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The Use of the Pedicled Nonislanded Foot Fillet Flap to Avoid an Above-the-Knee Amputation after Trauma

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Background: Lower extremity trauma can have a devastating effect on the quality of the life of patients. To avoid limb amputation and its associated social stigma, many patients spend years undergoing multiple costly procedures, with prolonged hospital stays, all the while hoping for an elusive limb salvage. People with lower limb amputation experience higher energy requirements for walking, reduced aerobic capacity, and slower walking speeds, when compared with people with normal limbs. A below-knee amputation (BKA) is functionally superior to an above-knee amputation.

Methods: Between 2012 and 2023, five patients underwent BKAs with a nonislanded foot fillet flap reconstruction of the BKA stump. Four of these patients had undergone previous multiple procedures in attempts at limb salvage. While two patients had sustained recent trauma, three were operated on electively.

Results: All the BKA stumps healed without any complications. Only one patient complained of phantom limb pain. One patient will require the reconstruction of a lateral knee collateral ligament.

Conclusions: This case series demonstrates the versatility of the pedicled foot fillet flap in addressing the different complications of lower extremity injury that may result in an unusable limb. The utility of this technique is especially valuable in low-resource settings where the built environment may be unfriendly to nonbipedal ambulation, and an urgent need for a return to economic productivity. Because prostheses are fairly accessible in Kenya, return to ambulation and economic productivity are anticipated following a BKA. *(Plast Reconstr Surg Glob Open 2024; 12:e6070; doi: 10.1097/GOX.0000000000006070; Published online 27 August 2024.)*

INTRODUCTION

Lower extremity trauma can have a devastating effect on the quality of the life of patients. Lower limb amputations (LLAs) have functional, psychological, social, and economic implications for the patient and their family.[1,2] Although the decision to perform a limb amputation rather than attempt limb salvage is largely dependent on the extent of the vascular, soft tissue, and bone injury,[3] in sub-Saharan Africa, additional factors that may militate against patients and families consenting for amputation include a lack of adequate information, fear of complete loss of independence, and the associated loss of economic productivity.[4,5] In many parts of Africa, family members often have to be consulted before patients can consent to the procedure.[4,6] To avoid limb amputation and its associated social stigma, many patients spend years undergoing multiple costly procedures, with prolonged hospital stays, all the while hoping for an elusive limb salvage.[4,5] Multiple attempts at limb salvage are also reported from high-income settings.[7] Such patients may ultimately become physically inactive, and even wheelchair-bound, whereas those who elect to undergo primary amputation may return much earlier to independent ambulation with a prosthesis and a productive life.[8,9] Although amputation remains a last resort for many patients and their surgical providers, the quality of life and pain control are improved in amputees who recognize the value of the procedure and accept their outcomes, leading to an early return to active lives.[2,4,8]

The primary aim of LLA is to enable patients to attain the best quality of life, along with the avoidance of repeated future hospitalizations for the management of limb complications.[10] An important consideration in LLA is the stump length; people with LLA experience higher energy

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requirements for walking, reduced aerobic capacity, and slower walking speeds, when compared with people with normal limbs.[11] The more proximal the amputation, the greater the extent of gait morbidity and energy expenditure: above-knee amputation (AKA) patients exert 65% more energy to walk at half the speed of nonamputees.[12–16] Therefore, every effort should be made to perform LLA at the lowest functional level possible, ie below-knee amputation (BKA). A BKA, because it preserves the knee joint, is functionally superior to an AKA. People with AKA are more likely to be nonambulatory after a year. Additionally, AKA is associated with significantly higher postoperative mortality rates than BKA.[17–21]

In patients undergoing LLA, who have insufficient soft tissue coverage of the injured limb, "spare parts" surgery may help transform an imminent AKA into a BKA.[22–25] Spare parts surgery uses undamaged tissue from otherwise nonsalvageable or amputated limbs in the reconstruction of complex tissue defects, with the added benefit of no associated donor site morbidity.[25] While most are reported as a strategy in acute trauma, spare parts surgery may also be used electively to reconstruct a functional knee in a limb that was previously unusable.[26]

In lower limb reconstruction, the foot is often distal to the site of injury/morbidity and remains well-perfused and sensate, and therefore, it serves as an excellent source of soft tissue, a "spare part," for a foot fillet flap.[27] The foot fillet flap achieves the main aims of amputation, as it provides a sensate, durable soft tissue cover that maximizes stump length.[22–29] Foot fillet flaps are axial-pattern flaps that can be used for composite tissue transfer either as pedicled or free flaps.[25] Pedicled flaps may be based on the posterior or anterior tibial neurovascular bundles, or both.[27] Unlike flaps from other donor sites, foot fillet flaps have been shown to offer a true protective sensation.[22,25] A sensory flap provides longer-term flap viability, increased prosthesis compliance, and reduced susceptibility to pressure wounds.[28,30] Additionally, skin from the sole is especially suited for weight bearing, as it efficiently absorbs shear forces.[26,29]

The authors describe their experience with a series of five patients managed with the foot fillet flap, so as to avoid an AKA.

METHODS

Ethical approval for this study was given by the institutional ethics review board.

Between 2012 and 2023, five patients underwent BKAs with a nonislanded foot fillet flap reconstruction of the BKA stump. Patient demographics, clinical presentation, and outcomes at the last clinic visits are presented in Table 1. Three of the five patients presented at different stages after having experienced road traffic accidents; one patient had sustained burn injuries as a child, whereas the cause of injury was unknown in the fifth patient.

All patients except patient 2 had their BKAs reconstructed with a pedicled foot fillet flap as a salvage procedure after having undergone previous interventions. The indication for amputation was uncontrolled infection following trauma in patients 1 and 5, whereas patients 2, 3, and 4 each had a nonfunctional leg that lacked adequate mobility, strength, and length.

Takeaways

Question: What is the foot fillet flap, and what are the potential indications for its use in a low-resource setting?

Findings: The pedicled foot fillet flap is a versatile tool that helps transform imminent above-knee amputations into below-knee amputations, with minimal complications.

Meaning: The pedicled nonislanded foot fillet flap is especially useful for surgeons in LMICs because it is associated with fewer complications and permits salvage of the knee joint, thereby improving amputee mobility with prosthesis in an otherwise difficult-to-navigate built environment for the nonbipedal individual.

Authors' Surgical Technique

With the patient under spinal anesthesia, the limb is cleaned, draped, and then elevated for at least 5 minutes before application of a tourniquet. This empties the limb vasculature of blood, but leaves sufficient intravascular blood for ease of vessel identification during dissection, allowing the preservation of the neurovascular bundle(s), and careful hemostasis. If the tibia is not already exposed by trauma, a longitudinal incision on the skin is made from the determined level of tibial transection (between 12 and 18 cm below the tibial tubercle) to the dorsum of the second toe, down to bone. (Figs. 1 and 2) The tibia is transected at the level of the amputation, and dissected free of soft tissue circumferentially distally to the ankle joint. The fibula is then exposed, transected at least 3 cm proximal to the tibia, and similarly dissected free, distally to the ankle joint. In the foot, the calcaneus is dissected free after the rest of the foot skeleton has been excised. Depending on the amount of desired tissue, the soft tissue of the toes are retained in the foot (Figs. 3 and 4). The anterior leg compartment is resected, and the anterior tibial vessels ligated proximally. The lateral leg compartment is similarly resected, while preserving the uninjured, the peroneal vessels. If the remaining soft tissue can cover the BKA stump adequately, then the stump is fashioned. Additional on-table muscle-debulking is performed until desired stump bulk and coverage is achieved, always taking care to preserve tissue directly adjacent to the neurovascular bundles. The posterior tibial vessels and tibial nerve are the mainstay of the flap, and the posterior compartment muscles, especially the gastrocnemii muscles, are not debulked, so as not to imperil blood supply to any overlying skin. These muscles effectively protect the neurovascular bundles from compression and kinking, an issue that would be of concern in island foot fillet flaps. (Fig. 4) All the patients in this series had sustained extensive skin cover loss, with or without loss of muscle bulk (Fig. 2); the gastrocnemii muscles provided important tissue for the coverage of the salvaged stump. All the skin on the flaps was used to cover the stump. (Figs. 4 and 5) None of the patients followed up so far has required stump

Table 1. Patient Demographics with Presenting Complaints and Surgical Outcomes

Patient No.	Sex/ Age (y)	Presenting Lesions	Cause of Injury	Time Since Injury	Prior Treatments	Comorbidities/ Complications	Postoperative Complications	Time until First Prosthesis (mo)	Length of Hospital Stay (d)	Knee Range of Motion and Sensation	Duration Follow-up (mo)
1	M/28	Circumferential degloving injury of right lower extremity, with exposed segmental tibia/fibula fracture	Road traffic accident	25 d	Five debridements	Gross contamination; massive skin necrosis and infection; alcohol use disorder	Phantom pain	Lost to follow-up	17	Inadequate follow-up. Splinted at 0 degree extension on discharge. Stump sensation could not be evaluated	Lost to follow-up
2	F/16	Complex contractures involving the right knee and ankle	Burn	16 y	None	Resides in a refugee camp	None	Lost to follow-up	22	Fixed at 45 degree flexion preoperatively, distracted to 130 degrees. Not seen again after removal of distractor	4 (Lost to follow-up)
3	M/24	Right foot lympedema, in equinus	Unspecified trauma	18 y	Circumferential skin graft of mid-distal right lower limb	Multiple large lymph nodes in groin and popliteal fossa (lymphangitis)	None	5	7	Initially fixed 135 degrees. Postoperatively 20 degrees–90 degrees flexion. Normal stump sensation.	5
4	M/25	Degloving injury of distal thigh, leg, and dorsum of foot; lower limb lymphedema and extensive ulceration	Road traffic accident	5 y	Multiple skin grafts at a different facility	Limb lymphedema, chronic nonhealing wounds	None	6	14	0 degrees (extension) to 130 degrees, preoperatively. Range regained postoperatively. Normal stump sensation.	36
5	M/34	Extensive soft tissue loss and degloving injury of leg leg; open fractures of the left tibia, fibular head, and ankle joint; laceration of anterior tibial vessels, and deep peroneal nerve	Road traffic accident	5 d	Four debridements	Infected open left ankle joint dislocation	Lateral knee instability	5 months since surgery. Awaits surgery for lateral collateral ligament	42	0 degrees (extension) to 100 degrees. Normal stump sensation	5

F, Female; M, Male.

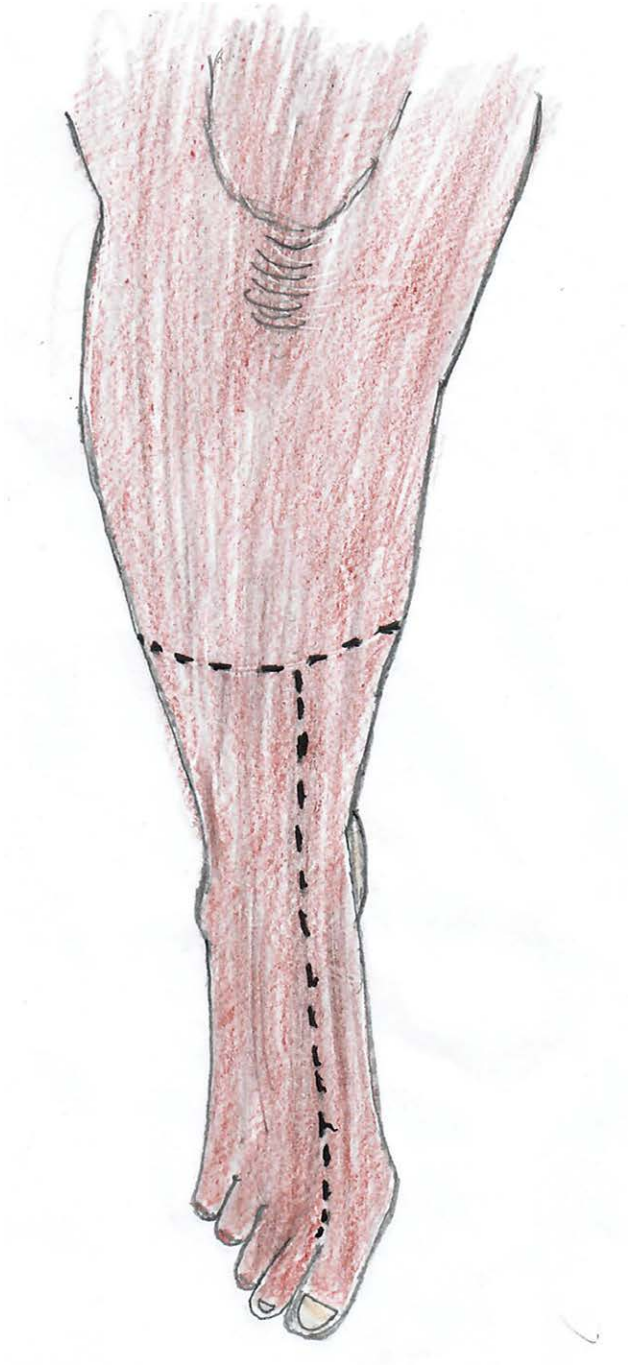

Fig. 1. The dotted black line depicts site of tibial transection (transverse line) and skin incision (longitudinal line) for a planned foot fillet flap procedure.

Fig. 2. Patient 5 had an extensive skin flap avulsion and wound infection that affected his knee. (Note that none of the patients had a complete skin envelope).

debulking. Additionally, we ensure that the stump base is covered with healthy and durable integument, even when the plantar skin does not form the most distal part of the stump (Fig. 5). The tourniquet is then deflated to confirm hemostasis and flap viability, following which the flap is inset. The foot fillet flaps of patients 1–4 were perfused by the posterior tibial and peroneal vessels, while that of patient 5 was perfused by the posterior tibial vessels only, as the peroneal artery had been injured during the accident. Areas of the stump with no skin are skin grafted as needed. A typical foot fillet flap takes approximately four hours with blood loss of approximately 100 mL, as most of the procedure is performed under a torniquet; above- or through-knee amputations, on the other hand, take less than 2 hours, with blood loss of less than 50 mL.

In general, sutures and skin staples are removed at the end of postoperative week 2, and the stump is splinted in extension for the first 3 weeks. Once the wounds have healed, the stump is dressed with a compression stocking to aid the development of a firm, well-rounded stump,

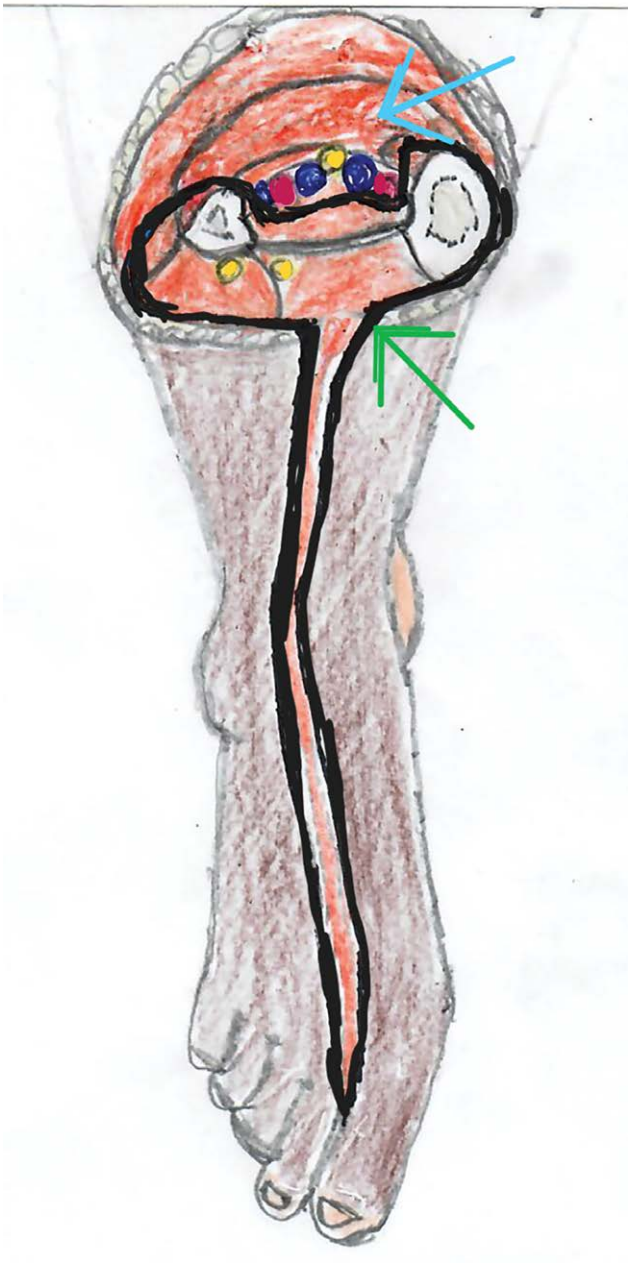

Fig. 3. Figure depicting foot fillet flap preparation: the black continuous line (green arrow) shows the line along which tissue is resected, including the anterior and lateral leg compartments. The posterior compartment (light blue arrow) is debulked on table, as needed, to avoid the need for future stump debulking.

Fig. 4. Patient 5, nonislanded foot fillet flap ready for stump reconstruction.

in preparation for prosthesis fitting. The patients begin range of motion exercises after week 3, with night splinting for another six weeks, after which night splinting is discontinued. Patients wait for six months between surgery and prosthesis fitting by the orthotists.

RESULTS

Table 1 provides an overview of the demographics and outcomes of the five patients in this series, and Figures 2, 4 and 5 are the preoperative and postoperative photographs of patient 5; these depict the surgical steps in performing a foot fillet flap procedure. Patient 2 experienced phantom pain, whereas patient 5 had lateral knee instability because of a destroyed lateral collateral ligament, and is awaiting reconstruction by the orthopedic team (Fig. 5). No other major morbidity or complication was reported by patients in this series. Patient 5, who of the patients in this series presented the most acutely, had the longest hospital stay, as patient-requested limb salvage attempts were

made before the BKA. He wanted limb salvage at any cost, despite counseling that this would not be possible, given the extensive trauma, muscle loss, and ongoing infection. It is anticipated, however, that he will develop early knee arthritis because of the initial fulminant septic arthritis.

On follow-up, knee joint range of motion and stump sensitivity were inconsistently recorded, and are reported in Table 1. Prosthesis fitting was done at 6 and 5 months after surgery for patients 1 and 3, respectively. Patients 2 and 4 were lost to follow-up, and data on their prosthesis uptake and long-term functional outcomes are not available, but their early postoperative results were favorable. Patient 5 is awaiting stump maturation and lateral collateral ligament reconstruction before prosthetic fitting.

DISCUSSION

Foot fillet flaps can be successfully used to reconstruct tibial amputation stumps, and thereby avoid AKAs, with minimal complications, as demonstrated in this patient series.[31,32] The case mix in this series demonstrates the versatility of the pedicled foot fillet flap in addressing the different complications of lower extremity injury that may result in an unusable limb. In the three elective cases (patients 1, 2, and 4), the injured leg was a burden, and the BKA enabled bipedal ambulation.

The utility of this technique is especially valuable in low-resource settings where the built environment may be unfriendly to nonbipedal ambulation, and there is an urgent need for a return to economic productivity.[33,34] The relative ease of access to free prostheses for below-knee amputees in Kenya means that these patients can all receive prostheses upon stump maturity.[35]

The primary goal of the reconstruction of complex lower limb defects is the attainment of skeletal stability, a stable wound cover, plantar sensation, and painless weight bearing. Successful lower extremity reconstruction does not always mean leg and foot preservation at all costs, but rather the attainment of optimal functional outcomes and avoidance of long-term problems. Unfortunately, because there are no algorithms that accurately predict what limbs can or cannot be salvaged,[36] patients and their doctors may spend years fruitlessly pursuing limb salvage.

The pedicled foot fillet flap is suited for patients in whom there is insufficient soft tissue and skin to provide stump coverage following a BKA. In such cases, achieving typical stump cover would not be feasible without having to shorten tibial length, or resorting to a through-knee amputation, with loss of knee function. The use of spare parts surgery, which employs a foot fillet flap, has been used to provide additional soft tissue cover to ensure the BKA stump is of adequate length, thereby maintaining knee joint function, and enhancing mobility.[25,28,37] While the majority of foot fillet flaps reported in literature have been used following LLA, they have also been used in a variety of other settings, including oncologic reconstruction.[38]

Foot fillet flaps by definition are composite axial flaps that may provide skin, muscle, fascia, and bone, as needed.[25] These flaps may be pedicled or free, islanded or nonislanded, and may incorporate bone, muscle, or skin, as required to reconstruct the defect. Foot fillet flaps may be based on the anterior tibial artery, posterior tibial artery, or both.[24,25,29,38]

All patients in this series received a pedicled myocutaneous nonislanded foot fillet flap based on the posterior tibial vessels. In the five patients, all the available skin on the fillet flap was to provide adequate stump integument cover. A few patients required additional skin grafts to cover the remaining open wounds. Patient 5 had a concomitant right mangled upper extremity, which made knee salvage a critical component of his care to enable him to ambulate independently without a walking aid in the long term.

Free foot fillet and islanded pedicled foot fillet flaps entail dissection of the vascular pedicle. Blood vessels are at risk of injury during such dissections in inflamed wounds, making anastomoses difficult in free foot fillet flaps.[39] A variety of other free tissue flaps have been described to cover the BKA stump for length preservation, including latissimus dorsi, rectus abdominis, scapular, and groin flaps.[22,40] These, however, entail the use of an additional flap donor site, a disadvantage obviated by the use of spare parts in foot fillet flaps.

Important potential complications of the islanded foot fillet flap include flap venous insufficiency and problems associated with pedicle redundancy such as pedicle kinking during flap inset and compression of the coiled pedicle in the stump pocket. The nonislanded pedicled foot fillet flap avoids neurovascular pedicle dissection and vascular anastomosis with their associated potential complications, giving this flap a much higher safety profile. Flap bulkiness is the main disadvantage of this flap, and flap debulking may be needed as a secondary procedure.[37,39] The senior author, while avoiding vessel dissection, performs muscle-debulking as primary as possible, without endangering skin perfusion.

The avoidance of microvascular anastomoses is the pedicled foot fillet flap's primary benefit over a free foot fillet flap or other free flaps for surgeons in many LMIC settings, where access to the financing, tools, or training necessary to support independent microsurgical practice may be limited.[41] The use of foot fillet flaps has been reported to reduce the likelihood of phantom limb pain; only one patient in our series reported phantom limb pain.[16]

CONCLUSIONS

The pedicled nonislanded foot fillet flap, using the spare parts principle, can be oncological to cover and lengthen BKA stumps, and therefore avoid AKAs. AKAs are associated with reduced functionality, more gait morbidity, increased energy expenditure, longer prosthesis fitting times, and more overall mortality when compared with BKAs. The pedicled nonislanded foot fillet flap is especially useful for surgeons in LMICs because it is associated with fewer complications and permits salvage of the knee joint, thereby improving amputee mobility with prosthesis in an otherwise difficult-to-navigate built environment for the nonbipedal individual.

Fig. 5. Patient 5, postoperative healed, stable stump. Note the obvious genu valgus deformity secondary to a lateral collateral ligament injury.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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