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Open tongue-type calcaneal fracture treated with the external fixation bent wire technique

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Traditionally, tongue-type calcaneal fractures have been treated using internal fixation. External fixation has been described to a lesser degree in the treatment of these injuries, though not in the setting of an open fracture. We present a case of an open tongue-type calcaneal fracture treated with external fixation, utilizing a tensioned wire affixed to the frame that imparts compression across the fracture site. With this method, maximal respect to the soft tissues is rendered, and soft tissue insult is minimized. This patient achieved timely soft tissue coalescence and fracture union, with a return to pre-injury activities. To our knowledge, this technique has not been previously described in the treatment of an open calcaneal fracture of the posterior tuberosity.

Keywords: Achilles tendon, avulsion fracture, circular frame, Gustilo-Anderson, Ilizarov technique

A fracture of the calcaneus, despite being the most common fracture regarding the tarsal bones, occurs only 11.5 instances in 100,000, according to a 10 year epidemiological study [1]. Open calcaneal fractures are diagnosed in merely 5-13 percent of these injuries collectively [2-5]. The surgical indications for calcaneal fractures are controversial. Soft tissue complications are abundantly reported in the literature concerning open reduction internal fixation of closed calcaneal fractures [6-9]. In fact, there is literature advocating non-operative treatment of displaced intra-articular fractures to attempt prevent these soft tissue complications [10]. However, an open calcaneal fracture is considered a surgical emergency. This situation presents a unique surgical obstacle regarding initial stabilization and definitive fixation. A variety of techniques have been described in the initial and subsequent management of open fractures in general [11-16]. The literature, however, is scant with recommendations addressing minimally invasive soft tissue friendly surgical options for open calcaneal fractures.

The primary goals of open fracture management include prevention of infection and soft tissue compromise, which can be achieved through aggressive surgical irrigation and debridement, parenteral antibiotics, anatomic reduction of the fracture and stabilization of the osseous fragments.

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Osseous union and restoration of function are also sought, as with treatment of any orthopedic injury [17]. This often requires a staged surgical approach with initial debridement and often external fixation for stabilization, followed by internal fixation once soft tissues have coalesced [18]. This protocol, although arguably the gold standard in open fracture management, is not without drawbacks. These includes increased hospital and patient costs, length of hospital stay and associated risks such as deep vein thrombosis, as well as risks of anesthesia [19-23]. The primary aim of this case report is to present a single stage technique for the treatment of open tongue-type calcaneal fractures. In this report, one patient with an open calcaneal fracture underwent irrigation and debridement with application of external fixation and fracture fixation through bent wire technique, achieving a favorable outcome. Despite some literary evidence supporting multi-staged surgical management of open calcaneal fractures, this report provides a single stage technique that has shown promise regarding reduction of soft tissue complications and return to function, while reducing the aforementioned multi-stage surgical pitfalls.

Methods

A single patient received external ring fixation with bent wire technique after presenting to the emergency department with an open tongue-type calcaneal fracture. This was a work related injury resulting from a steel beam impact and laceration through a work boot. Clinically the patient presented with a medial heel deficit measuring 1.0 cm x 6.0 cm down to the level of bone, with minimal gross debris present (Figure 1). An adjacent full thickness deficit was noted to the plantar heel, not extending to bone (Figure 1). Tenting of the posterior heel was evident. The patient was deemed neurovascularly intact on examination. Standard radiographs diagnosed an isolated tongue-type calcaneal fracture (Figure 2), with evidence of intra-articular involvement of the posterior facet visualized on CT scan (Figure 3). The patient received TDaP tetanus vaccine and Ancef upon arrival to the emergency department.

Figure 1 Clinical photograph of the patient upon presentation to the emergency department. The large medial defect extends to bone. The smaller, more posterior defect, did not extend to bone. There was no evidence of gross contamination.

Figure 2 Lateral radiograph demonstrating the tongue-type calcaneal fracture with significant displacement.

Initial bedside irrigation and debridement was performed, however closed reduction of the posterior tuber avulsion was unsuccessful. Verbal and written consent was obtained to then proceed with surgical intervention.

Figure 3 A CT scan clearly demonstrates the intra-articular nature of the fracture. Soft tissue emphysema is clearly evident.

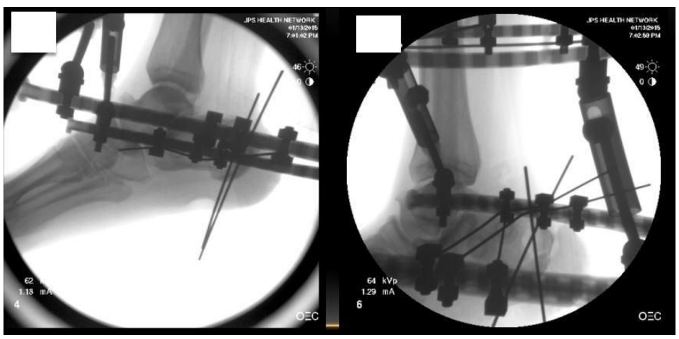

Figure 4 Intraoperative fluoroscopy demonstrates anatomic reduction of both fracture lines

Figure 5 Closure of the medial heel defects using subcuticular Monocryl.

Operative Technique

The patient received IV antibiotics preoperatively and under mild sedation was brought into the operating room. He was placed supine on the operating table. A formal surgical “time-out” was performed in which the patient, procedure and site were identified. The patient underwent general anesthesia without complication and the operative limb was scrubbed, prepped and draped in usual aseptic manner. A tourniquet was not raised so as to appropriately control hemostasis intra-operatively. The soft tissue defect was irrigated with 9 liters of sterile saline and closed primarily utilizing subcuticular Monocryl® (poliglecaprone, Ethicon, Inc., a division of Johnson & Johnson, Somerville, NJ). After application of a standard pre-built multi-plane Ilizarov external fixator to the operative extremity, two k-wires were placed in bicortical fashion through the superior fragment of the calcaneus and a single k-wire was placed through the inferior fragment, also bicortically. Manually, the superior wires were then bent down to the frame inferiorly, imparting compression across the fracture site. Tensiometers were then used to tension the wires to the foot plate at 75N. After tensioning, intraoperative fluoroscopy was utilized to confirm anatomic reduction and fracture compression (Figure 4). A secondary fracture of the plantar aspect was also noted on fluoroscopic imaging and fixated using two 2.0mm Steinmann Pins. The incision site was closed with subcuticular Monocryl (Figure 5). An incisional negative pressure wound vac was applied to the site of open fracture and the operative extremity was placed in a compressive dressing. The external fixator was then dressed in a sterile surgical dressing. Immediate post-operative radiographs are presented in Figure 6.

The patient was admitted for IV antibiotics based on our facility’s open fracture protocol. The incisional vac was removed prior to discharge at post-op day 2. The laceration was reinforced with simple suture after debridement of mild skin edge necrosis at the apex.

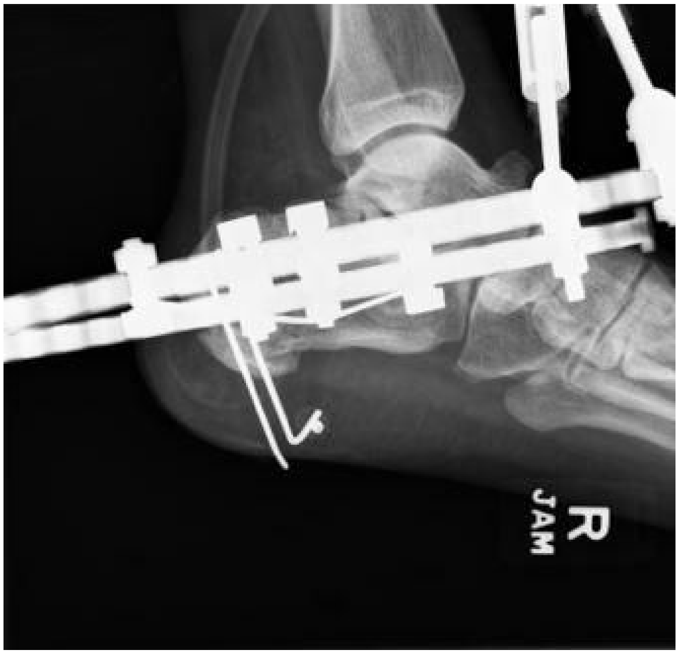

Figure 6 Postoperative lateral radiograph demonstrating anatomic fracture reduction.

Figure 7 Clinical image at 2 weeks postoperatively after suture removal. The Steinmann pin was removed as well due to loosening.

Figure 8 Clinical image at 5 weeks showing the superficial nature of the wound.

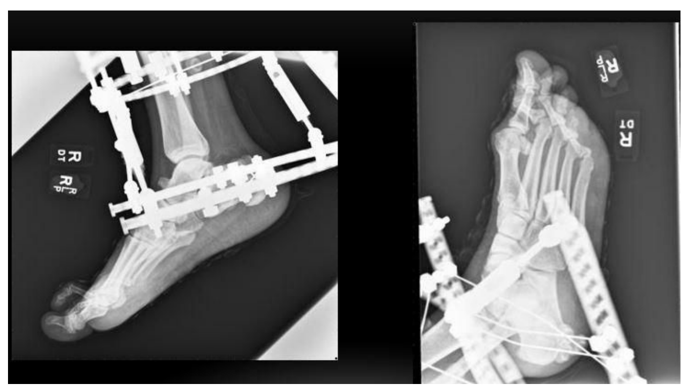

Figure 9 Trabeculation is seen across the fracture lines on lateral and lateral oblique radiographs at 5 weeks post-operatively.

Results

The patient was evaluated in clinic at one week and two weeks postoperatively for soft tissue scrutiny. In the interim, the patient had been undergoing twice weekly dressing changes via home health with packing changes to area of apical necrosis and silver dressings along the coapted skin edges.

Figure 10 Lateral radiograph at 10 weeks postoperatively with union noted at the primary fracture line.

Figure 11 Union of both fracture lines is appreciated at 4 months post-operatively.

Sutures were removed at two weeks as well as the Steinman pin due to loosening (Figure 7). The apical wound was addressed in clinic with serial packing and ultimately porcine trilayer grafting. At 5 weeks, the wound was superficial (Figure 8 a,b). Trabeculation could be appreciated radiographically at this time via standard radiograph (Figure 9). Osseous union was visualized at eight weeks postoperatively. The patient underwent external fixator removal (Figure 10) and amniotic graft application at 9 weeks postoperatively for stagnant healing of the apical wound.

Figure 12 Clinical image of the patient 10 months post-operatively.

The patient was then transitioned to full weight bearing over the next four weeks with progression through a controlled ankle motion boot. Radiographs at 4 months display union of both fracture lines (Figure 11). At the most recent appointment, 10 months post-operative, patient has returned to work without restrictions. Currently, the patient's only complaint is intermittent pain and tenderness to touch along the medial heel. According to the patient, the frequency of these sensations has slowly decreased over time. It is unclear at this time to what extent his neuritic symptoms will resolve. His medial heel has remained ulceration free and is in neutral position in resting calcaneal stance position (Figure 12 a,b). It was noted that the patient had a slight increase in heel width, however the patient was able to return to tennis shoes and work boots that he was wearing pre-injury without complaints.

Discussion

In their seminal work Takahashi, Mitsuaki, and Saegusa described a technique treating a similar calcaneal fracture presentation. Although their case report describes a closed injury, the principles of careful soft tissue management remain the same through the application of external fixation. While their efforts attempt to prevent an impending open fracture, the so called "open fracture in evolution", we present an attempt to prevent further insult to an already compromised soft tissue envelope. In closed injuries, the "Hurricane Strap" form of internal fixation that we have previously described has been our preferred fixation modality for tongue-type calcaneal fractures. Ilizarov fixation was first described for this fracture pattern by Ramanujam et al., however, the reduction was maintained by placing the ankle in plantarflexion by way of the fixator and thus reducing the deforming force of the Achilles tendon. In their technique, Steinmann pins are placed across the fracture site but not affixed to the frame. Yet, prolonged immobilization of the ankle joint in a high degree of plantarflexion could result in contracture that would make weight bearing after fixator removal difficult. Takahashi et al. were the first to describe reduction by way of tensioned wires. To our knowledge, we are the first to describe this technique in the scenario of an open fracture. Fixation of the interfragmentary wires to the fixator itself in a tensioned fashion has the advantage of imparting active compression across the fracture site rather than simply holding the fragment in place and relying on a static joint position. Conceivably, the resistance to failure would be greater biomechanically superior to a non-tensioned interfragmentary pin or wire that cannot effect compression. A saw bone model allows for a true appreciation of the technique (Figure 13 a,b). A schematic is provided to further illustrate this method (Figure 13c).

We concede that this technique would be of limited use with smaller osteoporotic fragments. In contrast however, we do not suggest fixation of these fragments.

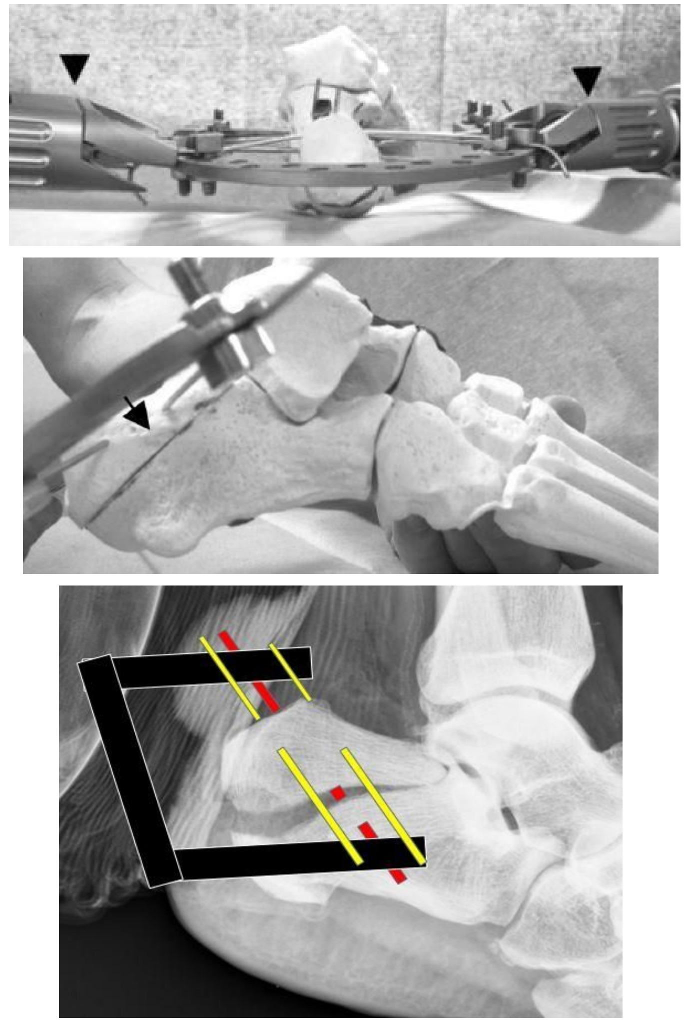

Figure 13 Bent wire construct (A) a sawbone model allows for easy visualization of the construct with the tensioned wire passing through the displaced fracture fragment. The wire is tensioned and the concave side of the arc faces in the desired direction of compression. (B) Compression across the fracture fragment from a lateral perspective. (C) A schematic of the technique superimposed on a lateral radiograph (Figure 13a and Figure 13b Reproduced from: A new treatment for avulsion fracture of the calcaneus using an Ilizarov external fixator, Injury, 44(11), Takahashi M, Noda M, Saegusa Y., 1640-3.Copyright (2013), with permission from Elsevier).

We distinguish a true tongue-type fracture, as treated in this article, from the smaller Achilles avulsion fractures described by Beavis and Rowe, and the "Iowa" fracture described by Kathol [6,7,8]. Tongue-type fractures are akin to the cleavage or "wedge" type fractures detailed by Hedlund, or the Essex-Lopresti described tongue-type fracture without frank joint collapse [9,10]. Given their size and extra-articular nature, smaller avulsion fractures can often be excised without biomechanical consequence. The Achilles can then be re-anchored to the remaining calcaneus as described by Greenhagen [11]. This is especially useful in the osteoporotic host where screw fixation is especially apt to fail, in whom these avulsion-type fractures are more common. The fracture described by Ramanujam would in fact be one such fracture pattern were we would recommend excision given its small size. Patients incurring tongue-type fractures tend to be somewhat younger than those sustaining avulsion fractures, which are largely insufficiency fractures in osteoporotic patients. In the event of a true tongue-type fracture, fixation is mandatory given their predisposition for soft tissue compromise and often concomitant articular involvement.

With respect to open fractures involving the posterior calcaneal tuber, internal fixation has been the method of choice for many authors. In this scenario, retained internal fixation could of course serve as a nidus for infection and require removal, necessitating substantial incisions and thus further soft tissue trauma. Additionally, depending on the location and size of the soft tissue deficit, their initial placement could demand further dissection into the already tenuous soft tissue environment.

Delays in the treatment of these injuries can undoubtedly lead to the need for rapid ascension of the soft tissue coverage ladder, even requiring free tissue transfer [21]. These delays can be especially common in the neuropathic host. In the scenario of free tissue transfer, our technique would provide both protection of the flap as well as minimal insult to the transferred tissue. The precarious position of the posterior lower extremity in the non weight bearing patient can make offloading of this area difficult without external fixation.

In conclusion, the bent wire technique has shown to be a valuable tool in our treatment of an open tongue-type calcaneal fracture and is our standard approach to treating these injuries. With minimal surgical insult to the soft tissues, wound healing concerns can be mitigated to the greatest extent possible. In the future, studies of larger sample sizes, biomechanical testing, and even direct comparison of this presented method to other fixation techniques would be useful.

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