to-moderate soft-tissue defects of the Achilles tendon region, who underwent surgical reconstruction with local flaps based on posterior tibial perforator branches.
Results: All patients healed successfully in terms of aesthetic and functional aspect. In only one case a transient venous congestion was observed and this resolved spontaneously.
Conclusions: Although the surgical technique requires much care and skill, including an extremely gentle dissection of perforator vessels, local propeller flaps should be considered the first-line choice for reconstruction in small-to-medium size soft-tissue defects in the Achilles region.

Introduction

Defects of the lower leg with exposed tendons or bones are still one of the most challenging areas in plastic and reconstructive surgery due to the paucity of reliable local cutaneous or muscle flaps [1]. In particular, even a small traumatic or a non-traumatic defect in the Achilles region traditionally requires free-tissue transfer. Thus, free flaps are often recommended as the treatment of choice, but they are relatively complex and require microsurgical expertise and prolonged operating time [2]. Furthermore, not all patients are willing or healthy enough to undergo free tissue transplantations. For these reasons, there is a constant search for reliable local alternatives in lower extremity reconstruction. Since the first description of the fasciocutaneous flap by Ponten in 1981 [3], several flaps have been described to cover skin and soft-tissue defects of the lower third of the leg [4,5]. Loco-regional flaps are often quick and easy to harvest, but the unpleasant bulky sight over the Achilles tendon poses a problem while wearing footwear, hence, they may require secondary debulking. In addition, these flaps are frequently associated with significant donor-site morbidity and poor cosmesis. Harvesting a local perforator flap provides a like-for-like tissue reconstruction in terms of colour, texture, and thickness without significant donor site morbidity. Although local perforator flap technique requires microsurgical dissection, it does not require vascular suturing and can thus be defined as a microsurgical non-microvascular flap, as reported by Georgescu et al. [6] Avoiding vascular sutures means the surgical act is quicker compared with microvascular flaps, and the pedicle can be skeletonised under magnification with a loupe rather than a microscope [7]. In 1982, Zhang et al. first described the reliability of flaps designed on the posterior tibial vessels [8]; subsequently, many authors [9,10] confirmed the safety of basing the flap distally, either on a septo- or musculocutaneous perforator from the posterior tibial artery [11]. The posterior tibial artery perforators are connected in an axial network, which enables the surgeon to raise large designed flaps that can inset into defects of different sizes and shapes [12]. In such settings, posterior tibial perforator flaps are the ideal solution for small-to-moderate soft-tissue defects in the Achilles tendon region.

We report our experience with eight patients affected by small-to-moderate soft-tissue defects of the Achilles tendon region, who underwent surgical reconstruction with local flaps based on posterior tibial perforator branches.

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Materials and methods

Patients

From February 2002 to June 2007, eight patients were admitted to our Department of Plastic and Reconstructive Surgery, I.R.C.C.S Policlinico San Donato, and eight posterior tibial artery perforator flaps were harvested as a primary surgical procedure for reconstruction of soft-tissue defects in the Achilles tendon region. All the patients were male, with a mean age of 46 years (range from 33 to 68 years). All cases were cutaneous dehiscences after subcutaneous tendon rupture repairs with exposure of the Achilles tendon. The average time from the original tendon repair to presentation at our department was 7 months. Angiography was performed before soft-tissue reconstruction in each patient to exclude vascular anomalies or pathologies. All patients were labelled as "vascularly normal". Two patients had the co-morbidity of diabetes mellitus and one was an occasional smoker. The length of the defects varied between 3 cm and 8 cm and the width between 1.5 cm and 4 cm (Table 1).

All cases were treated with debridement. In two out of eight patients, we performed an immediate reconstruction of the Achilles tendon region with a local perforator propeller flap, which was harvested from the posterior tibial artery. The remaining six patients had a local soft-tissue infection, which was efficaciously treated with a targeted antibiotic therapy (based on swab cultures). The presence and treatment of infection delayed the reconstructive phase for an average of 24 days (range 15–36 days). In all cases, the ankle was immobilised with a dorsal below-knee plaster splint in a neutral position of 100° for 3 weeks, followed by 3 weeks offloading mobilisation. After this last period, every patient started a full weight-bearing status without any assistant devices. Follow-up was 15–38 months.

Anatomy

The posterior tibial artery is the largest terminal branch of the popliteal artery. This artery supplies several perforators, each accompanied by two venae comitantes, predominantly septocutaneous, and arising from within two intermuscular septa, as described by Whetzel et al. [13]: one located between the soleus and flexor digitorum longus, and the other between the flexor digitorum muscle or tendon and the medial aspect of the tibia. The posterior tibial artery perforators are consistently the largest of the lower leg, particularly in the middle third of the leg. As studied by Tang et al. [14], the vascular territory (primary zone) of perforators supplied by the posterior tibial artery is 30 cm^2. In the distal zone, septocutaneous perforators of the posterior tibial and peroneal arteries form two longitudinal chains adjacent to the Achilles tendon. These chains anastomose superiorly with the perforators of the middle zone. Thus, a distally based pedicled large skin flap can be safely based on these septocutaneous perforators [15].

Surgical technique

The cutaneous perforators around the defect are identified and marked using a hand-held Doppler flow metre and the axis of the flap is marked in between the perforators. The patient is positioned prone. A pillow is placed under the opposite hip so that the medial aspect of the leg is better exposed. The surgical procedure is performed with the patient under epidural anaesthesia. A pneumatic tourniquet is cautiously placed around the thigh to prevent exceptional bleeding, but normally it is inactivated to enable the perforator pulsatility to be checked continuously. Meticulous homeostasis is achieved using a bipolar coagulator. After surgical excision of any necrotic or infected tissue, the size of the defect is revealed.

The exploratory initial incision is made on the part of the flap proximal to the defect. As a free flap is the alternative, the exploratory incision should be positioned to enable access to the recipient vessels, if possible.

The flap elevation is performed suprafascially, identifying and preserving the reliable perforators encountered. A number of potentially useful perforators are usually exposed. As D'Arpa et al. clearly say, once all the perforators are identified, the best one is chosen based on pulsatility, calibre, number and calibre of accompanying veins, proximity to the defect, subcutaneous course and orientation, and proximity to a sensory nerve [16]. Once the best perforator has been chosen, all of the other perforators are ligated. The perforating artery and the concomitant veins are gently dissected long enough to prevent kinking of the vessels when the flap is repositioned. When high rotations (more than 90–100°) are needed, the skeletonisation of the perforator or exposure of the posterior tibial artery is necessary to reduce the risk of kinking. All the fascial strands that may potentially cause vascular compromise through kinking of the vessels are dissected. The shape of the flap can then be re-evaluated and adjusted according to the location of the perforator. The remaining outline of the flap is then incised and the flap is undermined until it is completely islanded. The raised flap can now be rotated into the defect. When an angle of more than 120° is needed, the apposition of a polar safety stitch can be useful to reduce the risk of venous and arterial occlusion [17]. If there are any signs of kinking of the pedicle by any residual fascial strands, they might need further division. The insetting of the flap and wound closure are performed using 3-0 or

Table 1
Comorbidities, wound sizes and treatment timings.

Patients	Age (years)	Soft tissue defects dimensions (cm)	Comorbidities	Time between dehiscence after tendon suture and presentation at our department (months)	Details	Time between debridement and surgical reconstruction (days)
1	54	3 × 4	Diabetes mellitus	6	Soft-tissue infection	36
2	44	6 × 3		5		Immediate reconstruction
3	68	7 × 4		10	Soft-tissue infection	18
4	37	5 × 1.5		7	Soft-tissue infection	30
5	42	8 × 3	Diabetes mellitus	3	Soft-tissue infection	24
6	33	4 × 4	Occasional smoker	9		Immediate reconstruction
7	55	5 × 4		5	Soft-tissue infection	15
8	35	5 × 3.5		11	Soft-tissue infection	21

4-0 nylon half-buried sutures with penrose drains in situ. The donor site is closed primarily when the flap area is small, otherwise a split-thickness skin graft is used. Leg elevation, maintenance of adequate blood pressure and temperature (to prevent spasm of the perforating artery) are critical for the first postoperative 96 h. The flap is monitored hourly during the first 24 h, every 4 h for the next 24 h, and every 6 h for the last 24 h. Clinical parameters that must be evaluated are skin colour, capillary refill, skin temperature, and evidence of postoperative bleeding. The first skin grafting dressing is usually performed on the 5th postoperative day and flap sutures are removed on the 14th postoperative day.

Results

In five out of eight patients we performed a posterior longitudinal propeller because, as a general rule, the flap should be longitudinally in the limbs [18], particularly when large flaps have to be harvested. In six out of eight cases there was a high degree of rotation of the pedicle (more than or equal to 120°).

The length of the flaps varied from 5 to 18 cm (average 9.3 cm) and the width from 4 to 6 cm (average 4.4 cm). In no case did the procedure have to be aborted. No flap necrosis was observed, except for a small superficial necrosis of the tip of the longest flap (Case 5), which healed by secondary intention in 15 days. In Case 4, a transient venous congestion was observed that resolved spontaneously. No complications like osteomyelitis or soft-tissue infection recurrence were observed. The donor site could be closed primarily in all cases treated with a posterior longitudinal propeller and the appearance of the donor-site linear scar was highly satisfactory. In three out of eight cases, where we chose a round flap, split-thickness skin grafts were used (Table 2). There was a good cosmetic result with a satisfactory skin match in all cases after a follow-up of 15–38 months. No infective recurrences were recorded. None of the patients had problems wearing shoes.

Fig. 1. Wound dehiscence with tendon exposure in Achilles region.

Fig. 2. Harvesting of a posterior tibial artery perforator flap.

Example: case 3

This was a 68-year-old male patient affected by a chronic wound dehiscence after tenorrhaphy for subcutaneous Achilles tendon rupture (Fig. 1). The patient first underwent debridement and wound swab cultures revealed an infection by *Staphylococcus epidermidis* spp. Consequently, the patient was treated for 14 days with targeted antibiotic therapy with levofloxacin at 500 mg per day. Once negative swab cultures were obtained, the patient underwent a second operation with debridement and soft-tissue reconstruction with a local propeller perforator flap, which was harvested on a posterior tibial perforator vessel (Fig. 2). The wound completely healed in 21 days. At 1-year follow-up, the outcome was aesthetically and functionally satisfactory, with no recurrences (Fig. 3).

Discussion

The reconstruction of the lower extremities remains a challenge for plastic surgeons and successful soft-tissue coverage of exposed

Table 2
Flap details and complications.

Patients	Flap design	Flap dimensions (cm)	Rotation degrees	Perforator emerging site	Flap complications	Closure of donor site	Follow-up (months)
1	Round	7 × 5	180	Between FDL[a] and soleus muscle		Split thickness skin graft	20
2	Posterior longitudinal propeller	8 × 4	100	From soleus muscle		Primary	15
3	Posterior longitudinal propeller	12 × 4	180	Between FDL and soleus muscle		Primary	18
4	Posterior longitudinal propeller	10 × 3	150	Between FDL and soleus muscle	Transient venous congestion	Primary	24
5	Posterior longitudinal propeller	18 × 5	180	From soleus muscle	Superficial distal flap necrosis	Primary	15
6	Round	5 × 4	120	Between FDL and tibia		Split thickness skin graft	38
7	Round	6 × 6	90	From soleus muscle		Split thickness skin graft	24
8	Posterior longitudinal propeller	8 × 4	150	Between FDL and soleus muscle		Primary	15

[a] FDL – flexor digitorum longus.

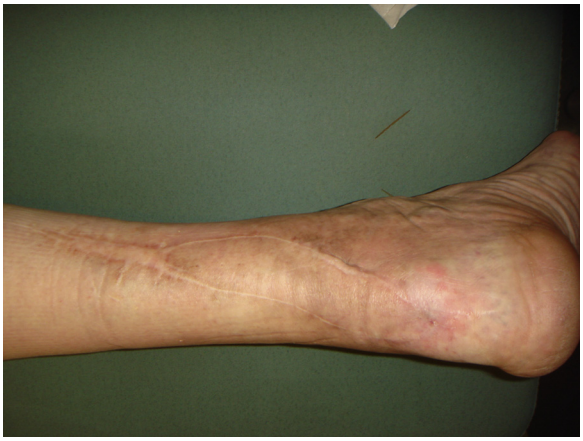

Fig. 3. Follow-up at 1 year.

tendon, bone and joint is often a decisive procedure for limb salvage [19]. Although a free flap can provide sufficient tissue for reconstruction, not all patients are suitable candidates for free-tissue transfer because of existing co-morbidities. Moreover, the appearance after initial free-tissue transfer is often bulky. The use of a local cutaneous flap is limited because regional muscle or myocutaneous flaps are associated with aesthetic and functional deficits, and they may not always reliably reach the lower leg.

Pedicled perforator flaps have a reasonably reliable blood supply, spare the major vessels and muscles, avoid microvascular anastomosis and can provide a wealth of thin soft-tissue for lower leg reconstruction. Furthermore, as the propeller perforator-based flap is a local flap, the characteristics of skin texture and thickness of the subcutaneous tissue are very similar to the missing tissue, making debulking and thinning unnecessary. The morbidity of the donor site is limited to the same area of the body already affected and the donor site itself is partially covered by the flap.

The harvesting of a propeller perforator-based flap is relatively easy. Through direct visualisation of the vessels, the surgeon can choose the pedicle with the best characteristics, both for position and calibre, therefore increasing the chance of a successful reconstruction. According to the literature the dissection plane is usually subfascial [20]: indeed, to increase the vascular reliability of the flap, we prefer to include fascial plane within the flap itself. On the contrary, the advantages of a sovra-fascial approach comprises a uniform anatomic plane from where to choose the pedicles, an easier dissection at the sites where the muscular septa join the muscular fascia, and a less consistent donor site defect (i.e. avoid muscle bulging).

In 1987 Taylor stated that the position and calibre of cutaneous perforators are highly variable between individuals and are often asymmetric even within the same individual [21]. In contrast, Schaverien and Saint-Cyr showed that there are three consistent clusters (at 4–9 cm, at 13–18 cm and at 21–26 cm from the intermalleolar line) where a posterior tibial perforator can be found in 80% of cases [22]. The posterior tibial artery supplies four to five septocutaneous perforators that emerge from the inter-muscular septum between the soleus and flexor digitorum longus muscles to supply the overlying integument; three or four musculocutaneous perforators arise through the medial aspect of the soleus from the posterior tibial artery, and other musculocutaneous perforators emerge from the posterior and lateral aspects of the soleus muscle and supply the skin around the region of the Achilles tendon. In such a setting, the posterior tibial artery and its perforator vessels are an optimal source for local flaps in reconstruction of the Achilles region. Moreover, as recently demonstrated [23], perforators from the posterior tibial artery are most favourable as source vessels due to their constant subfascial directionality, which is almost always near to 90–100°; this angle of fascial perforation would reduce both the arc of rotation and possible vascular constriction and kinking of the pedicle. This is confirmed by Schaverien et al. [24], who found a high reliability of propeller flaps when based on perforators originating from the posterior tibial vessels [6].

In contrast to the literature, where venous compromise is usually a major concern for propeller flaps [25,26], there was no failed procedure in this study, perhaps due to the extremely gentle dissection of the pedicle, the avoidance of excessive tension when suturing the flap, and the application of the polar safety stitch (PSS) to reduce the pedicle torsion in relation to the amount of rotation of the flap.

Conclusion

According to the authors' experiences, propeller flaps enable reconstruction of small-to-moderate defects because of the large skin islands that can be harvested safely on a single perforator, and their remarkable excursion granted by the pedicle dimensions. In our view, the relatively simple but extremely delicate surgical technique and the good cosmetic and functional results make the propeller posterior tibial perforator flaps the best choice to resurface complex soft-tissue defects of the Achilles region.

Conflict of interest

None declared.

Role of the funding source

None.

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