A sensate lateral sural artery muscle perforator flap

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Introduction

After the groundbreaking evidence by Koshima (1,2) and Allen (3,4) of the versatility and reliability of cutaneous flaps nourished by only the musculocutaneous perforators of either the rectus abdominis or gluteus maximus muscles, the race was on to prove a similar capability for all other known musculocutaneous flap territories. The first detailed anatomical study of the gastrocnemius muscle perforators (5) was soon corroborated by Cavadas, et al, (6) who also included the first large series of medial sural artery muscle perforator flaps, primarily used as a free flap. From an historical standpoint, it is incredulous that Taylor and Daniel (7) as early as 1975 in their cadaver dissections had already recognized that the intramuscular dissection of a gastrocnemius musculocutaneous perforator back to its respective sural vessel could be the basis for a potential new skin flap donor site. It was not until two decades later that Montegut and Allen (8) used this information to present the first clinical cases.

The medial sural artery muscle perforator flap would be called the MSAP flap using the Canadian terminology (9), or the MS Medial Gastrocnemius muscle perforator flap if one prefers to include both the source vessel and the muscle intermediary as part of the nomenclature (10). Whereas in over 90% of patients a major medial gastrocnemius perforator does exist to allow use of the MSAP flap, not uncommonly, no major perforators are found over the lateral head of the gastrocnemius (6,11). Therefore, up to this point in time, only the MSAP flap has been consistently utilized. There have been many variations of the MSAP flap theme including chimeric free flaps (12), cross-leg free flaps, (13), local flaps (14), and as the thin flap of choice with the patient in a prone position (11). A lateral sural artery muscle perforator flap [LSAP], if technically feasible, may be more advantageous for lateral knee coverage as a local flap, which can in addition be sensate.

Surgical Anatomy

Nutritive flow to the fascial plexus of the calf depends on both superficial cutaneous (direct) and deep musculocutaneous (indirect) perforators (15). An inverse relationship typically exists between these systems, so if the superficial system predominates, the original plan may have to be altered by conversion to a more traditional calf fasciocutaneous flap such as the posterior calf flap of Walton (16,17), the sural artery flap (18), or the lateral sural cutaneous artery island flap (19); or even to use a gastrocnemius muscle flap instead (20).

The origin of the medial or lateral sural artery either is directly from the popliteal artery or sometimes from a common sural trunk, in either case at about the level of the knee joint (21,22). Anomalies are not uncommon, as for example Potparic found a double medial sural artery in 15% of cadavers, and sometimes even more (21). The external diameter of either artery at its origin is approximately 3 mm.; and there are usually 2 venae commitante, each about 3.5 mm. in caliber (21,22). The source artery next enters the deep surface of the muscle along an elongated interfascicular hilum with many longitudinally oriented branches extending as far as the point of insertion of either head into the Achilles tendon. Vascular communications exist between the lateral and medial heads so that total muscle survival is possible even after removal of either of the source vessels (23).

The majority of musculocutaneous perforators arise from very superficial medial or lateral sural branches, along the posterior aspect of the muscle closest to the deep fascia. These perforators tend to be clustered in the distal half of the muscle and arise near the raphe separating the 2 heads (5,6,24). The subfascial course of the perforators after exiting the muscle may be tortuous. These characteristics contribute to the potential for a very long vascular pedicle averaging 15 cm. (range: 10-17.5 cm.)(5).

Venous drainage can be a unique problem. The perforator venae comitantes usually parallel the course of the artery unless that perforator arises near the midline (5). In anatomical studies, the perforator veins often then would diverge toward venous branches accompanying the medial sural cutaneous nerve instead (5). Since the exact course may be unclear, it is recommended that a subcutaneous vein should be kept in reserve with any of these flaps, as this may prove to be the only means later for venous outflow.

Sensation to the skin overlying the heads of the gastrocnemius muscle is from branches of the posterior femoral cutaneous nerve in the region of the popliteal fossa (22), and the lateral sural cutaneous nerve to the lateral calf in its proximal two-thirds (22). The medial sural cutaneous nerve does not innervate this area (22).

Method

The patient is positioned to best access the defect. The prone position is the easiest to allow a full and unimpeded assessment of the entire calf (11). In the supine position, harvest of a MSAP flap requires that the hip be fully abducted and externally rotated; or, conversely, for a LSAP flap fully adducted and internally rotated. A semilateral position with the contralateral hip down may allow even better visualization of the lateral calf.

An important landmark is the knee joint which coincides with the level of origin of the medial or lateral sural artery. Except in the extremely obese, the raphe between the heads of the gastrocnemius can be easily seen to mark the midline of the calf. Remember that the medial head usually is the longer (5). The proximal path of any obvious subcutaneous veins should also be traced.

Although color Duplex ultrasound may be more sensitive (25), the ubiquitous audible Doppler probe is more pragmatic for the preoperative identification of any perforators (26). The majority of perforators tend to be clustered in the distal half of either muscle head and within a few centimeters of the midline (5), but this can be quite variable. Design of the flap should be centered about the most distal reasonable perforator, or slightly eccentric as needed to lengthen the vascular pedicle. The maximum size possible for this flap is not known, although it should not be much different from more conventional calf fasciocutaneous flaps since they both rely on the same fascial plexus. According to Walton, the vertical limits of the latter are from the superior flexion crease of the popliteal fossa to the junction of the middle and lower third of the calf (equivalent to the insertion into the triceps surae), and transversely from the medial to lateral mid-axial lines (17). Direct closure of the donor site can be achieved only if the flap is less than 7 cm. in width.

The use of a tourniquet without limb exsanguination facilitates visualization of all vascular structures. The posterior and/or distal border of the chosen flap should be incised first through the deep fascia and raised to identify and confirm the adequacy of the proposed perforator(s) to the flap. If not, the design of the flap must be altered or aborted. If adequate, the remaining boundaries of the flap are incised, with special care taken to preserve any proximal superficial veins as a reserve conduit for venous outflow (5). In addition, if a sensate flap is desired, along the proximal border any branches of the

posterior femoral cutaneous nerve to an MSAP flap or the lateral sural cutaneous nerve for an LSAP flap should be isolated and preserved.

Next, the usual tedious intramuscular dissection of the desired perforator or perforators (if others line up in a straight array from the same source vessel branch) must be completed through the particular head of the gastrocnemius muscle until the desired pedicle length and/or vessel caliber has been obtained. All muscle branches as encountered must be carefully cauterized or hemaclipped. If used as a local pedicled flap, this dissection ceases as soon as the flap can reach the defect without tension. After the tourniquet is deflated, the adequacy of flap perfusion must be assessed prior to flap transposition.

CASE EXAMPLE: Sensate LSAP Flap

A 20 year old male was involved in a motor vehicle accident with a skin avulsion of his lateral left knee and concomitant quadriceps tendon rupture (Fig. 1). A 4cm. x 11cm. LSAP flap was designed eccentrically about a single musculocutaneous perforator initially identified by an audible Doppler probe. During elevation of the flap, at its proximal border a branch of the lateral sural cutaneous nerve entering the flap was found and preserved. Intramuscular dissection of the perforator through the lateral head of the gastrocnemius muscle ceased once this island flap could reach the defect. The flap and its attached cutaneous nerve were then passed through a wide open subcutaneous tunnel and inset over the knee defect. Primary donor site closure was possible. At 6 months follow-up, the patient has full knee extension, and sensation to touch throughout the flap.

Discussion

The medial or lateral sural artery muscle perforator flaps are almost “ideal” thin cutaneous flaps even in moderately obese patients. They are especially valuable for defects of the posterior body, particularly if the patient must be kept in a prone position (11). The potential long vascular pedicle with large caliber vessels allows a local pedicled flap to reach the popliteal fossa, the upper 3/4 of the tibia, and even as far cephalad as the suprapatellar region (6).

Unfortunately, anatomical anomalies are the norm within the calf region. It is possible that no major musculocutaneous perforators can be found emanating from either head of the gastrocnemius, which would totally preclude use of a muscle perforator flap option (5). A secondary plan must always be considered. Venous drainage through the deep system can also be a problem. Inclusion of a subcutaneous vein as an alternate outflow pathway is prudent. If a skin graft is necessary for closure of the donor site, a significant aesthetic deformity is created which would be unacceptable, especially for women.

The basic anatomy and approach to either the medial or lateral sural artery muscle perforator flap have few differences. The MSAP flap has been previously emphasized in the literature, as the presence of musculocutaneous perforators from the medial head of the gastrocnemius is virtually always insured (5). The opposite is true with the lateral head. An example here of use of the LSAP flap proves that that too is possible if the circumstances warrant. In addition, this version has an added advantage in that the LSAP flap can be successfully transferred as a sensate flap.

Conclusion

The medial or lateral sural artery perforator flap should be considered if a thin cutaneous flap is desirable, especially true in the obese patient where there may be few other options. The advantage of the LSAP flap is that the lateral sural cutaneous nerve can be included to make this also a sensate flap.

List of figures

Fig. 1: (A) left knee wound with quadriceps tendon repair exposed laterally [arrow], (B) design of LSAP flap [“x” mark the site of “perforators” identified using an audible Doppler, vertical line (right) coincides with the defect at level of knee joint, margins of lateral head of gastrocnemius muscle also outlined], (C) elevated island LSAP flap [black arrow = branch of the lateral sural artery (note the path of its intramuscular dissection above), white arrow = branch of lateral sural cutaneous nerve, p = perforator], (D) healed flap inset at lateral left knee, with calf scar noted after primary closure of donor site.