Perforator local flaps in lower limb reconstruction

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Introduction

Recent advances in our understanding of the arterial basis of flap perfusion have led to more refined reconstruction in all areas of the body. This knowledge, combined with technical innovations in the approach to flap design and dissection, has opened up an exciting new era of flap surgery. It is not sufficient to simply achieve soft tissue cover for a particular reconstructive problem. Expectations have risen such that the goals of reconstruction should include functional restoration as well as producing the best possible aesthetic result (1,2).

The concept of perforator vessels based flap has evolved from this improved understanding of flap perfusion. Extensive clinical experience has since confirmed that perforator flaps are safe and reliable in achieving the goals of reconstruction while at the same time minimising the degree of donor site morbidity (3). Consequently many flaps in existence have been revisited. Where muscle is not needed it has been shown that it can be selectively left behind undamaged during flap harvesting without jeopardising its safety (4). On the other hand, when a muscle or bony component is needed, it can often be harvested on its own vascular pedicle, separate from the fasciocutaneous component, to allow for greater freedom of tailoring the flap to the defect and its subsequent inset. This forms the basis of the compound or "chimera" flap (5).

Lower limb reconstruction has certainly benefited from this development of perforator flaps, both pedicled and free (6,7). The distally based island fasciocutaneous flap, based on a single perforator, has allowed defects on the often awkward distal third of the lower limb to be covered reliably. The distal reach of this flap has meant that areas previously considered unreachable by a local flap can now be resurfaced. Obvious advantages include a much quicker procedure which can be performed with the simplest of instruments. This is particularly attractive to any plastic surgeon who may be working in isolation, sometimes in remote regions of the world without access to sophisticated microsurgical facilities. Further advantages include the functional preservation of the underlying muscles and the aesthetic result can be good.

Surgical technique

Local perforator flaps have the particular challenge of design and execution having to be centred on the perforator vessels. In the lower limb the main perforators arise from the three major vessels - the posterior tibial, the peroneal and the anterior tibial arteries. In my experience the perforators arising from the first two are easier ones on which to base the flaps. Further considerations need to be given to avoid transgressing onto the subcutaneous border of the tibia and thereby risk having to put a skin graft over it if the flap is unable to provide cover. For a similar reason it is best to avoid exposure to the tendinous part of the tendo-archilles. Finally it would be desirable to try and avoid damage to the saphenous nerve or the sural nerve depending on which side of the leg the flap is based.

Design of the flap

With these guidelines in mind one can now set out to design the flap around the defect. A handheld Doppler ultrasound scanner is helpful to locate the most promising perforator artery to use. A provisional flap design can then be drawn as follows (Fig.1). Firstly the distance between the perforator and the distal edge of the defect is measured. This value is then transposed proximally, again measured from the perforator, and one centimetre is added. This forms the proximal limit of the flap. Next the width of the flap needed to cover the defect is determined as follows. The width of the defect is measured. This value is then used to determine the proximal flap width, adding half a centimetre to allow for tissue contraction and to facilitate easy closure without tension. It is important that the lateral dimensions of the flap, at the point where the perforator pedicle enters the flap, is equidistant in order that when the flap is eventually rotated around to fill the defect there is no excessive sideway tension on the perforator during closure.

Raising the flap

A thigh tourniquet is used and the leg is exanguinated by elevation and compression of the popliteal artery for one minute. This allows emptying of most of the blood from the leg but retains enough in the perforator vessels to allow for easier identification during exploration. For raising a flap based on the posterior tibial artery perforator, the patient is placed in a supine position and the leg is slightly abducted and externally rotated. For raising a flap based on the peroneal artery perforator, the patient is also supine with a sandbag placed under the hip which is flexed and internally rotated. The knee is bent and a further sandbag placed under the foot allows the leg to be stabilised for the procedure.

The perforator vessels are located through an exploratory initial incision (Fig. 2). It is important for safety and easier assessment to make this incision quite a generous one. The approach to the pedicle could be supra-fascial or sub-fascial, with the latter being generally easier and less bloody. Unless you are already very experienced with raising perforator flaps the sub-fascial approach is probably also safer as it allows easier visualization of the pedicle. With this initial incision, a number of potentially useful perforators are usually exposed. A visual assessment of the perforators is then made to choose the best pedicle for the flap (Fig.3). This is based on its position, size and whether there is any potential injury to the pedicle. In general it would be wise to avoid a perforator that is within one to two centimetres from the wound unless there are no other suitable ones available. On the other hand it is best not to choose a perforator too far away from the defect as this would make the flap unnecessarily long.

When the decision is made, the perforator that is finally chosen for the flap may not necessarily be the one located pre-operatively on Doppler ultrasound and on which the initial design of the flap is based. That is not a problem because the planning and raising of the flap should allow for flexibility of re-designing and adjustment of its dimension. I call this the concept of a dynamic approach to designing and raising a perforator flap. With this approach, once you have decided that the pedicle chosen is the best in terms of its location, size and suitability to sustain the flap the design of the flap should be re-checked and if necessary adjusted. In particular one should ensure that the proximal edge of the flap, when it is finally rotated into position, is capable of reaching the distal margin of the defect comfortably and would not place the pedicle under any tension.

Once that critical decision has been made about the perforator to use, time should next be invested in careful dissection around the pedicle. The pedicle should be cleared of all muscular side branches for at least 2 cm. If possible I try to clean the pedicle from its vessel of origin to the point where the pedicle penetrates the deep fascia of the flap. Next, there should be a meticulous division of all the fascial strands that could potentially cause vascular embarrassment through kinking of the vessels (Fig. 4). One should pay particular attention to

those around the venae commitants, since they are relatively low pressure systems and are therefore more susceptible to compression once the flap is rotated into position. In my opinion safety of the flap is enhanced by such a radical dissection around the artery and venae commitants. Obviously great care and gentleness should be employed during this crucial step of the operation. The use of magnification is important for this part of the dissection. A pair of 2.5x magnification loupes would be sufficient. The surgical instruments I use for this critical step of the dissection are also fairly simple – a pair of tenotomy scissors and a pair of Debakey forceps (Fig. 4).

Once the pedicle is secured raising the rest of the flap is quick and straightforward. Once the flap has been completely islanded it should be left in its original position and the tourniquet released. It is important to allow it to perfuse and to allow the spasm of the vessels to relax, in its original position, for 10 – 15 minutes before the flap is rotated into the defect. Topical vasodilators, such as papaverine or verapamil, can be instilled around the pedicle at this point.

Rotation and insetting of the flap

Once the flap perfusion is satisfactory it is ready to be rotated into the defect (Fig. 5). The flap is carefully lifted from the wound bed, attached only by its pedicle, and rotated around this pedicle into the defect. At this point it would be helpful to imagine a clock face with the pedicle being in the centre and the minute arm as representing the proximal long axis of the flap while the hour arm points to the defect. The direction of rotation depends on the angle between the proximal long axis of the flap and the defect. This angle can be anything from, say 90º to a maximum of 180º. It is not necessary to rotate it beyond 180º because you can simply rotate the flap in the other direction. When the defect is at the 6 o'clock position and the flap has to be rotated 180º this is the most extreme position with the pedicle being placed under the maximum spiral twist. In this situation I always firstly turn the flap clockwise into the defect and then look closely at the pedicle (Fig. 6), focusing on how comfortably the venae commitants are positioned, looking in particular for any sign of kinking by any residual fascial strands which may need further division. I will then turn the flap counter-clockwise and do the same examination of the pedicle. Once I decide which rotational direction is the most comfortable for the venae commitants, and there is no further necessity to divide any more fascial strands, I then secure the flap into position with the first two skin sutures placed on either sides of the axis of the pedicle. These two sutures should be carefully positioned to ensure that the pedicle is not put under any traction tension either in a proximal or distal direction. If a suction drain is used it is important to place it carefully under the flap and secured well away from pedicle. If necessary I place a loosely tied absorbable suture to hold the drain in a particular position on the wound bed. Thereafter the rest of the flap inset and wound closure should be straightforward. If the donor defect can be closed without excessive tension that simplifies the final stages of the operation and produces the best aesthetic result. One should however not be tempted to close the secondary defect of the wound so tightly such as to risk the blood supply of the flap or cause swelling of the distal leg from a tourniquet effect. In that situation a skin graft is preferable (Fig. 7).

Post operative care

It is important to realise that an operation does not conclude with the insertion of the last suture. The care you put into the planning and raising of the flap need to be continued over into the post operative care. Bandaging must not be too tight as that, combined with post operative swelling may cause vascular embarrassment. A window is made in the dressing to observe the flap, especially the tip. A below knee to toes Plaster of Paris back-slab is applied if there has been a skin graft applied directly to the muscle of the proximal leg or if it is necessary to keep pressure off the flap – this usually applies to the peroneal based flap used to cover defects on the lateral malleolus. The reason is that, when lying supine, the patient's leg naturally goes into external rotation and there is a risk of crushing the flap and its pedicle. A well moulded back-slab, keeping the leg in neutral position or slightly internally rotated will act as a safeguard against this. It could literally make the difference between success and failure. The leg is kept slightly elevated on one pillow and a bed cradle is used to keep any heavy blankets from putting pressure on the leg.

APPLICATION

The distally based island perforator flap has been given the nickname of the "propeller flap" on account of the fact that it rotates around a single perforator like the two blades of a propeller. It is an asymmetric propeller (Fig. 8), with a bit of the tip of one of the propeller blades clipped off.

I have found this flap to be very useful in covering difficult or awkward defects on the distal third of the lower limb, especially around the medial (Fig. 9) and lateral malleolar (Fig. 10) regions of the ankle joint. These are common sites of poor healing following compound ankle fractures and, not infrequently, following internal fixation of malleolar fractures. The flap can also be extended to reach defects on both the anterior as well as the posterior aspect of the ankle joint where the Achilles tendon may be exposed from a wound breakdown following a repair of the tendon. It can even be stretched to reach the lateral aspect of the foot where there has been a wound breakdown following internal fixation of a calcaneal fracture.

Local flap solution, be it muscle or cutaneous based, has always been difficult for defects on the distal lower leg due to a shortage of spare local tissue. It has therefore been traditionally taught that these areas usually require a free flap to provide cover. However, the defects are often only of a small to moderate size and seems that if a safe local flap can be found it should surely be preferable. Using the approach described above, I have found that the propeller flap is a very safe flap to use, with a failure rate of about 5% and this is comparable with the failure rate of any free tissue transfer.

Conclusion

When the basic technique of dissection has been mastered, the design and application of local perforator flaps for wound cover around the lower limb, as well as the rest of the body, can be very successful, providing a high quality reconstruction with minimal morbidity. It also saves on operating time and does not rely on expensive microsurgical facilities which are not that readily available to surgeons working in a large part of the world. At the same time it does not provide an inferior reconstruction compared with a free flap. In many ways it is in fact superior when one considers how well the propeller flap fits and contours into the defect.

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List of figures