Use of the Sole Flap to Convert an Above Knee Amputation to a Below Knee Amputation in Trauma

Dear Editor,

An amputation is often a better option in patients with severe lower limb trauma when the prognosis of a limb salvage procedure is not ideal. It also minimises morbidity and mortality.[1] The level of amputation is determined by the zone of injury and availability of soft tissue cover beyond the level of bone amputation. This means that patients with severe segmental injuries involving the leg often end up with an above knee amputation (AKA) or through knee amputation (TKA) instead of below knee amputation (BKA).

We report 3 cases involving the use of sole flaps (2 free flaps and 1 pedicle flap) in segmental crush injuries to convert a potential AKA/TKA to a BKA by providing adequate cover for a below knee stump. The approach allows for knee joint salvage and increased stump length. Although the use of sole flaps to achieve better soft tissue cover in BKAs have been reported,[2-8] the authors revisit this subject with a series of 3 case reports, and discuss the merits of the procedure and its effect on patient outcome in the short- and long-term.

Case 1

A 42-year-old female pillion rider was involved in a road traffic accident. She sustained a Gustilo grade 3C distal right tibia fracture and a segmental fibula fracture, with degloving injury involving extensive soft tissue and neurovascular injury (Fig. 1A). The ankle and foot remained attached via thin strands of skin and soft tissue. The distal posterior tibial and anterior tibial neurovascular bundles were severed. The decision to perform a BKA was made in view of extensive tissue injury and loss.

Wound debridement was done and free sole flap from the amputated foot was harvested based on the posterior tibial artery. The donor vessels (posterior tibial artery with 2 venae comitantes) were anastomosed with the recipient vessels (anterior tibial artery with associated venae comitantes), and an additional vein (long saphenous vein) was anastomosed with posterior tibial vein. The tibial nerve was repaired to its proximal stump. Intact medial gastrocnemius muscle was rotated medially to provide muscle cover to the anteromedial aspect of the BKA stump (Fig. 1B). The patient subsequently underwent further wound debridement of the stump and split thickness skin grafting to the wound. The flap healed well and she was discharged 52 days after reconstructive surgery.

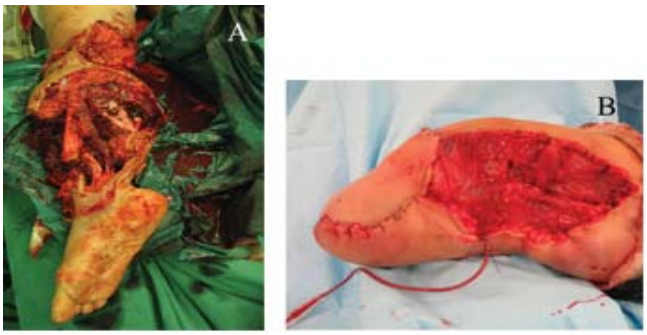

Fig. 1. A 42-year-old female was involved in a road traffic accident. A) Extensive soft tissue damage of right leg. B) Postoperative image of the limb with sole flap.

Postdischarge, she was fitted with a prosthesis and was able to ambulate with crutches. At 9-month follow-up, she reported paresthesia at the sole flap and tenderness at the lateral aspect of the stump. At 24-month follow-up, paresthesia and tenderness persisted. Excision of sural nerve neuroma and trimming of fibula prominence were done. At 30-month follow-up, no paresthesia or stump tenderness was noted. The patient was able to ambulate independently with prosthesis, with a normal range of motion of the knee.

Case 2

A 44-year-old male passenger of a lorry was involved in a road traffic accident. He sustained a complete traumatic amputation of his left leg, through the midshaft of the tibia and fibula, with extensive segmental soft tissue loss. However, there was minimal soft tissue damage of the left foot.

A decision for a BKA was made in view of the segmental defect with gross contamination and an intermittent period of hypotension during resuscitation. A fasciocutaneous free flap was harvested from the left foot based on the posterior tibial artery and 2 associated venae comitantes (Fig. 2A). The flap was then inset to the BKA stump, with the donor vessels and nerves anastomosed to their corresponding proximal

Fig. 2. A 44-year-old male was involved in a road traffic accident. A) Fasciocutaneous free flap harvested based on posterior tibial artery. B) Postoperative image of the limb.

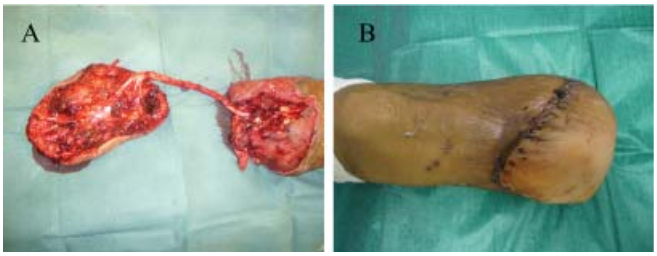

Fig.3. A 31-year-old male was hit by a car. A) Image of the pedicle sole flap harvested based on intact posterior tibial vessels and tibial nerve. B) Image of the operated limb 1 week after the surgery.

stumps. Fascia of gastrocnemius and a full thickness skin graft were also used to provide adequate soft tissue cover (Fig. 2B). The patient subsequently underwent further wound debridement and flap haemostasis in view of recurrent bleeding postoperatively. He was discharged 21 days after the reconstructive surgery, with the flap healing well.

At 3-month follow-up, the patient was accommodating well to the prosthesis. However, a small necrotic area over the stump was noted, which healed spontaneously. At 8-month follow-up, he had occasional serous fluid discharge, which healed with conservative treatment. At 4-year follow-up, the patient was ambulating unassisted with prosthesis and was able to walk up and down the stairs well. He had full range of motion of the knee and the stump had decreased in size with no pressure ulcers.

Case 3

A 31-year-old male construction worker was at worksite when a car hit him. He sustained bilateral leg injuries and left iliac crest fracture.

The left leg sustained comminuted tibial and fibula fractures (Gustilo grade 3B) with extensive soft tissue loss. After initial wound debridement and external fixation, hemisoleous and medial gastrocnemius flaps were used to provide soft tissue coverage for an initial limb salvage attempt. However, the left leg developed wound infection with multi-resistant *Acinobacter baumanii*. Wound debridement was performed and a decision was made for a BKA. A pedicle sole flap, based on the intact posterior tibial vessels and tibial nerve (Fig. 3A), and a split thickness skin graft were used to cover the stump. The patient tolerated the operation well with no complications.

The right leg sustained a Gustilo grade 3A tibia fracture. Wound debridement was performed and the fracture was temporarily stabilised with an external fixator. Two days later, minimally invasive plating osteosynthesis (MIPO) of the tibia was done as a definitive treatment. The right tibia and left iliac bone subsequently healed without complications.

The flap remained viable and healed well (Fig. 3B). At postoperative day 10, patient returned to his native country and was lost to follow-up.

Discussion

Although there are potential benefits for limb salvage, there are problems with multiple procedures, prolonged recovery, and sometimes, poor outcome despite all the best efforts. Amputation is a single-stage procedure with quick healing that enables the patient to get back his functional level with a prosthesis, and is an attractive option. However, with severe crush injuries around the proximal or midtibial level, surgeons often have to resort to an AKA/TKA, which has definite disadvantages over a BKA.

The amputation level is an important factor that determines the patient's functional outcome.[9] A BKA allows for a higher rehabilitation potential and ambulation level.[10] Patients with BKA also require lower energy consumption during ambulation.[11] Preservation of the knee joint and tibial length provides increased proprioception and improved mechanical advantage of a prosthesis, thereby improving the gait.[7]

In a segmental injury of the leg, while the intervening bone and soft tissue segment is damaged, the foot is usually spared. This provides the option of harvesting a fasciocutaneous flap of the sole or instep, which may include part of dorsal skin of the foot if necessary, based on the posterior tibial vessels to provide soft tissue cover for the stump. This may be done either as a free or pedicle flap. The tibial nerve should be preserved if it is intact, or repaired to the proximal stump to achieve a sensate flap. This approach enables a BKA to be done in cases that would otherwise have required an AKA/TKA.

In cases with intact tibial neurovascular bundle to the foot, a pedicle sole flap could be raised (Case 3). Care must be taken to ensure that the long intervening segment of the posterior tibial vessels do not kink as the flap is inset, but to be coiled gently into an area that is not subjected to pressure. Should there be a problem with the long pedicle,

this can be converted into a free flap by excising the excess length. In cases where the posterior neurovascular bundle is severed or crushed, free flap is done with anastomosis to the corresponding components in the proximal stump (Cases 1 and 2).

The use of a sole flap provides a well vascularised soft tissue cover, which heals primarily and can serve as a good cushion for weight-bearing, offering pressure absorption and dispersion properties that increase tolerance to constant ambulation load.[8] In addition, a sole flap with an intact tibial nerve (Case 3) provides a sensate weight-bearing tissue, reducing the risk of ulceration. If the tibial nerve was severed in trauma, nerve anastomosis can be performed to provide at least partial sensation (Cases 1 and 2).

The use of a sole flap does have its disadvantages. Increased surgery time and surgical risk may make it unsuitable for patients who are medically unstable or unfit. Most significant is the need for surgeons with specialised expertise, including microsurgery, supported by the appropriate infrastructure. This is especially so for free flaps, which may not be suitable in places without such resources.

Conclusion

Patients with segmental crush injuries of the leg with severe soft tissue damage may be better treated with a BKA with stump coverage using a sole flap, instead of an AKA/TKA. Though orthopaedic surgeons primarily manage these injuries, the option of a BKA with a sole flap should be kept in mind. Hence, an early referral to a reconstructive microsurgeon would be beneficial. Close collaboration in the management of such difficult injuries would ensure the best possible outcome for patients.

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