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Preservation of lower extremity amputation length using muscle perforator free flaps

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Summary Coverage of any lower extremity amputation stump must be durable to resist external forces, well contoured, and thin enough for proper shoewear or prothesis fitting. Preservation of bone length to maximise the ability to ambulate is also of paramount importance. If local soft tissues are inadequate to fulfil these prerequisites, consideration of a microsurgical tissue transfer is a reasonable option, especially to cover bone or save a major joint. Muscle perforator free flaps, as shown in this series of eight patients using four different donor sites, are a versatile alternative for the necessary soft tissue augmentation. Multiple choices are available and often even from the involved lower extremity to minimise further morbidity. The vascular pedicles of this genré of flaps are relatively exceedingly long and of respectable calibre to facilitate reaching an appropriate recipient site. They can be sensate if desired. Of course, muscle function is by definition preserved. Complications are minimal and usually related to the reason for the amputation in the first place.

Lower limb amputation can, in the proper circumstances, be a reasonable and definitive reconstructive option. The level of amputation then becomes the critical decision so that the patient will maintain maximum mobility and independence.[1] In addition, any soft tissue envelope over the amputation stump must be mobile enough to absorb shear and direct forces for long term durability, have reasonable contour and proper thickness for adequate prosthesis or shoewear fit, and possibly be sensate.[1–3] Bone shortening just to allow convenient soft tissue closure may, in the long term, be detrimental for achieving these goals.[1,2] Although stump skin traction or tissue expansion have been used, usually a flap is the better way to overcome insufficient skin coverage, while maintaining bone length.[1,2,4] If myofascial local flaps are unavailable, fortunately microsurgical tissue transfers remain a valuable and proven alternative to achieve the most optimal outcome.[1–6]

In emergency situations, occasionally lower extremity replantations have been successful to avoid the sequelae of a traumatic amputation[7,8]; but more commonly the amputated limb itself has been valuable as a source of vascularised tissues for stump closure, especially as a foot fillet[4,5,7] or salvage of parts[1] that will avoid a donor site elsewhere.

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Such an option is not available when confronted with the need for a secondary wound closure. Historically, muscle and/or musculocutaneous free flaps were often used[2–4]; but as the muscle invariably atrophied, the resulting flap reshaping delayed definitive prosthetic fitting and became a source of recurrent stump ulcerations.[4,9]

Fasciocutaneous flaps, commonly based on the subscapular axis,[5,6,9] could be better tailored to the defect. With the advent of muscle perforator flaps that rely on musculocutaneous perforators, a greater diversity of choices for skin flaps have become available to fulfil a similar role,[10,11] yet still maintaining the major advantage of muscle function preservation that might otherwise be even more important following a limb amputation.

Methods and materials

Over the course of the past 23 years we have used various muscle perforator free flaps and on eight occasions they have been used to preserve maximum limb length following a lower extremity amputation (Table 1). These were equally divided into two groups, i.e. either to maintain metatarsal length so as to preserve ankle dorsiflexion and prevent an equines deformity of a weight-bearing heel, or to keep the knee joint to prevent a higher level above-knee amputation. All were secondary reconstructions, either delayed a few weeks after the primary amputation only when it became obvious that skin coverage was inadequate, or done electively as part of a planned amputation of an intact but infirmed lower extremity.

The specific muscle perforator flap donor site was always chosen so that the patient could remain in either a supine or prone position, while simultaneously allowing access to the recipient vessels and defect. If supine, whenever possible the ipsilateral extremity was used to limit the extent of morbidity to a single limb. Four different donor sites, standardised following the Canadian system[12] for perforator flap nomenclature, were used according to their intrinsic attributes. The medial circumflex femoral artery perforator-gracilis flap (MCFAP-g, sic. medial groin flap) donor site deformity is the most minimal from an aesthetic standpoint (Fig. 1).[13] The medial sural artery perforator (MSAP) flap is relatively thin, even in an obese individual, and essentially permits an immediate cross-leg flap.[14] The lateral circumflex femoral artery perforator-vastus lateralis flap (LCFAP-vl, sic. anterolateral thigh flap) has been considered the 'ideal' soft tissue flap as it has a long pedicle of large calibre, large potential surface area, can be sensate if the lateral femoral cutaneous nerve is included, and can include multiple other tissue components including muscle or fascia lata if desirable.[15] For the only patient in this series treated in a prone position, the thoracodorsal artery perforator flap (TDAP) had the largest available surface area. Even so, as a safety precaution, the cutaneous branch of the circumflex scapular vessels was included essentially for 'supercharging' what would be a large, branch-based conjoined perforator flap.[16] The surgical approach to each of these flaps is appropriately well outlined in our current text.[17] All patients continue to be followed, with stump-related or other complications to date duly recorded (Table 1).

Table 1 Muscle perforator free flaps used for amputation stump coverage

Case[a]	Etiology	Defect	Timing	Donor site[b]	Size[c]	Sensate	Follow-up	Stump complications
1.54 m	Industrial runover	TMA eschar	Delayed	MCFAP-*g*	8 × 12	No	58 mo	None
2.28 m	MVA	Open B-K	Delayed	MCFAP-*g*	12 × 34	No	49 mo	Chronic skin infections
3.30 m	Industrial runover	Open TMA	Delayed	MSAP	4 × 12	No	38 mo	None
4.38 m	Chronic plantar neuropathic ulcer	Planned B-K	Elective	LCFAP-*vl*	10 × 25	No	33 mo	None
5.46 m	Neuropathic sole ulcer	Open TMA	Delayed	MCFAP-*g*	6 × 10	No	31 mo	Plantar ulcer at interface with flap
6.48 m	Industrial runover	Open medial foot TMA	Delayed	LCFAP-*vl*	5 × 18	Yes	24 mo	None
7.54 f	MCA	Tibial B-K nonunion	Elective	Salvage LCFAP-*vl*	15 × 34	No	21 mo	Ulcer from skin redundancy, surgical excision
8.27 m	MVA	Open B-K	Delayed	TDAP-CSAP conjoined	14 × 19	No	20 mo	None

m = Male, f = female. mo = months.
MVA = motor vehicle accident. MCA = motor cycle accident. TMA = transmetatarsal amputation. B-K = below knee.
CSAP = circumflex scapular artery perforator.
LCFAP-*vl* = lateral circumflex femoral artery perforator -*vastus lateralis*.
MCFAP-*g* = medial circumflex femoral artery perforator -*gracilis*.
MSAP = medial sural artery perforator.
TDAP = thoracodorsal artery perforator.
[a] Age, sex.
[b] According to Canadian nomenclature system.[12]
[c] In cm.

Figure 1 (A) Open transmetatarsal amputation stump. (B) Flap designed on ipsilateral medial groin, about gracilis musculocutaneous perforator (arrow) identified with audible Doppler. (C) MCFAP-g free flap with two perforators actually found as seen lying on the microgrid; the inferior vascular clamp is on the medial circumflex femoral source vessels. (D) Healed stump. (E) Plagued by recurrent plantar ulcerations at the flap interface, requiring proper local care only.

Results

A traumatic event was the inciting impetus for lower limb amputation in 3/4 of all patients in this series (Table 1). Two additional patients had infected neuropathic ulcers of the forefoot, with one patient electing to have a below-knee amputation and the other a transmetatarsal level toileting amputation. Unfortunately the latter patient, who is also diabetic, has recurrent episodes of similar ulcers at the interface of the flap and remaining sole, and is the only patient in this series that requires continued local stump treatment (Fig. 1); the flap itself remains uninvolved.

In all but one case, the donor site of the selected muscle perforator free flap was also restricted to the lower extremity. The MCFAP-g and MSAP flaps as smaller flaps were found to be better suited for foot coverage. The LCFAP-vl flap was more versatile, and capable of servicing any amputation site. One used for partial transmetatarsal amputation (TMA) closure was also the only sensate flap, as the deep peroneal nerve was easily accessible in the wound bed for a very simple neurorrhaphy. This did provide gross protective sensation to the end of that stump.

Mean follow up was 34.3 months, with three patients having stump-related complications. In addition to the aforementioned patient with persistent plantar neuropathic ulcers, another had chronic skin infections probably related to his hirsute medial groin area that eventually resolved with improved prosthetic fit. The third patient was somewhat unique in that the donor site of the flap used for stump coverage actually involved the amputated limb (Fig. 2). A LCFAP-vl free flap had initially been used for soft tissue coverage of her extensive lower leg wound. However, because of a prolonged course due to a tibial nonunion, the patient elected to proceed to a below-knee amputation, with the same flap retained as a 'local' turnover flap providing the only remaining simple soft tissue option for stump closure. In order to insure protection of the vascular pedicle, precise insetting was not immediately possible. Upon resolution of oedema, some skin redundancy caused an imperfect prosthetic fit that led to a stump ulceration that was finally controlled by removing the excess portion of the flap.

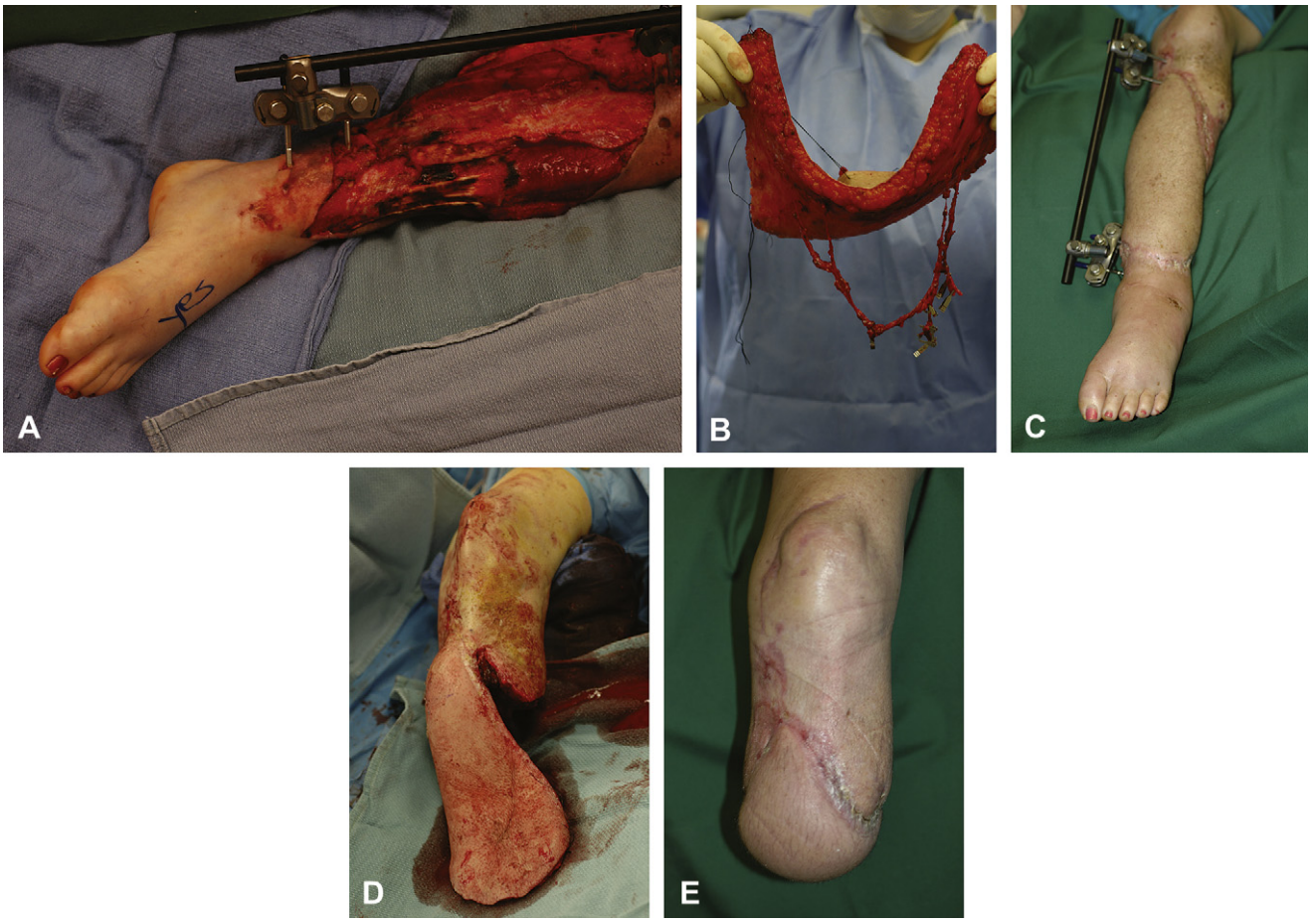

Figure 2 (A) Extensive left leg degloving. (B) Extremely large, free LCFAP-vl flap, serviced by multiple perforators. (C) Initial leg coverage. (D) Flap retained by proximal pedicle at time of elective below-knee amputation. (E) Soft tissue preservation of knee joint.

Discussion

Rather than accepting an amputation of convenience, the level of lower limb amputation should be appropriate to maximise overall function. Preservation of metatarsal length can sometimes even preclude the need for a prosthesis.[2] There is no question that the work of ambulation is halved if a below-knee level can be maintained.[4] Adequate soft tissue coverage that is durable, tolerant of weightbearing, well contoured, and not excessively mobile is preferable.[1–3] The typical paucity of remaining local tissues in the lower extremity often makes consideration of a free tissue transfer essential to achieve these goals.[2–5] Muscle and/or musculocutaneous free flaps have been observed to atrophy with the subsequent soft tissue redundancy predisposing to stump ulcerations.[4,9] Skin flaps from the subscapular axis have been championed as a better alternative,[5,6] yet this donor site is difficult to reach with the patient in a supine position.

Muscle perforator free flaps offer yet another choice for amputation stump coverage.[5,10,11] Often, the donor site can be from the same or contralateral lower extremity which simplifies patient positioning and allows a simultaneous two team approach. The vascular pedicle is typically long and of reasonable calibre. Unlike a muscle flap, this length includes not only that of the source vessel leading to the muscle hilum, but also the sum of the width of the muscle through which the musculocutaneous perforator is dissected, and its subfascial and suprafascial course which is often tortuous. These sometimes exceedingly long pedicles facilitate superior reach outside any zone of injury, without the need to resort to vein grafts. Flap surface area is virtually equivalent to the corresponding musculocutaneous flap.[18] If a cutaneous nerve is included, a sensate flap is possible, although this has not been proven in general to be essential for successful stump coverage as long as deep sensation is present.[2,3] Finally, with muscle perforator flaps, by definition no muscle is sacrificed and further function disturbance is minimised.

The selection of the donor site for a muscle perforator flap to cover an amputation stump primarily depends on the relative thickness of the patient's subcutaneous tissues and desire to hide any scar residua. As has been documented,[13] the MCFAP-g flap scar can be readily hidden near the groin crease or by clothing, even if a skin graft is needed to close the donor site. The LCFAP-vl flap is a potentially larger flap that has fewer anatomical anomalies than the former, and tends to be not as bulky, although the scar can be more conspicuous which will be a major concern for women.

The MSAP flap may be thin even in obese individuals.[14] The TDAP flap offers a large flap if the patient must be in the prone position. Although the use of muscle perforator flaps has been sporadically reported before as an option to maintain amputation stump length,[5,10,11] this series involving multiple donor sites demonstrates this to indeed be a versatile option for achieving this goal.

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