Successful Management of Open Calcaneum Fractures With Composite Bone and Soft Tissue Loss

A Report of Three Cases

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Abstract

Case: We report three male patients, ages 20, 22, and 54 years, who sustained open calcaneus fractures following a road traffic accident with a major composite bone and soft tissue loss salvaged successfully, with a minimum follow-up of 2 years. Wound debridement and an ankle-spanning external fixator were initially applied, followed by a free microvascular flap cover. After the flap healed, the ankle joint was fused and spanned with bridge plating. All 3 cases achieved fusion with foot plantigrade with a mean American Orthopaedic Foot and Ankle Society score of 76.

Conclusion: A combined orthoplastic approach in 3 stages is a good salvage option in complex calcaneal fractures.

Open calcaneus fractures are complex injuries that often result in long-term morbidity[1,2]. Post-traumatic bone loss of the calcaneus and soft tissue loss involving the hindfoot are devastating injuries, which can be limb-threatening. Historically, the reported complication rates are as high as 23.5% in open calcaneus fractures[3]. There are no treatment guidelines for approaching severe calcaneus fractures with significant bone and soft tissue loss[4]. We propose a combined orthoplastic approach, which involves a staged reconstruction protocol.

The patients were informed that data concerning their cases would be submitted for publication, and they provided consent.

Case Reports

Case 1. A 54-year-old gentleman presented 4 hours after a motor vehicle accident with an open wound of size 10 × 5 × 2 cm over the hindfoot and Gustilo type 3B calcaneus fracture with a large tuberosity avulsion and bone loss involving more than 50% of the body of the calcaneus. Under spinal anesthesia, all devitalized tissues were removed along with loose bone fragments, and a temporary ankle-spanning external fixator was applied. Twelve days later, the patient underwent a free microvascular anterolateral thigh flap cover for the defect. At 10 weeks postinjury, the ankle and talonavicular and naviculocuneiform joints were prepared for fusion by denuding the articular cartilage and fixed using a 4.5 AO-locking plate with the foot in the neutral position. The iliac crest bone grafts were packed at the fusion site. A below-knee plaster was applied for 6 weeks, non–weight-bearing with walker support was allowed, and weight-bearing as much tolerated was started after 6 weeks. Footwear with silicone insoles and adjustable straps was given to protect the flap site from developing ulcers. At 2 years of follow-up, the American Orthopaedic Foot and Ankle Society score (AOFAS score) was 80 (Fig.1).

Case 2. A 20-year-old man had sustained a significant crush injury to his right heel when his motorbike collided with a truck from behind. There was an open wound of size 8 × 5 × 2 cm over the posterior aspect of the heel with soft tissue loss. Radiographs showed a comminuted calcaneus fracture with bone loss. The patient underwent emergency debridement, and an ankle-spanning external fixator was applied. After 5 days, the soft tissue defect was covered using a microvascular-free gracilis flap. Six weeks later, with complete healing of the flap, the external fixator was removed, and a below-knee plaster was applied. Once the pin sites had healed, 8 weeks after flap surgery, ankle and medial column fusion was done using anterior bridge plating. Union at the arthrodesis site was achieved in 16 weeks. At the final follow-up, the AOFAS score was 78 (Fig 2).

Case 3. A 22-year-old man had a significant crush injury to his right ankle and foot following a road traffic accident, with consequential soft tissue loss of 15 × 10 × 3 cm around the lateral aspect of the hindfoot and partial heel-pad avulsion. He

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Fig. 1

A 54-year-old man presented following a road traffic accident, (**Fig. 1-A**) showing significant hindfoot crush injury and radiograph, (**Fig. 1-B**) external fixator application and anterolateral thigh flap cover, (**Fig. 1-C**) radiograph of bony fusion and anterior bridge plate, and (**Fig. 1-D**) final clinical photographs of plantigrade foot.

was diagnosed with calcaneus body fracture, cuboid fracture, and talonavicular dislocation. He underwent primary surgery elsewhere in the form of debridement for the open wounds, K-wire fixation for the talonavicular joint, and a calcaneal pin fixation extending across the ankle joint. He presented to us after 5 days. The calcaneus bone was found completely necrotic and was excised along with parts of the cuboid, and the ankle joint was spanned with an external fixator. The wound was then allowed to granulate, and a microvascular anterolateral thigh flap cover was done after 10 days. The soft tissue completely healed in 6 weeks. The patient then underwent ankle and medial column fusion using a 4.5 AO-locking plate bent on the surgical table to fix the ankle joint in a neutral position. The arthrodesis healed at 18 weeks without any complications. The AOFAS score was 68 (Fig. 3).

Surgical Technique

A 15-cm skin incision extended 5 cm above the ankle and distally up to the first metatarsal head. The ankle and talonavicular and naviculocuneiform joints were prepared by denuding the articular cartilage. The prepared joints were temporarily held with k-wires, and a 4.5 LCP (Synthes) was contoured using a plate bender and fixed with the foot in neutral position. The iliac crest grafts were harvested and packed into the prepared joints. Plating was completed with a minimum of 3 screws on either side of the ankle joint. Hemostasis was achieved. A below-knee plaster was applied.

Results

The patients were on regular follow-ups at 6, 12, 18, and 24 weeks and every 6 months after that until 2 years minimum. The average time for consolidation at the arthrodesis site was around 16 weeks (14-18 weeks). The mean follow-up period was 29.5 months (26-32 months). There was no evidence of infection or implant loosening in the patients. The surgical wound was primarily closed in all the patients, and we did not encounter any problems in wound healing. None of the patients complained of implant prominence. All 3 patients were healthy individuals with isolated foot injuries. They had residual ankle stiffness and limitations in walking on steep surfaces and squatting. However, they could return to their work with subtle lifestyle modifications. At the final follow-up, the average AOFAS score was 76 of 100 (68-80), signifying a good outcome. The split up of the patients' individual AOFAS scores is summarized in Table I.

Discussion

Injured limbs with massive bone loss are generally reconstructed using autologous iliac crest grafts, vascularized free fibula grafts, massive allografts, or bone transport [5-7]. There are only a few case reports described in the literature for the management of open calcaneus fractures with severe soft tissue and bone loss[7-10]. A below-knee amputation is a viable option in severely mangled extremities in elderly patients[11]. We followed a staged procedure of

Fig. 2

A 20-year-man sustained fall from a two-wheeler, (**Fig. 2-A**) showing bony defect over the calcaneus and soft tissue defect, (**Fig. 2-B**) defect covered with microvascular gracilis flap and skin grafting, (**Fig. 2-C**) radiographs immediately after plate fixation, (**Fig. 2-D**) 2 years of follow-up radiograph, and (**Fig. 2-E**) clinical pictures after flap healed.

management, with an initial soft tissue cover followed later by a fusion of the ankle and midfoot joints. Extensive bone loss of the calcaneus often results in disruption of the Tendoachilles attachment sites. These patients are prone to developing a calcaneus gait, resulting in point loading at the hindfoot, devoid of the tough native skin, ultimately resulting in ulcers. Thus, fusion of the ankle and midfoot joints was done to provide a stable, plantigrade foot with even loading during weight-bearing.

Mears and colleagues first described an anterior plate for ankle arthrodesis in 1991. They believed that the anterior tension plate converts the deforming forces of the Tendoachilles into compressive forces, which in turn realigns the ankle in all the planes. The increased rigidity provided by the anterior plate effectively counters the forces, particularly the cantilever bending forces in the sagittal plane[12]. Slater et al. stated that ankle arthrodesis using an anterior tension plate technique provides a rigid fixation[13]. Good outcomes following anterior ankle arthrodesis have been published by several authors[14].

We believe using a long plate increases the working length and decreases the screw density ratio, ultimately reducing the strain and efficiently bridging the curtailed calcaneum. Our fixation extended from the distal tibia across the talus into the medial column of the foot, as it is in line with the surgical incision and provides a broader surface for anchoring the plate. A longer plate also neutralizes the unopposed action of the tibialis anterior at the midfoot joints. A shorter plate spanning the tibiotalocalcaneal joints using a smaller incision is a good alternative option, as it minimizes soft tissue dissection and the risk of infection. However, concerns of a shorter working length, difficulty in screw placement in the calcaneum with bone loss, and unopposed action of the tibialis anterior persist. Fusion of the medial column joints was done as we preferred a single solid block of bone to provide a stable foot. Using a long plate and bridging, rather than fusing the midfoot joints could be a viable option.

Koski et al. reported 35 flap reconstructions in 31 patients with exposed calcaneal bones, and they concluded that soft tissues heal most rapidly with microvascular flaps. Gracilis muscle covered with split skin grafts gave an excellent contour to the foot. The literature also supports that free gracilis muscle transfer supplemented with skin grafts has excellent healing potential and gives a pleasing contour to the foot[15,16]. Our technique using a precontoured plate provided a useful salvage option. We did not encounter any problems in wound healing postoperatively. The waiting period of 6 to 8 weeks allowed the good soft tissue healing and resolution of the edema. The limitation of our study is a small series with 3 cases and a short-term follow-up.

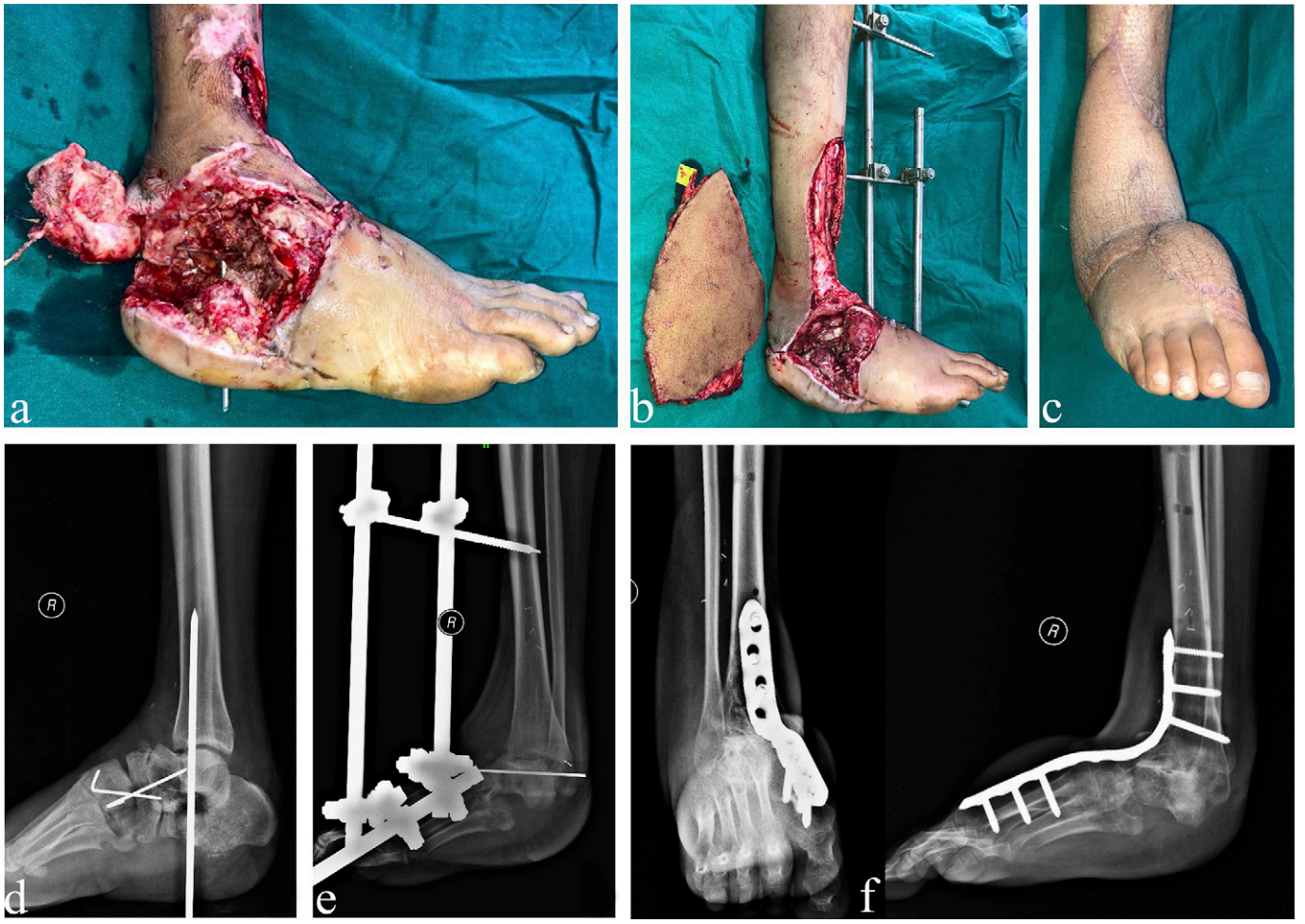

Fig. 3

A 22-year-old man with significant hindfoot crush injury, (**Fig. 3-A**) wound picture showing calcaneus bone loss, (**Fig. 3-B**) wound covered with anterolateral thigh-free flap, (**Fig. 3-C**) after flap wound healed, (**Fig. 3-D**) on arrival radiograph, (**Fig. 3-E**) radiograph after debridement, and (**Fig. 3-F**) final radiographs after ankle fusion.

TABLE I AOFAS Scores of the Three Patients

	Case 1	Case 2	Case 3
Pain	None	None	Mild, occasional
Activity limitation/Support requirements	None	None	None
Maximum walking distance	> 6 blocks	4-6 blocks	4-6 blocks
Walking surfaces	Some difficulty on uneven terrain	Some difficulty on uneven terrain	Some difficulty on uneven terrain
Gait abnormality	Obvious	Obvious	Obvious
Sagittal motion	Severe restriction (<15°)	Severe restriction (<15°)	Severe restriction (<15°)
Hindfoot motion	Severe restriction (<25% normal)	Severe restriction (<25% normal)	Severe restriction (<25% normal)
Ankle—hindfoot Stability	Stable	Stable	Stable
Alignment	Good, plantigrade foot, ankle—hindfoot well aligned	Good, plantigrade foot, ankle—hindfoot well aligned	Good, plantigrade foot, ankle—hindfoot well aligned
Total AOFAS score	80	78	68

AOFAS = American Orthopaedic Foot and Ankle Society.

Conclusion

In patients with significant bone and soft tissue loss around the calcaneus, a combined orthoplastic approach using the anterior bridge plate technique provides good results with a satisfactory return to work. Patient selection and counseling play a significant role. Medically fit individuals with isolated foot injuries are the ideal candidates. ■

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References

1. Dickens JF, Kilcoyne KG, Kluk MW, Gordon WT, Shawen SB, Potter BK. Risk factors for infection and amputation following open, combat-related calcaneal fractures. J Bone Joint Surg Am. 2013;95(5):e24.

2. Bevevino AJ, Dickens JF, Potter BK, Dworak T, Gordon W, Forsberg JA. A model to predict limb salvage in severe combat-related open calcaneus fractures. Clin Orthop Relat Res. 2014;472(10):3002-9.

3. Wiersema B, Brokaw D, Weber T, Psaradellis T, Panero C, Weber C, Musapatika D. Complications associated with open calcaneus fractures. Foot Ankle Int. 2011; 32(11):1052-7.

4. Swanson SA, Clare MP, Sanders RW. Management of intra-articular fractures of the calcaneus. Foot Ankle Clin. 2008;13(4):659-78.

5. Chimutengwende-Gordon M, Mbogo A, Khan W, Wilkes R. Limb reconstruction after traumatic bone loss. Injury. 2017;48(2):206-13.

6. Gubin AV, Borzunov DY, Marchenkova LO, Malkova TA, Smirnova IL. Contribution of GA Ilizarov to bone reconstruction: historical achievements and state of the art. Strateg Trauma Limb Reconstr. 2016;11(3):145-52.

7. Clowers BE, Myerson MS. A novel surgical technique for the management of massive osseous defects in the hindfoot with bulk allograft. Foot Ankle Clin. 2011; 16(1):181-9.

8. Williams CG, Coffey MJ, Shorten P, Lyions JD, Laughlin RT. Staged subtalar fusion for severe calcaneus fractures with bone loss. Open Orthop J. 2013;7:614-8.

9. Keeling JJ, Hsu JR, Shawen SB, Andersen RC. Strategies for managing massive defects of the foot in high-energy combat injuries of the lower extremity. Foot Ankle Clin. 2010;15(1):139-49.

10. Schade VL. Partial or total calcanectomy as an alternative to below-the-knee amputation for limb salvage: a systematic review. J Am Podiatric Med Assoc. 2012; 102(5):396-405.

11. Shawen SB, Keeling JJ, Branstetter J, Kirk KL, Ficke JR. The mangled foot and leg: salvage versus amputation. Foot Ankle Clin. 2010;15(1):63-75.

12. Mears DC, Gordon RG, Kann SE, Kann JN. Ankle arthrodesis with an anterior tension plate. Clin orthopaedics Relat Res. 1991;1(268):70-7.

13. Slater GL, Sayres SC, O'Malley MJ. Anterior ankle arthrodesis. World J Orthop. 2014;5(1):1-5.

14. Berlet GC, Prissel MA, Zulauf EE, Malloy McCoy AM. Ankle fusion outcomes utilizing anterior ankle plating techniques: a systematic review. Foot Ankle Orthop. 2022;7(1):2473011421S0011.

15. Yazar S, Lin CH, Wei FC. One-stage reconstruction of composite bone and soft-tissue defects in traumatic lower extremities. Plast Reconstr Surg. 2004;114(6): 1457-66.

16. Ulusal AE, Lin CH, Lin YT, Ulusal BG, Yazar S. The use of free flaps in the management of type IIIB open calcaneal fractures. Plast Reconstr Surg. 2008; 121(6):2010-9.