“The Practical Perforator Flap”; *the sural artery flap for lower extremity soft tissue reconstruction in wounds of war.*

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Introduction

When faced with wounds of war or similar devastating trauma mechanism options for replacement of soft tissue and for tissue coverage of exposed bone about the knee are limited. Injuries such as blast and high velocity gunshots translate unpredictable forces and may result in ongoing loss of soft tissue following initial debridement. Soft tissue coverage via vascularized flaps might be necessary for definitive treatment and to achieve both functional results and some degree of cosmesis. In austere conditions a plastic surgeon might not be readily available to provide vascularized flaps for this kind of injuries. A sural artery perforator flap is a straightforward solution to treat a massive tissue defect around the knee. Herein we discuss two cases in which military trauma surgeons with no additional training in plastic surgery used rotational flaps to treat large soft tissue injury.

The current case reports and review of literature outlines difficulties faced in an austere setting in managing a blast injury involving the popliteal fossa in a child and the treatment of a high velocity gunshot wound to the proximal tibia in an adult.

Case 1

A 9 year old Afghani girl sustained a injury to the popliteal fossa due to a blast in which four members of her immediate family perished, The patient was presented after 24 hours of transport to an International Security and Assistance Force (ISAF) Role 2 medical facility in Uruzgan, southern province of Afghanistan. After primary survey, she was resuscitated and given analgesia. The extent of the injury was assessed via the Red Cross Wound Classification [1] as E8X0C1F1V0M2. The initial debridement under general anesthesia included the proximal third of both bodies of gastrocnemius, an avulsed fragment of the medial femoral condyle and the fat of the fossa. A second fragment of the femur, involving the joint could be preserved and fixed in place with two Kirschner wires. The soft tissues were approximated over the knee joint line and a Vacuum Assisted Closure (VAC) device was applied to the wound. Change of dressings was performed two days later. A major part of the joint was exposed with copious egress of synovial fluid. The bone fragments and K-wires were removed and subsequently split skin grafts (SSG) were applied to the granulating tissue. Again a VAC was applied and the SSG was inspected after 3 days. The majority of the SSG took, but the problem of synovial fluid discharge persisted.

To deal with this problem a more robust coverage of the joint was required. A medial sural perforator fasciocutaneous island flap was performed. Preoperative audible Doppler assessment located 2 usable perforator arteries in the medial calf. The surgery was facilitated by general anesthesia, tourniquet use, and the use of 2.5X surgical loupes with the patient placed in prone position. A flap was designed such that the distal perforator artery was centrally located in the flap. The flap dimensions were chosen to provide sufficient coverage of the joint, but also to make primary closure of the donor site possible.

The lateral aspect of the flap was raised first, to allow identification of the perforators. The incision was deepened through skin and subcutaneous tissue down to deep fascia. Incision of the deep fascia allowed the medial body of the gastrocnemius muscle to be found and a sole perforator to be identified. Subfascial dissection was then completed, looking for a second perforating vessel as indicated by Doppler, but this vessel could not be found. The only perforator was released during proximal exploration up to the previously debrided blast wound. There were no superficial veins found in the flap.

The flap was applied to cover the defect over the medial aspect of the posterior knee joint, and sutured with absorbable sutures. The limb was immobilized in a slightly flexed position with the aid of a padded plaster of Paris cast.

A small amount of distal flap necrosis needed to be removed on the third postoperative day, the remainder of the flap being vital. The synovial fluid discharge from the joint had diminished, and stopped after applying some additional sutures. Simple dressings were then applied to protect the flap and SSG. At one month, the flap was stable and intact. The patient recovered uneventfully.

Case 2

A 25-year-old male was evacuated to the same medical facility as Case 1 after sustaining multiple high velocity gunshot wounds to the right hand, right proximal tibia and left upper leg (Figure 1). After primary assessment and resuscitation, the wound to the tibia was classified by the Red Cross Wound Classification [1] as E5X6C1F2V0M0 grade 3 type VF. The posterior side of right lower leg was intact and no neurovascular injuries were noted. The tibial wound was debrided, and a joint spanning external fixator was applied over the proximal compound fracture of the tibia. A VAC was applied over the 10 by 12 cm tibial wound (Figure 2). After two days a second debridement was performed.

At this point, the patient was considered for amputation. Nevertheless, he wished for limb salvage at any costs, since he was the sole provider for his family. A decision was made to attempt limb salvage by means of tissue coverage by use of a local flap. Prior to surgery both medial and lateral sural artery perforators were marked with use of duplex ultrasound. The perforators from the lateral sural artery were found to have a larger diameter compared to the medial perforators (2.3 and 2.2 mm vs 1.5 and 1.7mm), hence the lateral side was initially chosen for flap harvesting.

The patient was positioned in semi-prone position after bone graft harvesting had been performed from the right iliac crest. A near to midline approach was chosen to assess the perforators. The musculocutaneous perforators could not be dissected from the muscle to their origin since they were situated beneath the fibula. For this reason a medial sural artery perforator fasciocutaneous island flap was chosen. This approach provided enough length to cover the tibial defect after rotation. After deflation of the tourniquet, the broad based flap remained vital on the cutaneous perforators (Figure 3). The flap was inserted and the donor site was covered by split skin graft taken from the upper leg. On day 4, most of the flap was vital, with a small necrotic medial border. This was resected and treated with a VAC®. The wound was managed by dressings on the ward. The patient was mobilized non-weight bearing for one month followed by mobilization with a cast for another two months (Figure 4).

Discussion

The use of perforator flaps for either pedicled of free tissue transfer is well established. Fascial, or fasciocutaneous flaps may be harvested without significant disruption of the underlying muscle. Functional deficit is therefore prevented as the muscle remains in place. The medial sural artery flap is a Type A fasciocutaneous flap based on the sural artery, a direct cutaneous branch of the popliteal artery. The flap is well described for reconstruction for soft tissue defect as either a free graft or local flap in the upper 1/3 of the tibia. The flap can measure up to 12.9 x 7.9 cm and at least 1 perforator is found in each flap, with an average of 1.9 perforators found in the anatomical study by Thione et al [2].

Cavadas [3] first described the medial sural artery perforator free flap and provided precise topography of perforating vessels from the medial and lateral gastrocnemius muscle. Others have described the anatomy of the perforating vessels that supply the fascia and skin of the posterior calf in more detail [4-6]. Hallock [4] described that successful preparation of a medial sural artery perforator flap was possible in 90% of cases. Walton and Bunkis [7] suggested that the requirement to base such flaps on a dominant vessel is not required due the cutaneous vascular plexus between the heads of gastrocnemius. Nevertheless, it is not known whether this also the case in the affected limb after major trauma. Kim et al [8] described of location of the main perforators situated along a line from the midpoint of the popliteal crease to the midpoint of the medial malleolus. The first two perforators are most likely to be found at 8 cm and 15 cm, respectively, measured from the midpoint of the popliteal crease. In the cases described here audible Doppler or Duplex investigation was used across this line for identification of perforators. The flap was outlined as such that the distal perforator artery was situated in the center. This ensured maximum length for rotation. Cavadas [3] described the raising of the flap using a tourniquet and a non-exsanguinated limb. Preoperative Doppler sonography was demonstrated to be useful for locating the position of individual perforating vessels Hallock and Giunta et al Khan et al [9-11]. The use of loupe magnification as advocated by Cadavas [3] facilitated the identification and dissection of the perforator vessels. Particularly in the case of the child this strategy was of use, but was not applied during flap harvesting in the adult patient. Results of sural artery flaps are generaly favorable. Suri et al described use of this proximally based islanded sural artery flap for the lower thigh, knee, and upper leg defects in 37 patients. No complete failures in the series were seen with only one flap requiring additional bipedicled flap for the necrosis of distal margin [12]. Gill et al described results of their experience in soft-tissue reconstruction of leg and foot; of 168 flaps, 154 survived completely, 9 flaps suffered partial necrosis and 5 failed completely [13]. Okamoto describes similarities in anatomy for medial sural artery perforators in Caucasians and Asians suggesting that the medial sural artery flap may be universally possible [14]. A practical algorithm for lower extremity soft tissue coverage, including the medial sural artery flap, has been proposed by El-Sabbagh [15].

In both our cases, the patient was placed in the (semi)prone position. This allowed access to both the flap to be harvested and the placement of the flap onto the defect and has been found useful in previous studies [16]. Both cases were commenced by a posterior incision through the deep fascia. This allowed the perforators to be assessed prior to the final skin outline being incised. This strategy allows for a change of strategy based on the local course of the lateral sural perforators. Both flaps provided a robust thickness of tissue and provided adequate sealing of the joint and to cover bone. More significantly the flap pedicle length, even though limited in Case 1 by blast defect, allowed for sufficient rotation. In Case 1, the flap was rotated over 180 degrees to be placed upward onto the joint line and the skin defect could be closed primarily. In Case 2, the flap was rotated around the leg to overly the tibial tuberosity and proximal shaft defect. A split thickness graft allowed for tissue coverage of the harvest site.

The care of local nationals is a reality for most deployed medical forces in combat. Decisions regarding the extent of such humanitarian aid are made by commanding officers. Depending on the level of involvement, challenging surgical cases often need to be managed in a geographically and culturally sensitive fashion. Significantly, the constraints of war and equipment also impact on the management of local civilians. Local nationals are usually unable to be moved out of country for further care, necessitating a definitive local solution. In this context, the management of compound and complex lower limb injuries is a challenge for the deployed surgeon. The surgeon must deal with extensive soft tissue damage, often without having broad reconstructive experience or the benefits of a microvascular armamentarium. The study by Boopalan et al supports soft tissue cover of lower limb defects by a single team involved in bony stabilization and reconstruction using local flaps as an alternative if resources are limited [17].

Conclusion

Both cases described, represent local nationals in Afghanistan, who were delivered to an ISAF medical facility that is mainly equipped for damage control procedures. There were no alternative care providers nearby and no reconstructive surgery equipment was available. We believe, in such an austere setting, the medial sural artery perforator flap to be a feasible strategy for soft tissue reconstruction performed by trauma surgeons. It allows for soft tissue coverage of exposed critical bone and join, facilitating limb salvage without excessive consumption of resources or morbidity to the patient.

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Abstract

Background: Sural artery perforator flaps have been described for use as both local flaps and in free tissue transfer. We present the use of this flap for compound soft tissue defects of the lower limb in civilian casualties of armed conflict in Afghanistan.

Methods/Results: Detailed description of the management of blast and high-velocity projectile wounds of the lower extremity with the use of local sural perforator flaps and a review of literature.

Conclusions: Sural artery perforator flaps may be harvested to cover complex lower limb defects. The use of this technique is not limited to centers with complex surgical armamentarium per se, but is feasible for surgeons with good understanding of the local anatomy.

The subject matter for this paper has been presented at the British Military Surgical Conference 23-24 April 2009.

The authors declare no conflicts of interest.

Figure 1

X-ray of proximal compound tibial fracture

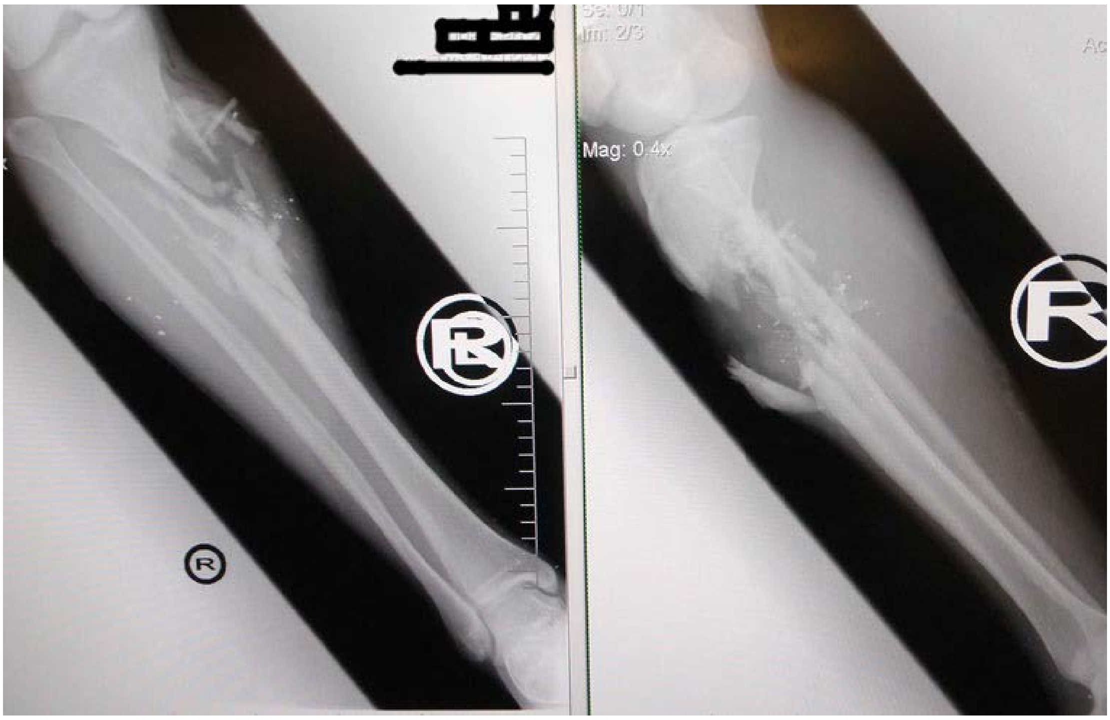

Figure 2

Soft-tissue defect of proximal tibia after joint spanning external fixator and debridement.

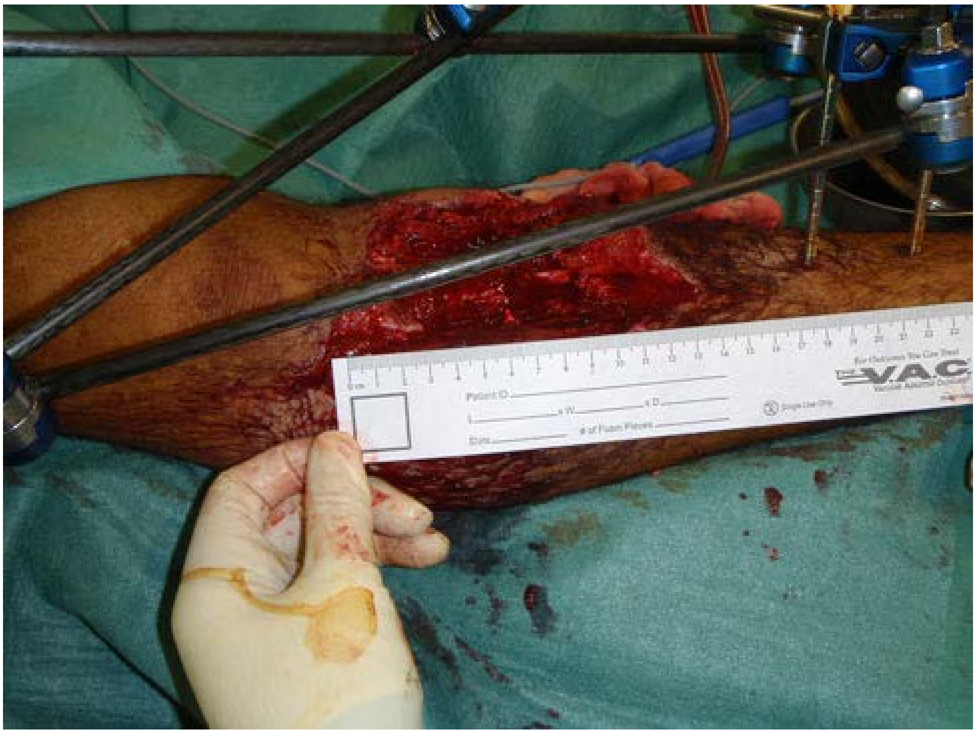

Figure 3

Medial sural artery perforator fasciocutaneous island flap in position

Figure 4

Final situation after medial sural artery flap and split skin graft

Figure 5

Anatomical specimen *right lower* extremity *MGH* medial gastrocnemius muscle head, *LGH* lateral gastrocnemius muscle head, *PA* popliteal artery, *SA* sural artery, *SV* sural vein, *SN* sural nerve, *LP* lateral perforators, *MP* medial perforators