Surgical management of a diabetic calcaneal ulceration and osteomyelitis with a partial calcanectomy and a sural neurofasciocutaneous flap

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The treatment of calcaneal osteomyelitis in diabetic patients poses a great challenge to the treating physician and surgeon. The use of a distally based sural neurofasciocutaneous flap after an aggressive debridement of non-viable and poorly vascularized tissue and bone that is combined with a thorough antibiotic regimen provides a great technique for adequate soft tissue coverage of the heel. In this case report, the authors describe the aforementioned flap as a versatile alternative to the use of local or distant muscle flaps for diabetic patients with calcaneal osteomyelitis and concomitant large wounds.

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he management of chronic calcaneal osteomyelitis has always been difficult to treat especially in patients with significant comorbidities such as insulin-dependent diabetes mellitus, peripheral vascular disease, and dense peripheral neuropathy. The treatment choice for these patients is eradication of the non-viable soft tissue and infected bone with preservation of the weight-bearing function of the foot. Masquelet et al. (1) introduced the concept of neurocutaneous flaps supplied by the vascular axis of the sensitive superficial nerves in the leg, the distally based sural flaps. The sural fasciocutaneous flap is extremely useful for the treatment of calcaneal defects. Its technical advantages include an easy dissection with the preservation of more important vascular structures of the limb and an allowance of complete coverage of the soft tissue defect in just one operation without the need for microsurgical anastomosis. The final outcome leads to a well-vascularized cutaneous islet and thus a reliable flap. This flap has also proven valuable for filling bony defects and treating bony infections since it can also provide a well-vascularized

muscle segment if necessary. The sural flap is designed on the proximal half of the posterior calf and has an adequate blood supply derived from retrograde perfusion of the vascular axis of the sural nerve to the musculocutaneous perforators of the gastrocnemius muscle. The aim of this case report is to present the treatment results from the management of a severe plantar calcaneal osteomyelitis with a large concomitant ulceration with a reverse flow sural neurofasciocutaneous flap in a patient with diabetes mellitus and dense peripheral neuropathy.

Case report

A 46-year-old female with a history of diabetes mellitus, morbid obesity, peripheral vascular disease, and dense peripheral neuropathy was initially treated in another facility (private outpatient clinic) for a calcaneal puncture wound with multiple incision and debridement procedures. The patient had a history of smoking for many years and also sustained a calcaneal osteomyelitis secondarily to the original infection with *Staphylococcus aureus* and *Pseudomonas aeruginosa* organisms (Fig. 1A).



Fig. 1. (A) Preoperative picture of the left calcaneal osteomyelitis with the large wound at initial presentation. (B) Preoperative angiography showing the popliteal artery occlusion.

In our facility, the patient had immediate non-invasive vascular studies that were followed with a lower extremity angiography that showed a vascular occlusion of the popliteal artery around the popliteal fossa (Fig. 1B). The patient had agreed to quit smoking and was educated on a diabetic diet regimen with tight control over her blood sugars. At that time, the vascular surgery team performed a lower extremity bypass surgery (femorotibial) with the use of a saphenous vein graft while our team performed a simultaneous aggressive debridement of all the necrotic bone and soft tissue. Intraoperative bone and soft tissue cultures and biopsies were also obtained.

A postoperative regimen of deep vein thrombosis prophylaxis (low molecular heparin) and intravenous antibiotics based on the culture results (Keftazidim: 2 g \times 3 doses and Vancomycin: 500 mg \times 3 doses) were initiated and the patient's vascular status of the lower extremity was monitored for approximately 3 weeks. A significant improvement of the skin temperature and blood perfusion of the limb was observed and it was confirmed with further Doppler non-invasive vascular studies.

At that time, the patient then had further surgical debridement and closure of the large calcaneal defect with a reverse flow sural neurofasciocutaneous flap. At the beginning of the surgery, a revisional resection of the calcaneal osteomyelitis was performed. The exact bone resection was defined with a macroscopical inspection under loop magnification $(6 \times)$ combined with blue

methylene fast staining and successive immediate multiple irrigations with normal saline solution. The procedure was followed with the flap dissection of the sural artery and associated neurovascular structures that were identified and ligated proximally. The flap's pivot point was located distally over the defect area and approximately 5-7 cm proximal of the lateral malleolar area. The flap was innervated with end-to-end coaptation of the sural nerve at the distal end of the lateral plantar nerves with epineural sutures. The sural flap was then rotated to the defect area and was secured without any skin tension (Fig. 2). The donor area was covered with a split thickness skin graft that was harvested from the ipsilateral thigh. The neurovascular bundle was covered primarily with an approximation of the angles of the 'Z'-initial incision in order to avoid skin tension. The rest of the uncovered areas were grafted with split thickness skin from the ipsilateral thigh. The sural flap dimensions were approximately 6.5×15 cm in diameter.

During the first postoperative week, the flap sustained a superficial venous congestion and approximately 5% of the flap coverage was lost due to skin necrosis. The venous congestion was managed with the use of a vasodilating agent Buflomedil Hydrochloride (600 mg \times 1 over 24 h) and an oral micronized purified flavonoid fraction (MPFF; Daflon, a vasoprotector and venotonic agent). The epidermal necrosis was healed after a minor surgical revision and loose reattachment of the flap margins. During the postoperative period the patient



Fig. 2. (A) Intraoperative picture showing harvesting of the large sural pedicle flap to cover the calcaneal resected osteomyelitis with a severe soft tissue loss. (B) Immediate postoperative picture showing the insetting of the sural flap at the recipient area with minimal skin tension.

continued the intravenous antibiotic therapy for 2 months, followed by oral antibiotic therapy for more than a 1-month period. Serial postoperative pedal radiographs had shown no evidence or recurrence of the calcaneal osteomyelitis. The patient was also kept non-weight bearing for approximately 3 months after the initial surgery. The flap was completely healed and the patient was ambulatory with a custom molded shoe at 4 months postoperatively (Figs. 3 and 4).

Discussion

The majority of diabetic foot ulcerations with underlying osteomyelitis are clinically unsuspected and often masked by infected and necrotic soft tissue. If the treatment of osteomyelitis in a diabetic foot ulceration is not adequate, the risk of lower limb amputation will increase (2). Chronic diabetic foot ulcerations with exposed or probing to bone upon clinical examination may be treated for osteomyelitis. Newman et al. (3) observed that osteomyelitis was present in 100% of diabetic foot ulcers in which the underlying bone was also exposed. Grayson et al. (4) also stated that 'palpation of bone in the depths of infected pedal ulcers in patients with diabetes is strongly correlated with the presence of underlying osteomyelitis.'

In our case report, the chronicity of the calcaneal exposure coupled with the inadequate soft tissue coverage led to the incidence of calcaneal osteomyelitis, which was surgically resected and covered with a reverse flow sural neurofasciocutaneous flap closure. The advantages of this flap compared to other covering methods are the simplicity of the design, the dissection of the pedicle sural flap that can be carried out with a loop magnification without the need for microsurgical instrumentation or anastomosis along with the preservation of the principle vascularization of the lower limb, and the need for only one operation. The sural flap constitutes for a well-vascularized cutaneous islet and offers the possibility of covering a broad range of areas with cutaneous defects in the distal malleolar areas. The sural flap can also be used in cases with serious peripheral vascular compromise as long as the peroneal artery is intact or when a microsurgical procedure is contraindicated. One of the few disadvantages of this flap is that by sacrificing the sural nerve, an inevitable anesthesia area appears over the lateral aspect of the foot that usually is well tolerated by the diabetic patient (5–7).

Masquelet et al. (8) was the first to describe the vascularization of the skin in the lower limb and the arteries that follow the trajectory of the peripheral nerves. The sural nerve projects distally in the leg and is in close approximation with the lesser saphenous vein. This nerve is supplied by the superficial sural artery in the proximal third of the calf and by fasciocutaneous branches arising from the peroneal artery in the distal half of the leg along with the suprafascial course of the sural nerve. The sural artery anastomoses with the peroneal artery by means of 3-5 fasciocutaneous perforators that ensure adequate inverse perfusion of the flap. The peroneal artery supplies the sural artery and venous anastomoses circulate along this artery to ensure venous return. Several authors have demonstrated that the main anastomosis of this arterial network is located around 5 cm proximal to the lateral malleolus (9-14). Some surgeons do not include the sural nerve in the flap based on the existence of a perforated branch of the peroneal artery that by itself is capable of perfusing the graft without the need to transfer the accompanying nerve (9, 10, 2, 15, 16). In our case report, the sural nerve was included in the pedicle flap dissection.

In addition, some authors have advocated the utilization of a Doppler test prior to the intervention that will confirm the integrity of the peroneal artery, its anastomosis with the fasciocutaneous branches, and the precise localization of the pivot point on which the flap should rotate (6, 9, 12). Additional lower extremity angiography may also be needed if the peroneal artery has questionable viability. In our case report the size of the flap was quite large (6.5×15 cm) and although (according to the literature) the complication rates increase secondarily to the harvested pedicle flap size, we did not observe a significant postoperative edema and any donor side morbidity.

In this case report, other alternatives for flap closure could have included the utilization of a free flap, lateral supramalleolar flap, and/or the posterior tibial perforator



Fig. 3. Postoperative outcome at 4-month follow-up.



Fig. 4. Final postoperative outcome and range of motion of the ankle at 7-month follow-up.

flap. Free flap reconstruction of defects requires a lengthy and costly hospitalization, microsurgical training and experience, special instruments, and a two-team surgical approach. The long operative time and functional donorsite morbidity are major disadvantages of this method, especially in patients with diabetes mellitus and multiple associated comorbidities. The lateral supramalleolar skin flap offers a range of coverage similar to that of the sural flap but the dissection is more difficult and offers no more advantages when it is compared to the sural flap. Theoretically, the sural flap does not cover as distally as the supramalleolar flap but it has been reported that the distally based sural flap is more reliable regarding the minimal venous congestion and has the ability to cover large weight-bearing areas of the foot (5). Finally, the posterior tibial perforator flap could have provided another alternative but its main disadvantages included a more difficult dissection and a larger learning curve (6).

In conclusion, the sural neurofasciocutaneous flap is a simple and reproducible method that can be utilized with a low rate of complications and needs to be considered for soft tissue coverage of any difficult to close calcaneal wound with concomitant osteomyelitis in patients with diabetes mellitus.

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