

Original Article

Experience with peroneus brevis muscle flaps for reconstruction of distal leg and ankle defects

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ABSTRACT

Objective: Peroneus brevis is a muscle in the leg which is expendable without much functional deficit. The objective of this study was to find out its usefulness in coverage of the defects of the lower leg and ankle. **Patients and Methods:** A retrospective analysis of the use of 39 pedicled peroneus brevis muscle flaps used for coverage of defects of the lower leg and ankle between November 2010 and December 2012 was carried out. The flaps were proximally based for defects of the lower third of the leg in 12 patients and distally based for reconstruction of defects of the ankle in 26 patients, with one patient having flaps on both ankles. **Results:** Partial flap loss in critical areas was found in four patients requiring further flap cover and in non-critical areas in two patients, which were managed with a skin graft. Three of the four critical losses occurred when we used it for covering defects over the medial malleolus. There was no complete flap loss in any of the patients. **Conclusion:** This flap has a unique vascular pattern and fails to fit into the classification of the vasculature of muscles by Mathes and Nahai. The unusual feature is an axial vessel system running down the deep aspect of the muscle and linking the perforators from the peroneal artery and anterior tibial artery, which allows it to be raised proximally or distally on a single perforator. The flap is simple to raise and safe for the reconstruction of small-to moderate-sized skin defects of the distal third of the tibia and all parts of the ankle except the medial malleolus, which is too far from the pedicle of the distally based flap. The donor site can be closed primarily to provide a linear scar. The muscle flap thins with time to provide a good result aesthetically at the primary defect.

KEY WORDS

Ankle defects; lateral malleolus defects; lower leg defect; muscle flap; peroneus brevis flap; pedicle flap; tendo achilles defects

INTRODUCTION

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The difficulties of soft tissue reconstruction of defects around the ankle have been approached by plastic surgeons in many ways over the last 50 years and the results have remained largely unsatisfactory cosmetically and functionally. This is because our techniques mostly create bulky flaps, which fit uneasily

into conventional footwear. This is particularly a problem when defects are small to moderate in size and lie over the malleoli or tendo achilles. The revolution of local flaps, mostly fasciocutaneous, which are now available for the reconstructions of the ankle usually fail to avoid bulk at the ankle and leave significant adjacent donor defects proximally.^[1,2] Most of them are based distally, with perforators which are not constant in size and position, and some require delay to be safe. Although free flaps avoid the adjacent cosmetic donor defects, they almost always produce a bulky ankle if they include subcutaneous fat, except in very thin patients. They also have higher rates of complications.^[3] Muscle flaps, whether pedicle or free, have the benefit of 'autothinning' with time, as the muscle atrophies, although the overlying skin graft is rarely ideal in respect of colour, contour and irregularity of surface.

This paper reports the use of the pedicled peroneus brevis muscle based proximally for defects of the lower third of the leg in 12 patients and distally based for the reconstruction of 27 defects of the ankle in 26 patients.

PATIENTS AND METHODS

Over the period between November 2010 and December 2012, 30 patients, including five females and 33 males with a mean age of 43 (range: 7-80) years, presented with injuries of the distal third of the leg or ankle requiring flap cover of exposed bone, open joints, bare tendon or metal implants, which were small to moderate in size, with the width of the critical area of the defect being less than 4 cm. 22 patients had sustained an injury to the right lower limb and 15 to the left. One patient had bilateral defects. Twenty patients were heavy manual workers, 12 were more skilled manual workers, four were office workers or professionals, one was a student and one was a 7-year-old child. All 38 patients sustained injuries in road traffic accidents: 21 fell from motor cycles in collisions, four had injuries in car collisions, eight were pedestrians who were hit by motor vehicles, four fell from a height and one fell from a bullock cart. A total of 38 patients with 39 flaps were available for assessment at a mean period of 8 (range: 1-20) months after surgery. The mean critical area of skin loss requiring flap cover was 16 (range: 4-40) cm².

The peroneus brevis flap was not our choice where the post debridement defect was wider than 4 cm, which is the average width of the stretched muscle. Pre-operatively,

the presence of peripheral pulses was confirmed to rule out vascular injury and peripheral vascular disease. No angiograms were done and it was not possible to isolate the perforator with Doppler study. We did not encounter any vascular problem when pre-operatively the dorsalis pedis and posterior tibial pulses were palpable. Three of 12 patients for whom proximally based flap was done had distal fracture of the fibula and nine of 20 patients for whom distally based flap was done had a fracture of the fibula; of them, five had undergone fixation for distal fractures with plates and screws. Usually, fracture of the fibula does not disturb the vascularity to the muscle. Even when a distal fracture is fixed, the perforators remain undisturbed as the dissection is in the subperiosteal plane.

SURGICAL ANATOMY

The peroneus brevis muscle is deep and anterior to the peroneus longus muscle originating from the junction of the upper and middle third junction of the lateral surface of the fibula. It is muscular up to, and sometimes beyond, the lateral malleolus and is inserted into the base of the fifth metatarsal. In the literature, it is described as both type II and type IV muscle based on its vasculature. Proximally, the neurovascular bundle enters the muscle within 2-4 cm of the upper end of the muscle. Several branches from peroneal vessels pierce the posterior septum and supply the muscle. It receives a few branches from the anterior tibial artery also.

The superficial peroneal nerve traverses the compartment on the anterior surface of the muscle, which is easily identified and separated from the muscle up to the point of the middle of the leg where it pierces the anterior septum to become subcutaneous.

SURGICAL TECHNIQUE

All of the procedures were performed under tourniquet control and spinal or epidural anaesthesia, except for the child, who had a general anaesthetic. All patients remained in a supine position throughout the operation. The foot rested on a small sand bag with the knee in 60-70° of flexion to prevent the foot from sliding down and to allow the ankle to rest in plantar flexion, and to relax the peroneus muscles and allow easy access to the peroneus brevis, lying deep to the peroneus longus [Figure 1].

Whether the flap is to be used as proximally based or distally based depends on the site of the defect. Standard skin markings are made as shown in Figure 1. The incision is made just posterior to the line of the fibula and deepened through the deep fascia to expose the peroneal compartment. It is easy to identify the peroneus longus tendon overlying the brevis tendon distally and separate the longus from the brevis from distal to proximal. The axial vessel system vital to the viability of the peroneus brevis flap is on the posterior surface of the peroneus brevis muscle close to the posterior septum [Figure 2], and has to be identified and protected. Small branches of this vessel system to the longus muscle are cauterised to leave the axial vessel system supplying the peroneus brevis intact.

Immediately anterior to this axial vessel is the attachment of the brevis muscle to the lateral surface of the fibula. It is important that the fibular periosteum is not raised with the muscle as this may give rise to heterotrophic ossification, if lying on the surface of the muscle under the skin graft after moving the muscle to its destination.

Three of 14 muscular branches from the peroneal artery in the posterior compartment perforate the posterior septum to enter the posterior surface of the peroneus brevis muscle. Some of them may, rarely, communicate directly with the axial system. Proximally, the branch of the superficial peroneal nerve to the peroneus brevis is accompanied by blood vessels to the muscle. There is also always a constant proximal perforator branch to the brevis muscle within 2-4 cm of its origin, which is the main pedicle of the proximally based flap. Another constant perforator to the muscle lies 6-8 cm from the lateral malleolus. This is most often the main pedicle of the distally based flap. At the level of this distal perforator, the axial system maybe small or absent. Between these constant perforators and beyond the distal constant perforator are a variable number of perforators, also arising from the peroneal artery.^[4]

The proximally based flap and the entire length of the muscle can be mobilised on the vessels running along the nerve, but we have always included the proximal peroneal artery perforator, which we perceive to be the main pedicle [Figure 3].

When planning a distally based flap, we initially keep 6-8 cm from the lateral malleolus to ensure inclusion of the distal constant peroneal artery perforator. While

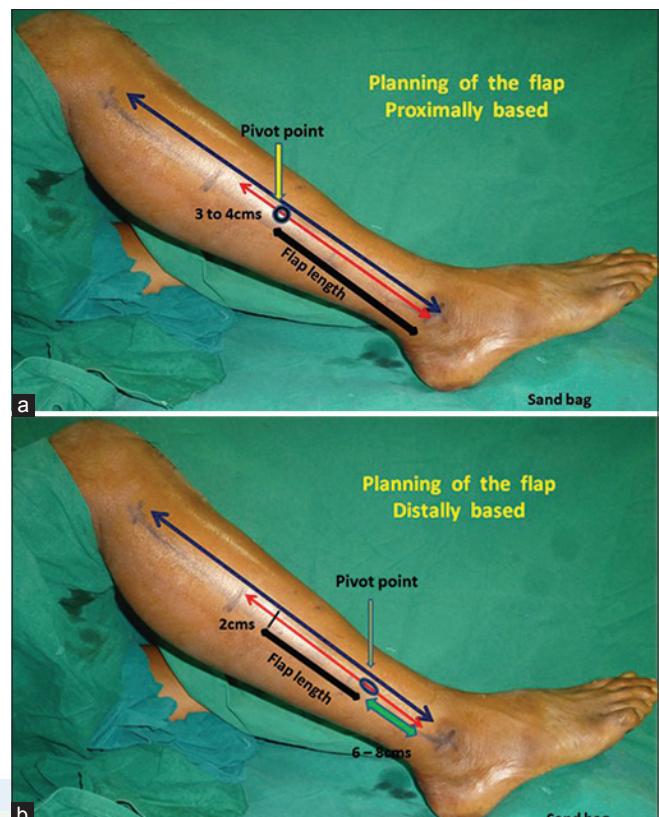


Figure 1: (a) Skin markings for raising the proximally based peroneus brevis flap, (b) Skin markings for raising the distally based flap. In both pictures, the line of the fibula is marked in blue and the line of the peroneus brevis muscle in red. The skin is incised just behind the blue line. The usual pivot point of each flap is marked with a circle and the thick black line extending from this circle indicates the safe length of muscle beyond each pivot point, which may be raised as a viable muscle flap

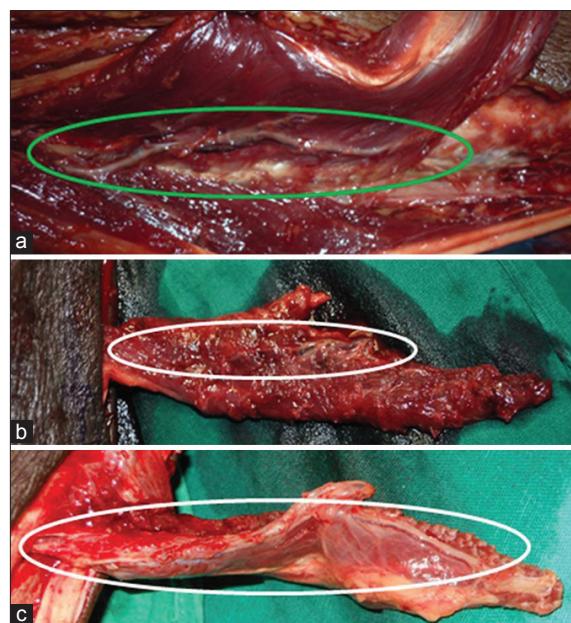


Figure 2: (a, b and c) Operative dissections of the peroneus brevis muscle, with the muscle rotated on its longitudinal axis after separation from the peroneus longus muscle to show the axial vessel system running along its posterior surface from proximal on the left to distal on the right in three different patients showing their consistency,



Figure 3: (a) A fracture of the distal third of the tibia in a road traffic accident, (b) Exposure of the fixation screw of the interlocking nail internally fixing the tibial fracture, (c) A proximally based flap tunnelled to the defect and sutured in position, (d) Early view of the reconstruction at 2 months from surgery before complete muscle 'autothinning'

raising the distal flap from proximal to distal, it is customary to keep any perforators of significant size in the distal half of the muscle. After the release of the tourniquet, we move the muscle to its eventual site in stages while clamping these branches sequentially from proximal to distal and repeatedly checking muscle perfusion, then ligating or cauterising them, until the muscle is in position [Figure 4]. During dissection, between the brevis muscle and the anterior septum, it is also necessary to identify and preserve any significant branches of the anterior tibial vessels perforating the anterior septum distally and leave these intact to enhance the vascularity of the distally based flaps. During this part of the dissection, care must be taken to protect the superficial peroneal nerve, which lies between the muscle and the anterior septum before passing through the fascia in the middle of the leg to enter the subcutaneous fat.

In most cases, the constant distal perforator remains intact. However, occasionally, this has to be clamped, then ligated to allow the muscle to mobilise distally. This leaves the muscle vascularised on more distal perforators. These are not dissected out if the axial vessel system is obvious distally at the level of the distal constant perforator. However, if the axial system is not obvious at this point, the more distal perforators must be identified visually before clamping the distal constant perforator or any other perforators distal to this.

Finally, the muscle is moved to the defect either by



Figure 4: (a) A fracture dislocation of the left ankle, (b) Exposure of the fracture and internal fixation just proximal to the ankle, (c) A completely dissected distally based peroneus brevis flap based on the standard 6-8 cm distal perforator, (d) Flap tunneled under a bridge segment of skin, sutured in position, (e) One month view of the reconstruction: The muscle is still bulky

incising the skin bridge, which is done mostly for lateral malleolar defects or by tunnelling subcutaneously, which is done mostly for defects over the tibia and anterior ankle. The muscle is inset, taking care to anchor the deep surface of the muscle to the wound while protecting the axial vessel on this surface. A split skin graft is then applied to the superficial surface of the muscle.

Immediately after surgery, all of these reconstructions are protected in a plaster of Paris ankle slab, although many also will have required external fixation for skeletal instability. Hospital stay is often determined by other injuries, but hospitalisation for this procedure alone is typically 5-10 days, with the plaster slab remaining *in situ* for 3 weeks. Once the skin graft over the muscle flap has stabilised, by 3 weeks, the limb is fitted with a pressure garment to reduce oedema. Thereafter, mobilisation is largely determined by orthopaedic and associated injury factors.

ASSESSMENT

In this assessment, we assessed the size of the defects covered for the different target areas of the leg and ankle.

Flap loss, either non-critical loss (usually distally) or loss with exposure of the underlying bone, open joints, bare tendon or implants was recorded for each target area.

Short to medium term assessment of these patients included recording the immediate complications of surgery, namely, minor infection, more significant infection requiring either intravenous antibiotics or

Table 1: Assessment of the suitability of the peroneus brevis muscle flap for reconstruction of the different anatomical sites of the distal third of the leg and ankle

Anatomical defect	Number of flaps	Flap pedicle	Mean defect size (cm ²)	Noncritical flap loss*	Critical flap loss**
Medial	6	Distal	11.5	1	3
Malleolus	-	-	-	-	-
Anterior ankle	4	Distal	23	0	0
Lateral ankle	13	Distal	14.5	1	0
Tendo achilles	1	Distal	18	0	0
Distal 1/3 leg	15	Proximal (11) Distal (4)	13.8		1

*Requiring secondary split skin grafting (2 cases), **Requiring further flap cover (3 cases) or vacuum-assisted closure and split skin grafting (1 case)

surgical release of pus, bleeding or haematoma collection.

Intermediate to long term assessment of reconstructions of the region, with more than 9 months of follow-up, were available for some patients and included consideration of the bulk, appearance of the ankle and the functional and cosmetic defects of the donor site.

RESULTS

The assessment of the use of this flap for different target areas of the leg and ankle is shown in Table 1. Overall, there was no case of complete loss of flap. Loss of flap in critical areas was seen in four cases (<10%) requiring further flap cover. Of these four cases, three flaps were done for medial malleolar defects.

No patient developed infection or acute bleeding in the operative area. There were no problems in closing the donor defect directly. One patient developed a haematoma under a part of a skin graft, requiring regrafting of approximately 30% of the muscle surface.

Two distally based flaps suffered minor distal loss, which required debridement and split skin grafting. Three patients, all with flaps used to cover the medial malleolus, lost a sufficient portion of the distal part of the flap to expose the critical underlying skeletal problem, although the actual loss of the flap was less than 3 cm in all three cases. Two of these defects required further reconstruction with a flap, one with a propeller flap and the other with a small free flap. The third one was managed with a topical negative pressure dressing followed by split skin grafting. One of the proximally based flaps showed necrosis of the distal part of the flap, exposing the fractured bone, which was detected at a follow-up after 2 weeks. This patient was a known diabetic. The defect was covered with a bipedicled flap.

All muscle flaps were bulky initially, but as the muscle atrophied, they became much flatter and more cosmetically acceptable. No flap required secondary debulking.

All the patients had a linear scar on the lateral aspect of the leg, but none had indentation. There was no functional deficit following this flap as long as the peroneus longus was intact.

DISCUSSION

Although the free flap is our most commonly used reconstruction around the ankle and distal third of the leg, when small critical areas of the skeleton in this region require full-thickness skin cover, we try to avoid these complex procedures. The plethora of local fasciocutaneous flaps of the leg, adjacent to the ankle, now available for reconstruction of the ankle may provide this cover, but mostly leave a bulky ankle with a significant donor defect immediately adjacent.^[1] Most of these flaps are perforator based and the position of the perforators, particularly on the lateral side, is not constant. They may also have been damaged in the primary injury.

Use of the proximally based peroneus brevis as a pedicled muscle flap was first described by Pers and Medgyesi in 1973.^[5] In 2001, Eren *et al.* described the use of the distally based peroneus brevis flap for reconstruction around the ankle.^[4] However, the main contribution to the literature on this flap has been the 109 cases reported in 2010 by Schmidt and Giessler.^[6] Other smaller series have also been reported.^[1,5,7-9] This muscle flap is easily raised, whether pedicled proximally or distally.

As a proximally based flap, the peroneus brevis is useful for cover of small defects of the distal third of the tibia down to the ankle [Figure 3]; particularly the perforators supplying the distally based peroneus brevis flap on the



Figure 5: (a) Fracture of the right ankle with lateral skin loss exposing an open joint, (b) Raising a distally based peroneus brevis flap, with an arterial microclamp across a perforator in the middle part of the muscle, before division of this perforator and distal dissection of the muscle with serial clamping and division of further perforators, (c) Flap sutured in place and skin of the donor site closed, (d) Long-term view of the reconstruction at 6 months from surgery with muscle 'autothinning' and no indentation at the donor site

lateral aspect of the leg adjacent to the ankle are constant and probably because they are deeper, seem to escape damage in most injuries of the ankle. The distally based flap can be raised with a segment of the vascularised fibula if needed. It is particularly a good choice for defects of the lateral malleolus and tendo Achilles, even in older patients.

Whether used for defects of the leg or ankle, the muscle, initially bulky [Figure 5], has the benefit of 'auto thinning' with time. As the muscle atrophies, it provides a better aesthetic result than local fasciocutaneous flaps, although the overlying skin graft is rarely ideal in respect of colour, contour and irregularity of surface [Figure 4]. This has particular value around the ankle as the reconstruction is less likely to interfere with footwear.

Several studies have shown that the loss of the peroneus brevis, with the peroneus longus still functional, does not cause instability of the ankle.^[1,10] All patients have the cosmetic problem of a linear scar on the lateral aspect of the leg. However, this scar is almost invariably narrow and with time, becomes difficult to see in a hairy male leg. There is also no indentation from loss of the muscle bulk. Although this feature has been commented upon often, the combined cosmetic advantage of very little donor defect of the distal third of the leg and little swelling at the ankle needs particular emphasis when the local alternatives currently being used are almost all fasciocutaneous flaps, which leave very conspicuous grafted donor sites with significant contouring defects, immediately proximal to the ankle, as well as a swollen ankle.

Schmidt and Geisler,^[6] used this flap, distally based for cover of the medial malleolus in three of 109 limbs and made no mention of problems with these three cases. However, we have found that the reach of this flap is not adequate for this reconstruction, with three of the six flaps for defects over the medial malleolus suffering tip loss of 2-3 cm. Our flaps were routed around the anterior aspect of the ankle. Eren *et al.* have covered the medial malleolus from the posterior route, taking the muscle behind the tendo Achilles.^[4]

This muscle flap has a unique pattern of vascularity. Several authors have considered it to be either a type II or type IV muscle in respect of its vascularity.^[7,8,11-13] However, its survival as either a proximally based or distally based flap, often on a single (but different) perforator makes it, by definition, neither type II nor type IV. Cadaveric angiography studies have shown that "as long as one pedicle is maintained complete filling of the muscle can be accomplished."^[14] This may be due to the very unusual axial vessel system on the posterior aspect of the muscle, linking the perforators. Most previous publications make no mention of this axial vessel or mention it only in passing.^[6] We found this axial vessel to be constant in the presence and position and this vessel configuration may be a maybe a 'type VI' pattern of vascularisation. During the dissections between the peroneus brevis muscle and the anterior septum during elevation of the distally based flap, we also observed perforators from the anterior tibial vessels feeding the distal muscle. These have not been reported previously. In two cases, these vessels were so large that we felt that the whole muscle could have survived on them alone. If present, they should certainly be preserved to augment the vascularity of the distally based flap.

With our short experience so far, the distally based peroneus brevis muscle flap could be the flap of choice for defects over the lateral malleolus, but is not worth trying for defects on the medial malleolus particularly when the defects are on the posterior aspect of the medial ankle. We had necrosis of this flap in three of six patients when we did it for covering the medial malleolar defects. We do not recommend this for medial malleolar defects.

CONCLUSION

To conclude, in our experience, we have observed that it is neither type II nor type IV muscle because it can be

raised as both proximally and distally based flaps. It is the presence of the axial vascular system, which makes the muscle survive on any single significant perforator as observed by Chambers and Arsen. The proximally based flap is good for narrow long defects of the tibia in the middle and distal thirds. A distally based flap is ideal for defects over the lateral malleolus down and up to the calcaneum and is probably the flap of choice for such defects. Even in the presence of fractures and plates of the lower fibula, we found this muscle reliable with intact vascularity to provide cover for the implants. We wonder why such a useful flap is being underutilised. However, we need to be careful while using this flap for medial malleolar defects. In this small series, three of six flaps done for medial malleolar defects had necrosis and required further procedures. Further, as a proximally based flap we can use this for reconstruction of the Achilles tendon tendo achilles and a distally based flap can be used as a composite osteomuscular flap. It can be converted to a microvascular flap with the proximal neurovascular bundle and in the future it can possibly be used as a functional muscle with adequate length of its distal tendon.

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