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Limb salvage for calcaneal osteomyelitis with pin to bar external fixation

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The prevalence of heel ulcers is as high as 18% in hospitalized patients. Due to lack of underlying muscle, protective fat pad, and constant pressure, poor tissue perfusion to the area inhibits healing. Concomitant comorbidities such as diabetes, neuropathy, and peripheral arterial disease provide added challenges to limb salvage. The incidence of surgical intervention in a diabetic patient with foot ulcers is 97%, with 71% going on to some form of amputation. Our study includes 10 patients with underlying calcaneal osteomyelitis who were treated with partial calcanectomy with primary flap closure and offloading pin to bar external fixation. Primary closure was achieved in 100% of patients with an average time of 106 days (ranging from 43 to 205 days), with no pin tract infections, revisional bone debridement, or subsequent BKA/AKA. Average follow-up time was 20.9 months (ranging 12 to 45 months). Partial calcanectomy with offloading pin to bar fixation allows for cost-effective fixation, accelerated healing, and a satisfying functional result in true limb salvage cases.

Keywords: Limb salvage, calcaneal osteomyelitis, external fixation, infection

Pressure ulcers to the heel are recognizably difficult to treat due to their anatomic location, and the prevalence of heel ulcers is as high as 18% in hospitalized patients [1]. The plantar and posterior aspects of the calcaneus are constant areas of pressure in both the sedentary or standing position. The lack of underlying muscle and common atrophy of its protective fat pad hinders tissue perfusion to the area. The associated diagnoses including diabetes, neuropathy, and arterial disease inhibits normal healing. Calcaneal ulcers are also accompanied by higher costs and have proven to be two to three times less likely to heal in comparison to forefoot ulcers [2]. Many of these patients are quickly consulted for a below knee amputation as a definitive treatment. Patients are able to use a prosthesis for a quick return to function, however, a BKA amputation increases energy expenditure by 25% and 33% of BKA amputees do not survive beyond two years [3,4].

Calcaneal osteomyelitis can be classified based on route of infection. The Waldvogel classification includes hematogenous, direct or contiguous, and chronic osteomyelitis [5-7]. Hematogenous osteomyelitis results in bacteria disseminated into the bloodstream emanating from an identifiable focus of infection or developing during transient bacteremia unrelated to infection. Direct or contiguous osteomyelitis is caused by spread from adjacent sources or contact between bacteria and tissue and may be traumatically or surgically induced. Chronic osteomyelitis is the result of the coexistence of infected, nonviable tissues and an ineffective host response [8]. The attempt of preserving the calcaneus

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is beneficial for functionality but is much more difficult to fully eradicate the infection. The utilization of a static external fixator frame enables both stabilization and immobilization to achieve complete offloading through the final maturation stage of wound healing. The SALSAstand has been introduced for this purpose and its construct prevents any unwanted tension on skin edges as well as pressure-induced ischemia due to weight bearing [9].

Excluding case studies, there is lack of literature evaluating the combination of partial calcanectomy with primary closure and external fixation. Our study aims to provide a reproducible surgical approach to the treatment of heel ulcers with underlying calcaneal osteomyelitis. Partial calcanectomy with primary flap closure and offloading pin to bar external fixation allows for cost-effective fixation, accelerated healing, and a satisfying functional result in true limb salvage cases.

Patients and Methods

Patients diagnosed with osteomyelitis of the calcaneus were treated with radical resection of the calcaneus with primarily closure and with utilization of SALSAstand pin to bar external fixation. All patients were treated by a single surgical attending from January 2016 to May 2019. The inclusion criteria included patients with type 1 or 2 diabetes mellitus, those with at least a Wagner stage 3 ulceration to the heel, patients who had been diagnosed with osteomyelitis of the calcaneus with MRI advanced imaging or white blood labelled indium scans if patient was unable to have MRI, over 20% involvement of the calcaneus, and a minimum follow up of 6 months after achievement of primarily closure.

In our experience these patients had multiple co-morbidities requiring a multi-specialty medical approach. Consults for infectious disease, cardiology, vascular, endocrinology, anesthesiology, physical therapy and internal medicine were used for safety and to increase efficacy of the operative procedure. Additionally, patient demographics were examined.

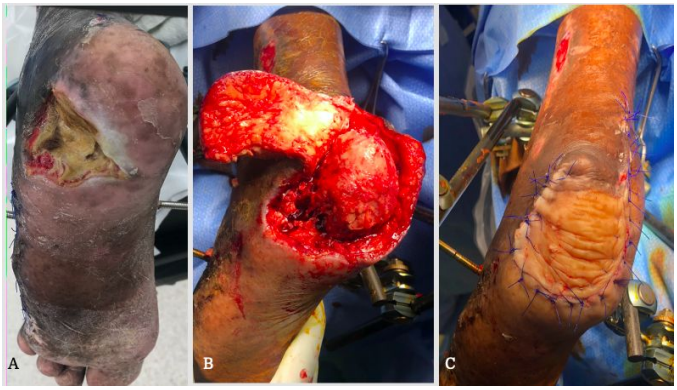

Figure 1 A - Plantar lateral wound probing directly to calcaneus. **B -** Posterosuperior Flap from achilles area rotated plantarly. **C -** Sutured flap over deficit, knots tied outside flap.

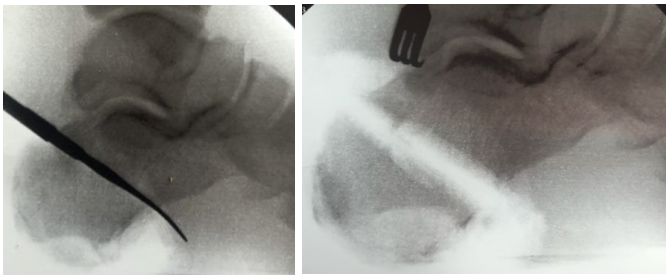

Figure 2 Planned resection of calcaneus with section taken. 0.5 cm margin using MRI guided resection.

Risk factors included obesity, hemoglobin A1C, peripheral vascular disease, history of tobacco use, and end stage renal disease. Other significant findings evaluated included history of attempted surgical treatment, number of operations required, and number of re-hospitalizations following the initial procedure.

Surgical Technique

The patients were placed under general anesthesia and were initially placed in the prone position. Thigh tourniquets were used unless a patient had recently undergone vascular intervention. A combination of two incisional approaches were utilized based on the location of the heel ulcer. Straight elliptical excisions for plantar wounds and a posterosuperior flap for posterior calcaneal ulcers (Figure 1). Full-thickness incisions were created with meticulous dissection to not harm the skin flaps. Once the flap was freed from attachments and the primary wound excised, the Achilles tendon was completely resected at its insertion. Utilizing a large saw, the calcaneus was resected from proximal superior to distal inferior in an oblique fashion (Figure 2).

Figure 3 SALSAstand method for offloading. Two half pins into tibia and two half pins into midfoot.

A margin of 0.5 cm of bone was resected from the involved bone via diagnostic advanced imaging. All the rough edges of bone were then smoothed down. Portions of the bone were sent to both microbiology and pathology. A combination of 2-0 Prolene vertical mattress technique and staples were utilized to ensure closure.

After proper closure of the flap, tourniquets were deflated and then the patient was flipped to supine position with care to prevent shearing forces or pressure on the flap. A pin to bar external fixation frame was then applied to the leg for offloading of the posterior flap. In safe zone 4, just distal to the midshaft of the tibia, using a parallel guide and clamp, two 5-0 half pins were placed into the tibial crest [10]. Two 45 degree elbows were placed in the tibial clamp and 2 bar frames were then extended toward the level of the forefoot and the heel. Two more 5-0 half pins were then inserted medially and laterally separately into the navicular and the cuboid to help construct the offloading frame. Fluoroscopy was employed to ensure placement. Pin to bar mechanism was then utilized to connect the two bars from the elbow to the midfoot pins as well as a large offloading "U" frame that went posterior around the heel (Figure 3). The "U" frame kept the patient from externally rotating the leg and forcing any pressure on the calcaneal flap. All the pin sites were covered with xeroform and dry dressing was applied to the leg.

All patients were still placed on intravenous antibiotics for 6 week depending on microbiology results. All patients were kept non-weight bearing to the operative leg until closure of the surgical wound. After complete healing, the external fixation device was removed and the patient was casted for custom solid AFO.

Results

A total of 12 patients were identified. Two patients were excluded due to one inadequate follow-up and one patient who was deceased before adequate follow-up, leaving 10 patients that met the inclusion criteria. Of those who met the inclusion criteria, 30% (3/10) were active tobacco smokers, 50% (5/10) were diagnosed with ESRD, 70% (7/10) had a history of PVD, previous surgical intervention occurred in 90% (9/10), average BMI among the 10 patients was 31 and average hemoglobin A1C was 7.5%. Demographic and medical history is seen in Table 1.

Patient Characteristics	Median or no. (percentage)
Patient Age	64
Gender	
Male	7
Female	3
BMI	31.3
HbA1C	7.6
Diabetes Mellitus	10 (100%)
ESRD	5 (50%)
PVD	7 (70%)
Current Tobacco Use	3 (30%)
Previous Surgical Intervention	9 (90%)
Follow up (months)	
Mean	15.9
Range	7 to 42

Table 1 Patient Demographics (N=10).

Complication	n
Dehiscence	3 (30%)
Flap necrosis	2 (20%)
Recurrent ulcer	2 (20%)

Table 2 Complications.

Variable	
Wound Size	6.4 x 5.6 cm (35.8 cm^2)
Average duration of wound	38 weeks (4 to 204)
Calcaneus resection size	122 cm3
Time to healing	106 days (43 to 205)
Time in external fixation	41 days (15 to 77)

Table 3 Pre and post operative results.

Mean wound size preoperatively was 6.4 cm x 5.6 cm (35.8 cm^2), mean size of calcaneal bone resected was 6.6 cm x 4.9 cm x 3.6 cm (116.4 cm^3). Average time to primary closure was 106 days (ranging 43 to 205 days), average days in external fixation devices was 41 days (ranging 15 to 77 days), and number of operating room visits following initial procedure was 1.5 visits (ranging from 1 to 3 visits). Complications encountered included partial wound dehiscence in 3/10 patients, flap necrosis in 2/10 patients, and re-ulceration in 2/10 patients.

Re-ulceration occurred at an average of 5 weeks post op (ranging 4 weeks to 6 weeks). Due to complications, subsequent adjunctive grafting occurred in 6 patients to aid in healing and 2 patients required rehospitalization. No pin tract infection, revisional bone debridement, or subsequent BKA/AKA was observed. Average follow up time was 20.9 months (ranging 12 to 45 months).

Discussion

A similar study by Akkurt, et al, utilized MRI guided debridement with application of Ilizarov external fixation for patients with pedal ulcers and concomitant calcaneal osteomyelitis.[11] The mean size of calcaneal osteomyelitis was 8.73 cm^3 (range 3–18 cm^3) and the authors advocated for a preoperative MRI-guided resection plus a maximum 0.5 cm of resection in depth as far as healthy osseous tissue was sufficient in all patients. The authors recommendations is the same guideline we utilized for our resection. The wounds healed in 18 of the 23 patients (78%), partial recovery occurred and subsequent flap operation was performed in three patients (13%), and below-the-knee amputation was performed in two patients (9%). Pin tract infections were the most common complication seen in 16 patients (69.5%).[11] Our study showed complete healing in 100% of patients with no below-knee-amputations or pin tract infection as a result. Pin tract infection was a common complication possibly due to the complexity of the frames in the study by Akkurt, et al.[11] We hypothesize utilizing a four half-pin fixation construct decreases the chance for pin tract infection and subsequent amputation. There is less chance of loosening and pistoning without smooth wire fixation. Bollinger, et al., performed partial calcanectomies and evaluated the functional status of their patients. Thirteen of the 22 patients had confirmed osteomyelitis. Eighteen patients were available for follow-up. Twelve had delayed wound healing that required either a split thickness skin graft or serial debridements. Nine patients had diabetes and all had delayed wound healing with an average follow up time of 27 months. They found that ulcers larger than 7 cm would not allow for a tension-free closure. They also recommended casting in plantar flexion for a minimum of 4 weeks post-operative. This study resulted in 100% satisfaction rates of its subjects. However over 50% had delayed wound healing with the need of additional surgical treatment [12]. Our experience saw similar results in delayed healing with subsequent grafting at 60%. A combination of biologics and split thickness skin grafts were utilized depending on size of surgical wound. With our average wound size of 35.8 cm^2, we found that even with larger deficits, utilizing a rotational flap allowed for tension free initial closure of skin.

Vac therapy is also a conservative option to attempt and close these long standing ulcers. However, the frequency of dressing changes, time needed, and prolonged non-weight bearing make the negative pressure therapy a very involved task. Nather et al., looked at wound vac therapy for diabetic foot wounds in 11 patients and administered VAC therapy for an average of 23.3 ± 10.3 days. Initial wound sizes ranged from 6.9 to 124.0 cm^2 and post therapy had an average reduction of 10.1 cm^2 with an average reduction of 24.9%, which was not statistically significant [13]. The use of wound vac therapy alone in diabetics cost an average of $13,262 for a 12 week therapy course [14]. Conservative treatment through vac therapy, debridements, and serial grafting increases both cost to patient and chance of infection. Our patient population only required 1.5 visits to the OR after the initial procedure where at least one of the visits involved was to remove the external fixation device. The average healing time after calcanectomy and primary closure was about 15 weeks where the average duration of the wound being present was 38 weeks. This procedure allows for complete eradication of infected bone and tissue, properly offloading, and primary tissue healing for practical and functional results.

Dalla Paola, et al., used a combination of the treatments discussed. They enrolled 18 consecutive patients with large heel ulcers complicated by osteomyelitis. Treatment was performed in a two-step manner, first including MRI guided resection of the infected calcaneus, application of circular external fixator, and negative pressure wound therapy with dermal substitute. The second stage included application of split thickness skin graft over the wound. Complete healing was achieved in all patients with mean time of 69+/- 64 days. Total time for maintenance of the circular frame was 78.2 +/- 31.5 days [15]. Another surgical alternative is the use of myofascial flaps to cover soft tissue deficits in the heel. The robust nature of the muscle belly aids in bone healing and increased antibiotic deliverance to the site of infection. Abductor hallucis, reverse sural artery, and saphenous flaps are all viable options depending on the size of muscle needed for coverage. However, these surgical procedures are technically demanding and require attentive wound care. Increased risk of flap breakdown may be attributed to the high pressure area they weren't designed for. Flap rejection is cited from 5% to 25% while diabetics have an increased rate of necrosis at 32% [16].

References

1. Cuddigan J, Berlowitz DR, Ayello EA. Pressure ulcers in America: prevalence, incidence, and implica- tions for the future. Adv Skin Wound Care 2001; 14:208-15.
2. Jacobs TS, Kerstein MD. Is there a difference in outcome of heel ulcers in diabetic patients and non-diabetic patients? Wounds 2000; 12(4):96-101.
3. Cuccurullo, Sara J. Physical Medicine and Rehabilitation Board Review. 2nd ed. New York: Demos Medical, 2010.
4. Pinzur MS. Amputation level selection in the diabetic foot. Clin Orthop. 1993; 296:68-70
5. Waldvogel FA, Medoff G, Swartz MN. Osteomyelitis: a review of clinical features, therapeutic considerations and unusual aspects (first of three parts) N Engl J Med. 1970 Jan 22;282(4):198–206.
6. Waldvogel FA, Medoff G, Swartz MN. Osteomyelitis: a review of clinical features, therapeutic considerations and unusual aspects (Second of Three Parts) N Engl J Med. 1970 Jan 29;282(5):260–266.
7. Waldvogel FA, Medoff G, Swartz MN. Osteomyelitis: a review of clinical features, therapeutic considerations and unusual aspects (Third of Three Parts) N Engl J Med. 1970 Feb 5;282(6):316–22.
8. Ciampolini J, Harding KG. Pathophysiology of chronic bacterial osteomyelitis. Why do antibiotics fail so often? Postgrad Med J. 2000 Aug; 76(898):479-83.
9. Clark J, Mills JL, Armstrong DG. A method of external fixation to offload and protect the foot following reconstruction in high-risk patients: the SALSAstand. Eplasty. 2009;9:e21. Published 2009 Jun 4.
10. Cooper P, Polysois V, Zgonis T. *External Fixators Of The Foot And Ankle*. Wolters Kluwer Health, Chapter 2. Published 2015.
11. Akkurta MO, Ismail D, Öznur A. Partial calcanectomy and Ilizarov external fixation may reduce amputation need in severe diabetic calcaneal ulcers. Diabetic Foot Ankle, 2017 8(1), 1264699
12. Bollinger M, Thordarson DB. Partial calcanectomy: an alternative to below knee amputation. Foot Ankle Int. 2002;23(10):927-932.
13. Nather A, Chionh SB, Han YY, Chan PL, Nambiar A. Effectiveness of Vacuum-assisted Closure (VAC) Therapy in the Healing of Chronic Diabetic Foot Ulcers. Ann Acad Med Singapore. 2010;39:353–8
14. Driver V, Blume P. Evaluation of Wound Care and Health-Care Use Costs in Patients with Diabetic Foot Ulcers Treated with Negative Pressure Wound Therapy versus Advanced Moist Wound Therapy. Journal of the American Podiatric Medical Association: 2014;104(2):147-153.
15. Dalla Paola L, Brocco E, Ceccacci T, Ninkovic S, Sorgentone S, Marinescu MG, Volpe A. Limb salvage in Charcot foot and ankle osteomyelitis: combined use single stage/double stage of arthrodesis and external fixation. Foot Ankle Int 30:1065–1070, 2009.
16. Germann G. Invited discussion: the simple and effective choice for treatment of chronic calcaneal osteomyelitis: neurocutaneous flaps. Plast Reconstr Surg 2003; 111:761–2.