Prospective Study Of Ipsilateral Perforator-Based Fasciocutaneous Flaps Of The Leg
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Abstract
Objectives: 1. Prospective clinical study to evaluate ipsilateral perforator-based fasciocutaneous flaps as a modality for covering leg defects. 2. To find out the usefulness of hand-held audio-Doppler in designing these fasciocutaneous flaps. Materials And Methods: A total of 23 patients (26 flaps) admitted with leg defects following trauma were selected for the study. Hand-held audio-Doppler equipment was used for identifying the perforator(s) around the wound and the flap was designed to include the same in its base. Results: Partial flap necrosis occurred in 2 cases, one of them requiring re-flapping; surgical site infections were encountered in 5 cases, and hematoma in one case. Conclusion: Considering the easiness of the procedure and lower ischaemic complications, we conclude that fasciocutaneous flaps are a simple, safe and reliable option for covering traumatic leg defects and hand-held audio Doppler is reliable in identifying perforators for designing these flaps.

INTRODUCTION
Severe blunt or penetrating lower extremity trauma frequently results in a soft-tissue deficit that exposes concomitant musculoskeletal injuries. Infection is a possible complication when there is a break in the skin barrier. It is for this reason that the effective provision of skin cover becomes a matter of urgency, though its provision has to be coordinated with the management of the other damaged structures, each of which carries its own imperative.

Soft-tissue cover of the lower extremity is a formidable challenge, and the difficulty is more pronounced in the most distal area of leg and foot. Primary wound healing rarely poses a problem for the thigh because a skin graft usually suffices, and numerous local skin and/or muscle donor combinations are possible. The minimal laxity of the cylindrical skin envelope of the leg oftentimes precludes primary approximation and exposed structures may not accept a simple skin graft. Local skin flaps in the leg even with a delay have been notoriously inadequate for this task, and distant flaps like cross leg flap may cause prolonged unjustifiable morbidity, when compared to free flaps. The classical approach for repair of proximal defects has been via the transposition of the neighboring soleus or gastrocnemius muscles. If the zone of injury has included these muscles or if it involves the distal third of the leg, any substantial skin necrosis may require the microsurgical transfer of tissue in order to obtain wound healing. Even within the best medical centers, these are lengthy procedures with an inherent rate of major complications in the lower extremity.

A relatively new concept described initially by Ponten in 1981 has shown that the inclusion of the deep fascia with local skin flaps has enhanced their survivability, such that whereas previously a 1:1 length to width flap ratio in the lower extremity was considered precarious, now 3:1 or larger so-called super flaps can be designed with greater reliability. In selected cases, e.g., relatively uncontaminated, small, or moderate-sized open wounds, the choice of a fasciocutaneous flap has allowed reconstruction of many lower leg defects which previously would have necessitated a free flap transfer.

Preoperative colour Doppler study helps in locating the main vessel and the site and size of perforators which in turn helps in designing the fasciocutaneous flap. Bedside, audio-Doppler is a useful alternative to colour Doppler and definitely helps in corroborating the findings of the colour Doppler.

MATERIALS AND METHODS
A total of 23 patients admitted with moderate size (3-15cm) leg defect with exposed bone (tibia/fibula) and/or fracture site or exposed Achilles tendon following trauma were
selected for the study. Patients with lower limb defects, where skin grafting is feasible, and patients with peripheral arterial disease were excluded from the study.

Before embarking onto the procedure patients were carefully examined clinically, particularly noting the extent of defect, availability of adequate adjacent healthy soft tissue for flap design and most importantly, perfusion of the limb. Basic blood investigations and imaging studies were done.

The perforators are identified about 1cm on either side of the vascular axis. After the initial few cases, perforators close to the defect were searched and marked. In our study, handheld audio-Doppler equipment (EMCO-D500) was used with 8MHz transducer frequency. After identifying the perforator(s), the flap was designed to include the same in its base.

All procedures were done under regional anesthesia (spinal or epidural). Pneumatic tourniquet without exsanguinations was used. Then the flap was planned in reverse. A piece of cloth was cut in the shape of the flap to be designed and made to pass through the stages of its transfer in reverse fashion starting from the site of the recipient defect, so as to avoid the flap falling short. Most of the flaps designed were transposition cum rotation in nature (24 flaps), only one being advancement type, and another being deepithelialised turnover type. Although strict restrictions in length of the flap was not followed, it was helpful to raise the flap longer than the dimension of the defect perpendicular to the longitudinal axis of the flap (approximately 2 times), so as to compensate for the length lost in transposition.

The presence of a perforator at the base was identified by either demonstration of the same (direct evidence), or by noting brisk bleeding at the distal most point of the flap and status of the flap (indirect evidence). No attempt was made to skeletonise the pedicle or the perforator.

In larger defects, our aim was to cover only the exposed bone/ fractured site/ tendon with the flap, and the remaining portion was covered by skin graft. Two patients in our study required double flaps - one superiorly based and one inferiorly based one. The donor area was covered by spilt skin grafting, harvested from the ipsilateral thigh.
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Figure 3
Figure 3: Flap transposed and sutured, to cover the primary defect and donor site covered with skin graft

Only one patient underwent advancement flap. Initially a V-Y type of advancement was planned, but as the edges could not be approximated, the donor site was covered with a skin graft.

Figure 4
Figure 4: Photograph showing an advancement flap covering the defect over the Achilles tendon and donor site covered with skin graft

Another patient underwent deepithelialised turn-over flap. Here skin graft was harvested from the donor site (deepithelialised) before raising the fasciocutaneous flap. Then the flap was raised in the subfascial plane and turned over to cover the defect. This procedure required split skin graft cover for both the donor and recipient site.

Figure 5
Figure 5 and 6: Photographs taken >3months after the procedure

RESULTS

Maximum size of the defect was 3-6cm in 65.4% of patients, 7-10cm in 19.2% and >10cm in 15.4% of patients.

In our study, 34.6% of patients had defects in middle third of the leg, 30.8% in the lower third, 19.2% over the Achilles tendon and 15.3% over the proximal third of the leg. The majority of the patients (69%) had the fracture site exposed at the floor of the defect, bone was exposed in 12% and in another 19% of patients the floor was formed by soft tissue.

Hand-held audio Doppler was used preoperatively to identify perforators and design the flap; 88.5% of flaps were designed to include a single perforator at its base and 11.5% of flaps were raised on two perforators.
The peroneal artery was the source vessel in 50% of our patients, the anterior tibial artery in 30.7% and the posterior tibial artery in 19.2% of patients.

Distally based flaps were raised in 68% of patients and 32% of patients had proximally based ones. In one patient, the flap was based on a subcutaneous pedicle. The majority of the flaps designed in our study were rotation cum transposition in nature (73.1%). Out of the remaining flaps, 19% were transposition flaps, 3.8% were deepithelialised turn-over flaps and 3.8% were advancement flaps.

Intraoperatively, a perforator was demonstrated in 7.7% of patients at the base of the flap and in the remaining 92.3% of patients, the presence of a perforator at the marked site was ascertained by noting adequacy of vascularity of the flap thus raised.

Postoperatively, surgical site infections at the recipient site were seen in 19% of patients, partial flap necrosis occurred in 7.6% patients. One patient (3.8%) had hematoma and partial graft loss was seen at the recipient site of the deepithelialised turn-over flap (3.8%).

DISCUSSION

The basic premise in lower extremity reconstruction is utilization of the simplest option that will result in preferred wound healing. Most defects in the leg that are not eligible for simple primary closure present challenging problems to the reconstructive surgeon. In comparison to the head and neck region, the vascular network that supplies the skin of the leg is less abundant, and also, the skin and subcutaneous tissue of the leg have decreased mobility.

Of late, there has been much controversy regarding terminology of perforator-based flaps. So, it is prudent to discuss the same before we move on to further details. Wei and Celik define “perforator vessels” as those whose source artery is deep and the branch that carries blood directly to the fasciocutaneous tissues in its course to reach the skin passes through the overhanging muscular tissue without exclusively following the intermuscular septum. Wei defined “perforator flap” as one where the skin vessel comes from the main pedicle through the muscle. By this definition, flaps raised on septocutaneous vessels or elevated as a musculocutaneous flap cannot be counted as a perforator flap. But, this concept has been simplified during the sixth international course on perforator flaps. The perforator vessels are now defined as direct to skin or indirect (musculocutaneous/septocutaneous).

In cases of musculocutaneous perforators, all flaps raised on them are named based on the muscle. In cases of septocutaneous vessels, the flap is named on the first named axial source artery.

A new terminology, perforator “plus” flaps has been proposed to describe flaps that are not fully islanded and that, despite having the dominant supply from the perforators, retain an additional source of random blood supply from the undetached portion of the skin.

Though the perforator flap nomenclature is in a state of flux and will undergo progressive refinements, it is believed that their potential in locoregional tissue replacement is underutilized.

The rationale for microsurgical reconstruction of the lower extremities most frequently is justified when dealing with wounds of the lower third of the leg. However, the highest incidence of free flap failure also occurs in this difficult region and for the polytrauma victim; this might be an unacceptable risk.

Previous standards for lower limb coverage, such as muscle flaps in the proximal or middle thirds of the leg, must still be indicated for the subacute, infected wound or in case of osteomyelitis, as the enhanced vascularity and inflammatory response provoked by muscle have been shown to be superior to those of fascial flaps. Muscle flaps may be contoured to obliterate dead space in a fashion superior to the less malleable fascial flaps. The donor site deformity is also less conspicuous using muscle only, as the fascial flaps require a skin graft to cover the donor site. But the muscle flap involves extensive dissection and sacrifice of important muscle. Split skin grafting over muscle flap though results in stable coverage and may preclude secondary skeletal procedures.

The local (ipsilateral) fasciocutaneous flaps appear in our series to be a reliable option. This may be of great importance in a compromised polytrauma patient as these flaps can be elevated and inset rapidly, perhaps more simply than even the alternative of limb amputation. The choice of any fasciocutaneous flap requires that an undisturbed relation exists between the fascia and its overlying integument. Disruption of these interconnections by the initial trauma or from prior surgical incisions precludes its consideration.

The fasciocutaneous flap has additional advantages over local muscle flaps or the more complex microsurgical tissue
transfers. The morbidity is significantly diminished, as the surgical plane of dissection is more superficial. The subfascial flap elevation is relatively bloodless, with little risk of haematoma. No muscle function must be expended. Since their dissection is simple and rapid, consideration of these flaps should be given a higher priority for coverage of leg defects.

Ponten first described fasciocutaneous flaps in 1981. The method rapidly became popular to the extent that within 3 years enough variations had been described for Cormack and Lamberty to form a classification according to patterns of vascularisation. The earliest review of the use of fasciocutaneous flaps in the lower leg comes from Barclay et al., who published their improved experience with this form of flap in 16 cases. Since that time there have been many variations in design, including cross-leg flaps, transposition flaps and pedicled island flaps both proximally and distally based. More recently, the anatomy of the perforating vessels has been closely investigated with the intention of basing fasciocutaneous flaps on these. As described earlier, the fasciocutaneous flaps are fed by either septocutaneous or musculocutaneous vessels. Locating the perforator is essential before surgery, as the flap has to be centered on it. Taylor et al. have demonstrated the usefulness of the Doppler probe in this regard.

Unfortunately, inherent in the design of local flaps in the leg is the inability to directly close the secondary defect in all but the smallest procedures. This means that a skin graft must be used, adding to the morbidity and extent of operation. Split skin grafting achieves closure of the defect at a cost; the resultant reconstruction lacks the normal contour of the leg and it heals with discoloration.

Many of the authors mention the possibility that the smaller secondary defects might be closed primarily. A bilobed modification of the fasciocutaneous flap was described by Maruyama in 1985 for defects in the upper third of the leg. More recently, Blair et al. described double V-Y advancement flaps, based on a subcutaneous pedicle, for closure of lower leg defects.

Most of the flaps used in this study were either transposition or transposition cum rotation in nature and required split skin grafting for the donor site. Only one patient underwent advancement flap, wherein part of the donor site was sutured, but most of it was covered with a skin graft, and one patient underwent deepithelialised turn-over flap, in which graft was harvested from the flap donor site to cover both donor and recipient sites. Superior-based flaps should be used preferentially, since distal-based flaps, although possible, have high incidence of flap necrosis. Even in our study all significant complications (flap necrosis) were seen with distal-based flaps.

In our study, bedside hand-held audio Doppler was used to locate the perforators preoperatively in all but one patient, in whom colour Doppler was used to locate the same. We find audio Doppler a simpler, cheaper and quite a reliable device for identifying perforators. In most of our patients (88%), the fasciocutaneous flap was designed to include a single perforator at its base. In two patients (12%), the flap was designed with two perforators and in another patient, one more perforator was seen intra-operatively (in addition to the one marked before) and was included in the design. Intraoperatively, in the majority of patients (92%), vascularity of the flap was ascertained by noting colour-texture of the flap and brisk bleeding at its distal most point. Only in two patients (8%), a perforator was demonstrated at the base of the flap. No attempt was made to skeletonise the pedicle or perforator. We were satisfied with the mobility attained and deemed it risky to dissect out the perforator.

In our study, after dividing the leg defect into upper, middle and lower third and that over the Achilles tendon, fasciocutaneous flaps were raised as superiorly or distally based fasciocutaneous flaps on perforators of the anterior tibial, posterior tibial and peroneal artery. In our study, 2 (7.6%) patients had partial flap necrosis, of which one patient required redoing of the procedure (based on another perforator) and the other was managed conservatively. Five (19%) patients developed infective complications at the recipient site, which we attribute to inadequate initial debridement. Only one patient (3.8%) developed hematoma which was evacuated and was managed conservatively. One patient had partial graft loss at the recipient site of the deepithelialised turn-over flap, and was regrafted. In our study, there were no donor site complications.

Niranjan et al. reported 40 cases of perforator-based V-Y flaps in the leg, out of which eight cases were traumatic in nature. In our series, all cases are traumatic ones and average size of the defect is greater. We fully agree with Niranjan et al., in that these flaps will not be suitable in avulsive and degloving traumatic wounds caused by high velocity injury.

**CONCLUSION**

With this study we conclude that moderate-sized leg defects can be covered easily and safely with least donor-site...
morbidty using locally available versatile perforator-based fasciocutaneous flaps. Fasciocutaneous flaps are a simple, safe and reliable option for covering traumatic leg defects and hand-held audio Doppler is reliable in identifying perforators for designing these flaps. Uncomplicated intraoperative positioning of the patient in supine position will also work in favour of surgeons and anesthetists thereby minimizing the cost and effort of the theatre personnel.

References
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