MEDIAL SURAL ARTERY PERFORATOR FLAP

Searching for new donor areas where free flaps could be harvested, Taylor and Daniel[143] were the first (in 1975), to describe a cutaneous flap of the calf, based on a vessel, which, branching off from the sural artery, traversed the medial head of the gastrocnemius muscle to supply the skin. In other words, a flap based in musculocutaneous perforator vessels.

During the era of fasciocutaneous flaps, multiple studies where addressed to search for nourishing vessels that supply cutaneous flaps in the calf region. Despite multiple anatomic studies about the superficial vascularization of this area, such as those published by Haerchst[45] or Ponten[126], superficial vascularization of the calf was unclear for the purpose of free tissue transferring. Different publications[32,132,154] concluded that vessels distribution in this area, or even their presence, made this area unreliable for harvesting microsurgical flaps.

Twenty-one years after the accurate description by Taylor and Daniel[143] about musculocutaneous vessels supplying a flap in the calf region, during the era of perforator flaps, it was Montegut et al in 1996[111] who first described the Median sural artery perforator local flap, supplied by a reliable and constant musculocutaneous perforator artery. First description about the clinical use of this flap, supported by an anatomical study, was presented by Cavadas et al.[17].

The medial sural artery perforator flap is a reliable and relatively thin flap, (between 4 mm and 10 mm) which can be elevated as a pedicled or free flap. A constant musculocutaneous perforator artery, which is present in more than 90% of the patients[17,49,74,142] nourishes the flap. Its donor site can be repaired primarily, or skin grafted. Another advantage is that it has a long pedicle if vessels are traced deep into the muscle (average length of 10 cm-12 cm) and at least one of the perforators has a diameter of 2 mm[155].

This flap can also be elevated as a neurosensitive flap, if the posterior femoral cutaneous nerve is included.

Disadvantages concerning this flap are mainly related to the donor site, because hypertrophic scars, numbness, paresthesia and even limited muscle weakness can occur after raising the flap. This also has to be taken into consideration for women, for aesthetic reasons.

Another disadvantage, that this flap shares with the majority of perforator flaps. is that it depends on the existence of at least one perforator artery, the emerging point of which, can vary considerably.

Indications

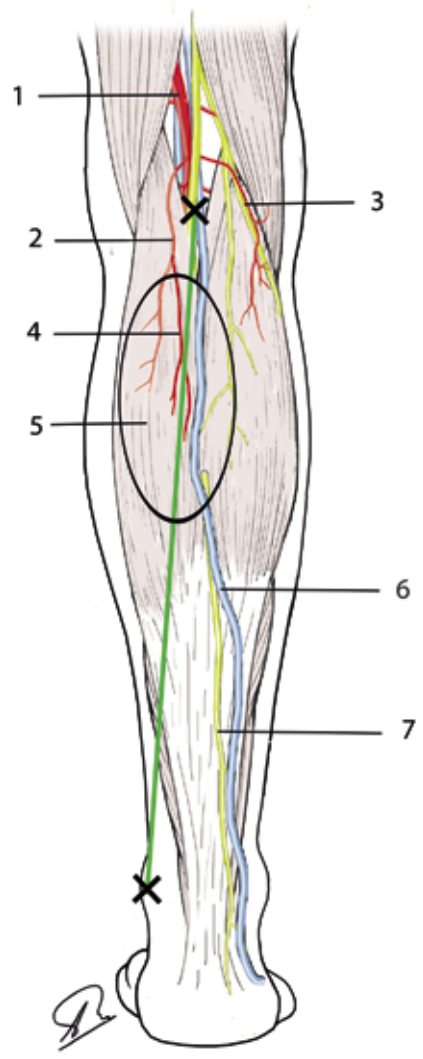
As a free flap (a relatively thin free flap) it can be used to repair head, neck, as well as intraoral defects[18,20,73,74], and defects of the extremities[63,70,165]. As a pedicled flap it has been mainly used to repair defects around the knee.

Vascularization and anatomy

The Medial sural artery perforator flap is supplied by a musculocutaneous perforator artery that branches off directly from the sural artery. This or these perforator vessels emerge from the medial gastrocnemius head to supply the skin over this muscle. References to localize the emerging point vary greatly between authors. Cavadas et al.[17] found a mean of 2.2 perforators emerging from 12 cm to 17 cm distal to the popliteal crease. While Wong et al. found between 2 and 6 perforators emerging between 6cm and 22.5 cm[157] found perforators between 10 cm and 16 cm. Perforators are usually found at a distance of 0.5 cm and 4 cm from the posterior midline[60,61]. These perforators may be absent in about 10% of patients so the flap should then be raised as a fasciocutaneous flap, instead of a perforator flap.

The calf region is vascularized by a mixed system of superficial and deep vascular systems. In this region it seems that there is an inverse relationship between these two systems[47] and when very small or none perforators from the deep system are present, it is the superficial system which vascularizes the flap.

Venous drainage used to come from the venae comitantes that accompany the artery. But for predominant perforator arteries emerging near the midline of the calf, venous drainage is addressed towards venous branches, accompanying the medial sural cutaneous nerve or the lesser saphenous vein. In these cases or when venous drainage is unclear a superficial vein should be included within the flap[46].



1. Popliteal artery
2. Musculocutaneous perforator branch of the medial sural artery
3. Lateral sural artery
4. Perforator branch from the medial sural artery
5. Skin island of the MSAP flap
6. Lesser saphenous vein
7. Sural nerve

Figure 7.90. Medial sural artery perforator flap: anatomical references.

Markings

References to find the most common point where perforator vessels emerge from the muscle were described by Kim et al.[76] and Kao et al.[73] with similar results. Markings start by localizing the midpoint over the flexion crease at the popliteal area and the midpoint of the medial malleolus, which are both marked out. A line is then traced between these two points. On this line a point is marked at 8 cm and a second point at 15 cm from the popliteal crease. About 2 cm around each point, perforator vessels can be localized.

Generally, authors conclude that emerging perforator points are about 10cm and 16 cm from the popliteal crease. But it is also true that it cannot be predicted precisely based solely on anatomic landmarks.

A preoperative mapping of perforator vessels can be precisely achieved if assisted with a Doppler acoustic device[164], colour duplex ultrasound[84] or CT angiography[58].

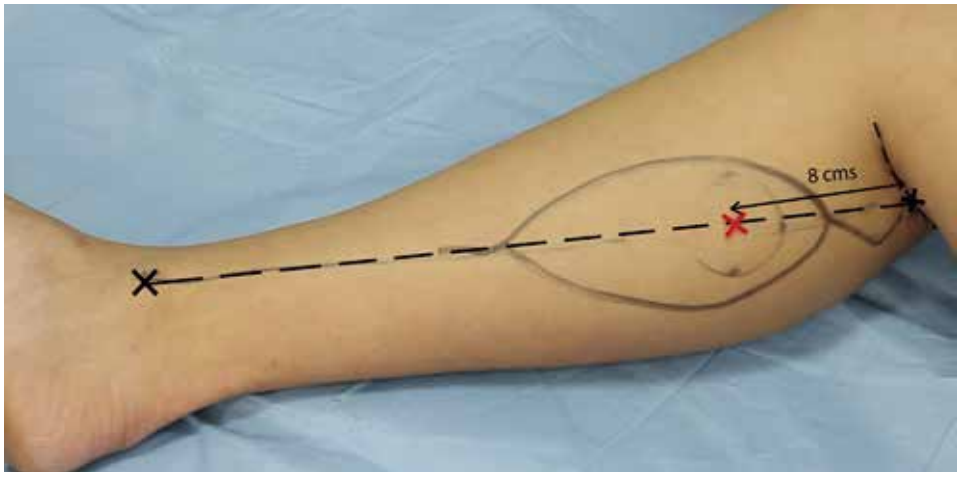


Figure 7.91. Midpoints on the popliteal crease and malleolus are marked and a line between them is traced. 8 cm distal to the popliteal crease, over the same line, a point is also marked out (red cross). Emerging points of perforator vessels are usually found inside a circle of 2 cm around this point. However, this anatomical landmark is approximate and not very accurate. Even when assisted by a Doppler device, the selected perforator has to be seen and identified before incising the entire skin paddle.

Elevation

The flap is generally raised with the patient in prone position, though it can also be elevated with the patient in lateral-supine position. The leg is then rotated outwards and abducted and the knee slightly flexed. As in most perforator flaps, no tourniquet is used to allow filling of vessels, especially the veins, and facilitate their visualization.

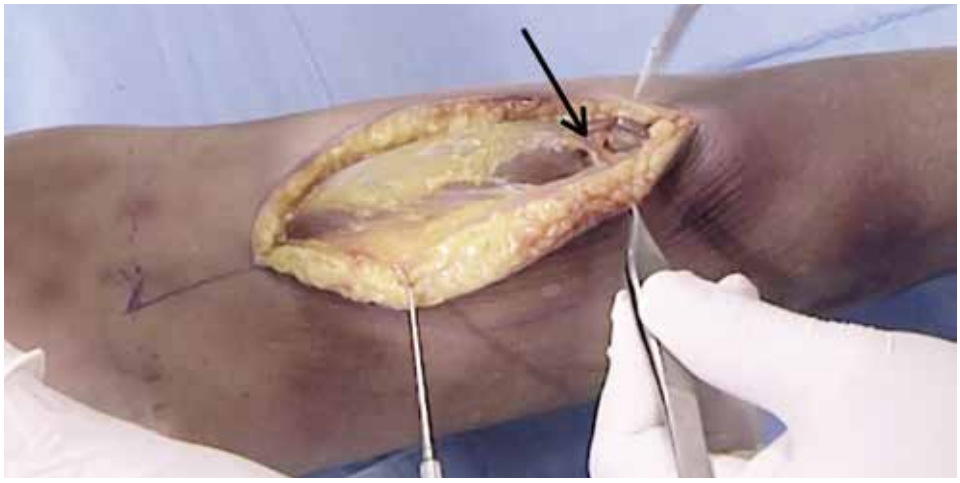


Figure 7.92. Skin incision is always performed keeping a safety distance of 2cm or 3 cm away from any suspected perforator. Incision is made deep to the fascia and blunt dissection is continued until any perforator piercing the fascia is localized. Any superficial vein entering the skin paddle should be preserved at this stage.

Figure 7.93. Once the perforator has been localized, the deep fascia is incised longitudinally to expose the medial head of the gastrocnemius muscle. There is always the possibility of finding no reliable perforators and the possibility of an accidental tearing at this stage. If so, the flap should then be raised like a fasciocutaneous flap.

Figure 7.94. The fascia is reflected with great care to expose the muscular fibers, which are incised longitudinally distal to the perforator vessels, which are not yet divided. Proximally, muscular fibers are also opened leaving a cuff of muscular and fatty tissue attached to the vessels; as additional safety and protection of the pedicle.

Figure 7.95. Fascia and muscle are opened from distal to proximal, isolating the perforator vessels and dividing and ligating any collateral branch to the gastrocnemius. Muscle fibres should not be spared and the pedicle should be left with a layer of muscular-areolar tissue.

Figure 7.96. By blunt dissection, perforator vessels are traced up to the sural artery and detached from the muscle in its lateral and deep aspects.

Figure 7.97. Once the pedicle has been completely individualized and the venous drainage checked, the skin island is incised on its medial aspect.

Figure 7.98. Medial sural artery perforator flap, rotated upward. It can easily reach medial and lateral aspects of the knee.

Dr. Jean Daniel Dunod.

DISTALLY BASED SURAL ARTERY NEUROCUTANEOUS FLAP

The distally based Sural flap was first described by Donski and Fogdestam in 1983[30] and later popularized by Masquelet et al.[102]. It is a neurocutaneous flap, which means that the vessel accompanying a cutaneous sensitive nerve, the sural nerve in this case, supplies the skin paddle of the flap. This type of vascularization was already suggested by Salmon in 1936[129], and Quenu and Lejars[127] in 1892. Different authors later stated that vessels accompanying cutaneous nerves, routinely penetrate the deep fascia and/or pierce it[13] while also traversing adipose tissue[115].These types of flaps were then named "Neurocutaneous perforator flaps" or "Venoneuroadipofascial flaps"[116].

The distally based sural artery neurocutaneous flap is not a complex flap, it is highly reliable, located far from the involved area and suitable for having its donor site repaired by primary closure.

However, it is not free of complications and as a reverse flow flap it is especially prone to complications in patients with associated vascular comorbidities such as diabetes, venous insufficiency and peripheral arteries diseases. Patients over 40 years old also seem to correlate with a higher risk of flap failure[10].

Indications

This flap is mainly indicated to repair defects on the lower leg[64], ankle or foot in different circumstances[2,7,35,71] and particularly, for anterior or lateral post-burn contractures of the ankle[114]. Even, treatment of calcaneal osteomyelitis has been successfully treated with this type of flap[169].

Vascularization and Anatomy

Vascularization of the distally based sural flap is based on the same mechanisms of arterial retrograde flow and denervation of venous valves that happens when proximal arteries which have reliable distal interconnections with branches from other main vessels, are divided. Distal anastomoses and the high-pressure system (as it is the arterial system,) allows a good retrograde flow in normal conditions. Venae comitantes, multiple intercommunicating branches and denervation of valves, is enough to ensure venous drainage to the opposite physiologic direction.

The artery accompanying the sural nerve pierces the deep fascia at the proximal posterior aspect of the calf and gives off several branches that vascularize the skin at the middle third of the calf. This artery courses distally with the sural nerve to anastomose with some of the 2 to 5 perforator vessels that originate from the peroneal artery, which can be found proximal to the lateral malleolus[141]. Anastomoses are located 3 cm-5 cm proximal to the tip of the lateral malleolus and constitute the rotation point for the Sural neurocutaneous flap.

Markings

The pivot point of the flap is localized about three fingers' breadth proximal to the tip of the lateral malleolus, midway between it and the Achilles' tendon and the lateral malleolus (fig. 7.99). The skin paddle is outlined with its vertical axis over the line between both Gastrocnemius muscles. Its upper or proximal limit is slightly above the junction of the two heads of both Gastrocnemius muscles. The skin island is outlined over the middle third of the calf, as the skin of the proximal third is no longer vascularized by the sural artery. Elliptical outlining of the flap (fig. 7.99, 7.100) will facilitate primary closing of the donor area.

Wider flaps will be able to resurface wider defects, but it is important to rationalize between width and the possibility of a primary closing of the defect. One cm may be the difference between a direct closure of the donor area or the need for skin grafting.