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CASE REPORT

Salvage of a below knee amputation stump with a free sensate total sole flap preserving continuity of the posterior tibial nerve

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SUMMARY. We illustrate the use of a free sole flap with intact posterior tibial nerve in the coverage of a below knee amputation 6 months after an explosive injury to a 12-year-old child. We discuss the indications for lower leg amputation in children, modalities of reconstruction of the amputation stump and possible reason for the observed change of colour of the flap persisting for 14 days.

The advent of microsurgery and free tissue transfer has reduced the indications for lower limb amputation following trauma to the lifesaving situation, where the patient may be too ill to survive a lengthy operation, and to the cases of severe local destruction. High velocity and high energy missiles create large 'zones of injury' where comminuted fractures, open joints, destruction of muscles or entire muscle groups, arterial disruptions and nerve lesions may complicate the soft tissue defects.[1–4]

The issue is no longer the mere survival of injured limbs, but the recognition that the potential for functional recovery and return of sensation may be low or even that rehabilitation to weight bearing may take a very long time (longer than 2 years). In such cases lower limb amputation becomes a serious option.[5]

The level of amputation itself is an important factor for consideration.[6–11] Below knee amputation is associated with faster and fuller rehabilitation compared to that through or above the knee. It allows decreased needs for energy required for ambulation, a more natural gait and more extensive physical activity.

The choice of the level of amputation is dictated by the necessity to cover the stump with appropriate soft tissue stable enough to withstand the forces acting upon it without ulceration or wound breakdown. In the ideal situation rapid rehabilitation with an optimal functional result allows for improved quality of life and rapid social reintegration. We present a case where all these issues had to be addressed in the consideration of the optimum modality of treatment.

Case report

A 12-year-old boy presented 6 months after both his lower limbs were injured in a bomb explosion in Bosnia. He had received primary care with removal of metal, debridement and conservative treatment of a fractured metaphysis of right tibia by immobilisation in Plaster of Paris. Severe bleeding from a large popliteal wound was stopped by tamponade.

He had had a stormy recovery because severe wound infection developed 3 weeks after injury in spite of intravenous antibiotics and regular dressing changes, requiring fasciotomies and wound drainage. When seen in our unit he was able to walk on his left leg, which was fully healed. Just below the right popliteal area was an elliptical non pulsatile swelling the size of a rugby ball. There was a 30 degree flexion contracture of the knee. The fractured tibia had healed with a 20 degrees varus deformity. The soft tissues of the lower leg were ischaemic, with plantar contracture of the toes and complete loss of active movement in the ankle joint and toes. Sensation on the medial side of the sole was intact but absent in other regions of the foot. On arteriography the popliteal artery had normal patency, but at the origin of the anterior tibial vessel a 4 × 1 cm pseudoaneurysm was observed. Beyond this the only perfusion to the lower leg was by way of collaterals.

At operation the popliteal vessels were carefully dissected, and distal to the trifurcation of the popliteal artery an 18 × 22 cm pseudoaneurysm of the anterior tibial artery, filled with blood clot, was found (Fig. 1).

All his lower leg muscles were ischaemic or fibrotic. The common peroneal nerve was found in continuity but severely contused and scarred. The posterior tibial nerve was intact. The tibial fracture was not united and numerous metal foreign bodies were found at the fracture site. Two large skin defects around the medial side of the knee joint of 20 × 6 cm and 10 × 4 cm could be seen.

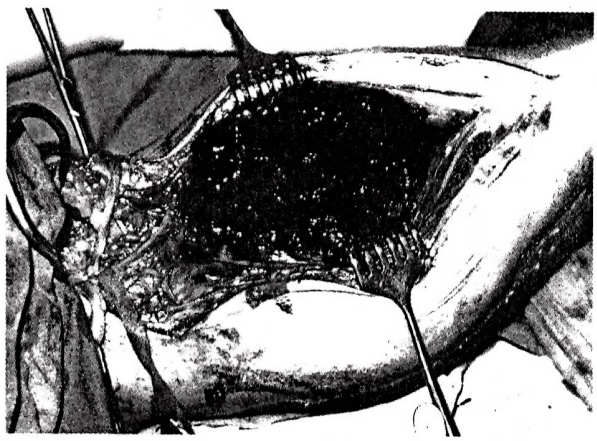

Figure 1—Pseudoaneurysm of the anterior tibial artery (18 × 22 cm) filled with blood clot just distal to the trifurcation of the popliteal artery.

It was felt that the potential for functional recovery of this leg was so poor that a below knee amputation was indicated. We decided to cover the amputation stump with the sole of the foot pedicled on the intact posterior tibial nerve to provide a sensate flap. The foot had been fed via collaterals, but we revascularised it by end-to-end anastomoses between posterior tibial vessels at the foot and anterior tibial vessels at their origin.

The length of the intact posterior tibial nerve was 32 cm (Fig. 2).

During the first 2 weeks postoperatively the flap looked cyanotic and engorged, although the capillary refill was slow (Fig. 3). After that it cleared and became pink, although the distal 3 cm of the flap were lost and the defect covered with a split skin graft (Fig. 4 A,B). The sensibility of the foot immediately following the first operation was normal. This was tested on day 3 by conventional tests (cotton-wool, pin-prick, static and dynamic two point discrimination) and compared to the normal side. He was discharged from our unit at 5 weeks after he had had two operations and was then transferred to the rehabilitation centre where he was fitted with a below knee prosthesis. He was seen at one year following amputation and reconstruction and is fully ambulating and has had no problem of wound stump breakdown. He also has normal sensation in the stump.

Discussion

The decision to proceed to amputation following traumatic injuries of lower limbs is never easy, particularly in children, and particularly when the posterior tibial nerve, a major contributor to the sensibility of the sole, is intact and functional.

The potential for recovery was deemed extremely low because of the severe ischaemic changes in the soft tissues. The residual muscles had no potential for function and would never have restored a functional limb even if revascularisation, and free functional muscle transfers had been attempted. In order to maintain a below knee amputation, flap coverage was necessary. In this case we were considering free flaps, to be revascularised and reinnervated by microvascular and microneural anastomoses to the local recipient vessels and sensory or mixed nerves. The advantages of the free flaps harvested from the amputated lower leg include no donor site morbidity. Using the innervated foot means thick and durable soft tissue coverage as well as potentially normal sensation in the stump. This may diminish phantom pain, improve

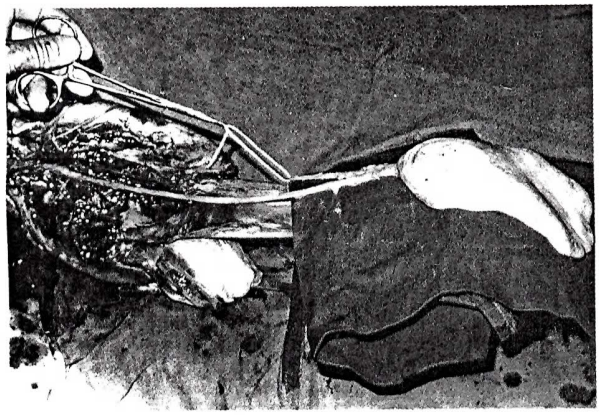

Figure 2—Following debridement of all ischemic muscles and harvesting of the suprafascial sole fillet flap and prior to below knee amputation. Note: preserved posterior tibial nerve (32 cm long) and divided posterior tibial vessels (vessel loop, 10 cm long).

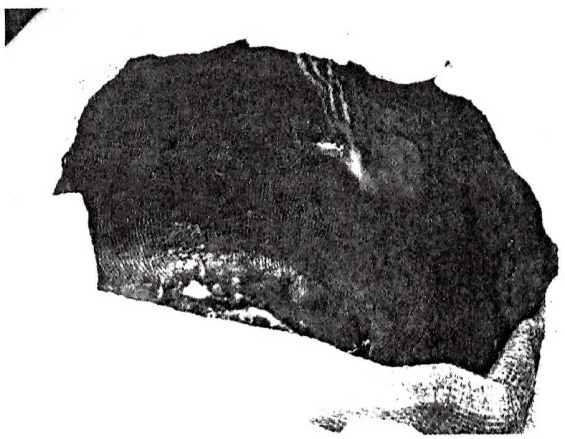

Figure 3—Livid (red-blue) colour of the flap through the postoperative phase in presence of a patent venous anastomosis and normal capillary refill persisting for 14 days.

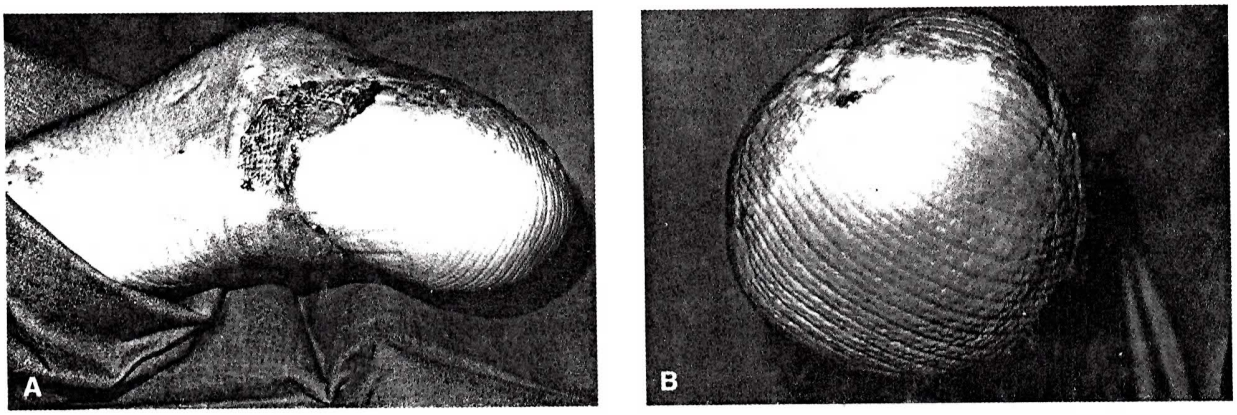

Figure 4—(A) 5 weeks following below knee amputation and reconstruction. Distal 3 cm of the flap were lost and covered by a split skin graft. (B) Weight bearing area of the amputation stump.

temperature discrimination and static two-point discrimination.[12] The use of the sole as a sensate flap pedicled on the posterior tibial nerve and vessels to cover an amputation stump has been described, with the advantage of complete preservation of circulation and sensation. We were obviously unable to do this since the lower leg vessels were fed only through collaterals. Only the distal 10 cm of the posterior tibial vessels showed no macroscopic sign of vascular damage under the operating microscope. We were able to anastomose this pedicle to the anterior tibial vessels 1 cm distal to their origin at the trifurcation of the popliteal vessels (see Fig. 2).

We have achieved our reconstructive goal: a stable and sensate amputation stump and have managed to fashion a below knee amputation as well as obtain the ideal cover for the stump able to withstand the stress and shearing forces of weight bearing and walking. The free sole flap has been used by others as a fillet flap, with[13] or without [12] nerve anastomosis, but only Kasabian et al have covered a below knee amputation stump with a free sole flap with preservation of the posterior tibial nerve in continuity. Their adult patient was treated acutely with four operations over 2 months to attempt limb preservation. In contrast we were faced with a chronic wound 6 months after injury in a child of 12.

Unlike the experience of Kasabian et al,[12] where the postoperative recovery was uneventful, we found that from the beginning, and persisting for 14 days, our flap looked 'congested' although the capillary refill test was normal and there were no anstomotic complications. Gallico et al, did not experience this problem after a free sole fillet flap transfer but they included the intrinsic muscles of the foot in the flap and anastomosed both the anterior and posterior tibial/dorsalis pedis vascular axes to the branches of the popliteal artery.[14] We raised our flap in the suprafascial plane because we could not use the plantar muscles which were fibrotic and relied upon anatomical data showing that the plantar skin is perfused through a rich subcutaneous vascular plexus derived from the posterior tibial and dorsalis pedis arteries.[15]

The purple congested appearance of the flap (Fig. 3) may be explained by considering the venous drainage of the foot. Perhaps performing an additional venous anastomosis would have been beneficial, although clinically there was no problem with the capillary return. It has been suggested that the intrinsic muscles of the foot act as a major pump to venous blood in the foot during the walking cycle[16] although other studies have shown that the venous pump in the foot remains active in spite of paralysis of the intrinsic muscles of the foot as observed in paraplegic patients.[17] Cadaveric studies have shown the intermuscular course of the deep plantar veins in the foot, and transcutaneous electric nerve stimulation to the intrinsic foot muscles was found to eject blood from the foot by compressing these deep plantar veins. As there were no intrinsic muscles in our flap, it is possible that the purple colouration we observed was due to the lack of a functional pump, or to an absence of deep drainage, the colouration persisting till alternative venous pathways opened up.

Conclusion

We describe a free foot fillet flap with preservation of sensation for coverage of a below knee amputation stump in a 12-year-old boy. We believe that preservation of intrinsic muscles may have prevented the livid change of colour of the flap which persisted for 14 days.

References

1. Yaremchuk MJ, Burgess AR, Brumback RJ. Lower extremity salvage and reconstruction: Orthopedic and Plastic Surgical Management. New York: Elsevier Science Publishing Co. Inc., 1989.
2. Yaremchuk MJ. Acute management of severe soft-tissue damage accompanying open fractures of the lower extremity. Clin Plast Surg 1986; 13: 621–32.
3. Yaremchuk MJ, Brumback RJ, Manson PN, Burgess AR, Poka A, Weiland AJ. Acute and definitive management of traumatic osteocutaneous defects of the lower extremity. Plast Reconstr Surg 1987; 80: 1–14.
4. Chapman MW. The use of immediate internal fixation in open fractures. Orthop Clin North Am 1980; 11: 579–91.
5. Keblish PA. Amputation alternatives in the lower limb, stressing combined management of the traumatized extremity. Clin Plast Surg 1986; 13: 595–618.
6. Fisher SV, Gullickson G Jr. Energy cost of ambulation in health and disability: a literature review. Arch Phys Med Rehabil 1978; 59: 124–33.
7. Gonzalez EG, Corcoran PJ, Reyes RL. Energy expenditure in below-knee amputees: correlation with stump length. Arch Phys Med Rehabil 1974; 55: 111–9.
8. Huang CT, Jackson JR, Moore NB et al. Amputation: energy cost of ambulation. Arch Phys Med Rehabil 1979; 60: 18–24.
9. Kegel B, Carpenter ML, Burgess EM. Functional capabilities of lower extremity amputees. Arch Phys Med Rehabil 1978; 59: 109–20.
10. Traugh GH, Corcoran PJ, Reyes RL. Energy expenditure of ambulation in patients with above-knee amputations. Arch Phys Med Rehabil 1975; 56: 67–71.
11. Waters RL, Perry J, Antonelli D, Hislop H. Energy cost of walking of amputees: the influence of level of amputation. J Bone Joint Surg 1976; 58A: 42–6.
12. Kasabian AK, Glat PM, Eidelman Y, et al. Salvage of traumatic below-knee amputation stumps utilizing the fillet of foot free flap: critical evaluation of six cases. Plast Reconstr Surg 1995; 96: 1145–53.
13. Gumley GJ, MacLeod AM, Thistlethwaite S, Ryan AR. Total cutaneous harvesting from an amputated foot – two free flaps used for acute reconstruction. Br J Plast Surg 1987; 40: 313–6.
14. Gallico GG III, Ehrlichman RJ, Jupiter J, May JW Jr. Free flaps to preserve below-knee amputation stumps: long-term evaluation. Plast Reconstr Surg 1987; 79: 871–8.
15. Hidalgo DA, Shaw WW. Anatomic basis of plantar flap design. Plast Reconstr Surg 1986; 78: 627–36.
16. Binns M, Pho RWH. Anatomy of the 'venous foot pump'. Injury 1988; 19: 443–5.
17. Gardner AMN, Fox RH. The return of the blood to the heart. London & Paris: John Libbey & Co., 1989.

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