The "Open-Envelope" Approach: A Limited Open Approach for Calcaneal Fracture Fixation

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Abstract

Background: Minimally invasive surgery (MIS) has a significant and evolving role in the treatment of displaced intra articular calcaneal fractures (DIACFs), but there is limited literature on this subject. The objective was hence to assess the clinicoradiological outcomes of DIACFs fixed with an innovative open-envelope MIS technique. **Materials and Methods:** 42 closed Sanders Type 2 and 3; DIACFs were included in this study. The Open-envelope approach was developed, which is essentially a limited open, dual incision, modified posterior longitudinal approach allowing excellent visualisation and direct fragment manipulation. The main outcome measures were American Orthopaedic Foot and Ankle Score (AOFAS) hindfoot score and preoperative and postoperative radiological angles. **Results:** The Bohler angle improved from a preoperative mean of 14.3° (range 0°–28°) to a postoperative mean of 32.46° (range 22°–42°). The Gissane angle improved from a preoperative mean of 135.83° to a postoperative mean of 128.33°. The postoperative improvement in Bohler and Gissane angles was highly significant ($P < 0.001$). The AOFAS scores at 6 months were excellent in nine patients, good in 15 patients, and fair in six patients. Three patients had residual valgus deformity of the heel. **Conclusions:** Open-envelope technique minimized soft tissue complications and achieved acceptable radiological reductions with good clinical outcomes.

Keywords: *American Orthopaedic Foot and Ankle Score, calcaneum fracture, displaced intraarticular calcaneal fractures, minimally invasive surgery, open-envelope approach*
MeSH terms: *Calcaneus; fracture fixation, internal; minimally invasive surgical procedures*

Introduction

The calcaneum is the most commonly fractured tarsal bone (>60%), with displaced intraarticular fractures accounting for up to 75% of calcaneal fractures.[1] The optimal approach for accurate reduction and fixation of calcaneal fractures remains controversial.[2] Treatment options include open reduction and internal fixation (ORIF), limited open reduction,[3,4] closed reduction and percutaneous fixation,[5-8] subtalar arthrodesis,[9] or nonoperative management in selected patients.[10] While the extensile lateral approach remains the "gold standard" to which other minimally invasive approaches are compared, the complication rate is reported to be as high as 30%.[2,10-12] Minimally invasive or limited open approaches attempt to reach the middle ground between the classical extensile exposure and nonoperative management.[2] These can vary from percutaneous techniques[13-15] to limited open sinus tarsi approaches[16,17] involving Kirschner wires (K-wires), screws, or plates with results comparable to the extensile approach and a lower prevalence of wound complications. The very fact that several approaches have been described makes it amply clear that there is no "one size fits all" for calcaneal fractures with the treatment being tailored to the individual patient. We describe the development of a limited open, dual incision, modified posterior longitudinal, "open-envelope" approach for calcaneal fracture fixation.

Materials and Methods

The study was conducted on patients attending the emergency department and the outpatient department of a tertiary care level trauma center from January 1st, 2014, to December 31st, 2016, after appropriate approval by the Institute Review Board. Patients were diagnosed by clinical examination, supported by X-rays (anteroposterior, lateral, and Harris axial views) and computed tomography (CT) scans. The CT scans of the foot included axial cuts at the subtalar joint and semi-coronal cuts to classify

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the calcaneal fractures as per the Sanders classification. Inclusion criteria were patients between 18 and 60 years of age, presenting within 3 weeks of trauma, Sanders Type 2 and 3 displaced intraarticular calcaneal fractures. Spine fractures without deficit with calcaneal fractures were included in the study. Open fractures, undisplaced fractures (Sanders Type 1) or severely comminuted Sanders Type 4 fractures, sensory/motor loss in both lower limbs due to head injury, or spine injury with paraplegia or those with severe crushing requiring amputation were excluded from the study. Pathological fractures or those with skin infection or ulceration were also excluded. Fractures fixed with the extensile approach were also excluded. The decision to treat the patient with the open-envelope approach was made in consultation with the senior author often taking into account associated injuries which may require concomitant fixation. Appropriate signed informed consent was obtained from each patient before surgery.

Operative procedure

After appropriate anesthesia, the patient was positioned in lateral decubitus position for unilateral calcaneal fractures with the foot brought to the edge of the operating table. For bilateral calcaneal fractures and patients requiring spine fixation, the patient was positioned in the prone position with the feet hanging off the table edge. This ensured easy access for a surgeon while allowing appropriate C-arm imaging [Figure 1]. A tourniquet was inflated after limb elevation.

A 6.5 cm-7 cm longitudinal incision [Figure 2] was made just lateral to the Achilles tendon. The incision started about 2.5 cm proximal to the lateral malleolus and extended distally to the heel-sole junction. Below the lateral malleolus, in the region of the calcaneal tuberosity, the incision was deepened directly to the bone. Proximally, a dissecting scissor [Figure 2b] was used to deepen the incision. This incision corresponded to the vertical limb of the classical L-shaped extensile incision albeit with a more proximal extension. As the incision was just lateral to the Achilles tendon, it was posterior to the sural nerve and thus did not endanger the nerve which remained anterior to it in the tissue flap.

In the distal part of the incision, a scalpel was used to sharply dissect and to initiate the lifting off of the lateral soft tissue envelope of the calcaneal lateral wall fragments just as in the extensile approach. An osteotome was then used in this interval between the lateral calcaneal wall and the soft tissues to further free this soft tissue envelope containing the peroneal tendons with their sheaths, sural nerve, and subcutaneous fat up to the calcaneocuboid joint [Figure 2c]. The scalpel was again used to sharply dissect off the calcaneofibular ligament and include it in the soft tissue flap to reveal the subtalar joint laterally. The proximal part of the incision improved access to the subtalar joint. The fat and the retrocalcaneal bursal tissue were removed with a Rongeur till the subtalar joint was visualized from the posterior aspect as well.

The lifting off of the soft tissue "envelope" ensured excellent visibility of the articular surfaces and the lateral wall up to the calcaneocuboid joint [Figure 3]. The approach allowed direct manipulation of fracture fragments under vision. For tongue-type fractures, a periosteum elevator was used to lever up the articular surface under vision, while simultaneously, the tuberosity was pulled down using a bone hook. At the same time, the varus or valgus deformity of the tuberosity was corrected by adjusting the direction of force on the bone hook [Figure 3a]. The approach allowed accurate reconstruction of the articular facet by providing an excellent view of the subtalar articular surface and the medial articular fragment as well. The reduction could then be provisionally held by K-wires.

In joint depression-type fractures, the calcaneal tuberosity was disimpacted using a periosteal elevator and pulled down using a bone hook. The depressed articular surface fragment was lifted up using the periosteal elevator under vision. Often, the articular fragment was found to be rotated 90° to face the calcaneocuboid joint. If required,

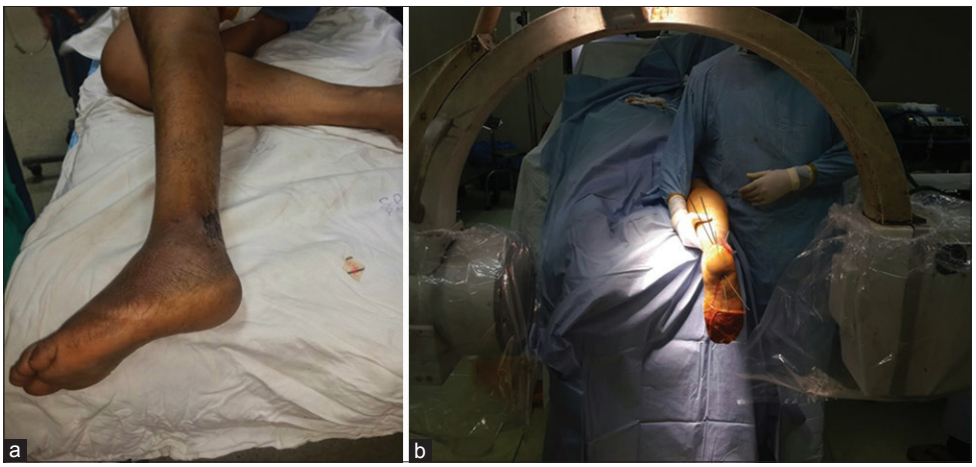

Figure 1: Clinical photographs (a and b) Showing position of patient in lateral decubitus or prone position with C-arm

Figure 2: Peroperative clinical photograph showing (a) skin incision (b) Dissecting proximal incision with scissors (c) Using an osteotome to lift the soft tissue envelope till the calcaneocuboid joint

the rotated fragment could be retrieved under vision, cleaned using a rongeur to determine the orientation, and then reinserted ensuring proper restoration of articular anatomy [Figure 3b]. A transversely oriented posterolateral to anteromedial K-wire or screw was used to fix it to the sustentacular fragment. The tuberosity was then reduced to the fragment and fixed with K-wires. Additional K-wires were used to hold the reduction of the fragment as required.

To prevent collapse of the lateral column, additional K-wires were passed from the tuberosity toward the calcaneocuboid joint in a posteromedial to anterolateral direction. The "open-envelope" approach ensured that the wires could be placed under direct vision as the tissue envelope had been lifted till the calcaneocuboid joint allowing direct visualization. The wires were clearly visible in the void left behind in the cancellous bone after restoration of articular congruity by elevating the depressed articular fragment [Figure 4].

As our experience with the approach improved, we introduced a second 1.5 cm vertical incision over the anterior process of the calcaneus under C-arm guidance. Only the skin was incised. A blunt-curved hemostat was used to dissect down. The peroneal tendons were identified,

Figure 3: Peroperative clinical photograph showing (a) using a bone hook to reduce the tuberosity. Articular surface clearly visible (b) Repositioning a depressed articular surface fragment

and the hemostat slid under them. This enabled us to slide a calcaneal plate without difficulty under the tendons using the hemostat [Figures 5, 6 and 7]. The screws for the distal end of the plate could also be easily drilled from the second incision. Furthermore, the second incision was also useful for introducing an elevator to help in reducing long tongue-type fractures with an intraarticular component.

The lateral wall fragments could then be impacted on to the lateral surface of the calcaneus under vision. If the comminution was severe, the fragments were removed especially below the lateral malleolus to prevent future peroneal impingement and were then used to fill the void created in the cancellous bone after reducing the articular fragment. After confirming the reduction and fixation under a C-arm with either K-wires or a plate, both incisions were then sutured. A suction drain was used exiting just proximal to the tip of the longitudinal incision.

Fractures that had been fixed with K-wires were supported by a below knee plaster cast. The K-wires were removed at 6–8 weeks postoperatively when radiographs began to show evidence of union. The calcaneal fractures which had been fixed with a plate were allowed immediate ankle range of motion. Patients were kept nonweight bearing till 8–10 weeks with gradual increase in weight bearing over the next 4 weeks. Comfortable footwear was advised. Patients were followed up at 3 weeks, 6 weeks, 3 months, and 6 months. American Orthopaedic Foot and Ankle

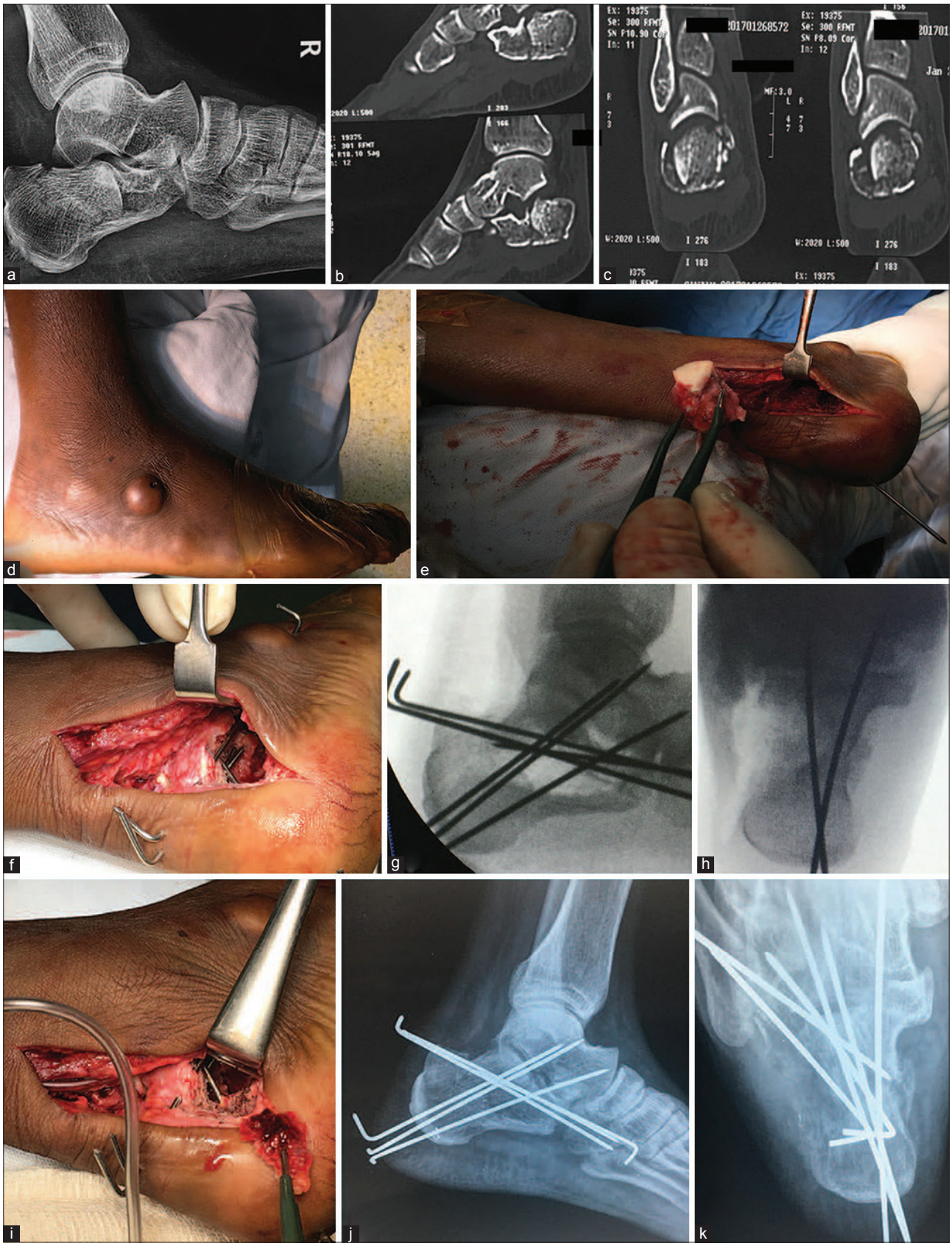

Figure 4: (a) X-ray of ankle joint lateral view (b and c) CT scan, showing joint depression type calcaneal fracture (d) Clinical photograph showing skin with large sebaceous cyst (e and f) Peroperative photographs showing intraoperative retrieval of depressed intraarticular fragment (g and h) Intraoperative fluoroscopic views showing void in cancellous bone after reduction of fragments. The K-wires are visible in void (i) Peroperative photograph showing that filling of void using lateral wall fragments and closure over suction drain (j and k) X-ray ankle joint lateral and axial views showing reduction and K-wires *in situ*

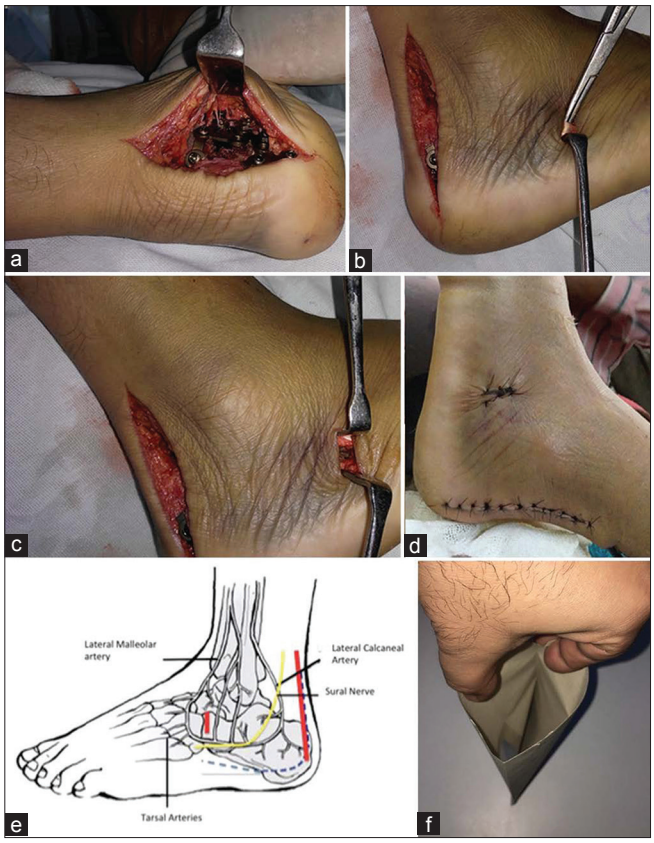

Figure 5: (a-d) Peroperative photograph showing both incisions and fixation for sliding plate fixation (e) A diagrammatic representation of the approach with the dual incisions in red colour (f) Peroperative photograph showing an "open envelope"

Score (AOFAS) ankle-hindfoot score was used to evaluate the clinical outcome (90–100 excellent, 80–89 good, 65–79 fair, and <64 poor). For radiological outcome, Bohler and Gissane angles were evaluated.

Results

143 patients presented during this period of 3 years. Of these, 26 were bilateral calcaneal fractures resulting in a total of 169 fractures. Of this total, 127 fractures were excluded. 25 fractures were excluded for being either Sanders 1 or 4, 10 fractures presented at >3 weeks from injury, 40 open fractures (including 6 bilateral) and 30 fractures (including 14 bilateral) with associated neural deficit or head injury and another 22 fractures which were operated via the extensile approach and were excluded. Thus, a total of 42 fractures in 30 patients were included in the study.

30 patients (42 fractures) were treated with the open-envelope approach within 3 weeks of injury. There were 21 males and 9 females. The right side was involved in 14 patients, left side in 4 patients, and bilateral involvement in 12 patients. The mean age at presentation was 31.3 years (range 18–56 years). Of the 42 fractures, 32 fractures were Sanders Type 3 and 10 fractures were Sanders Type 2. Of the 42 fractures, 23 fractures were

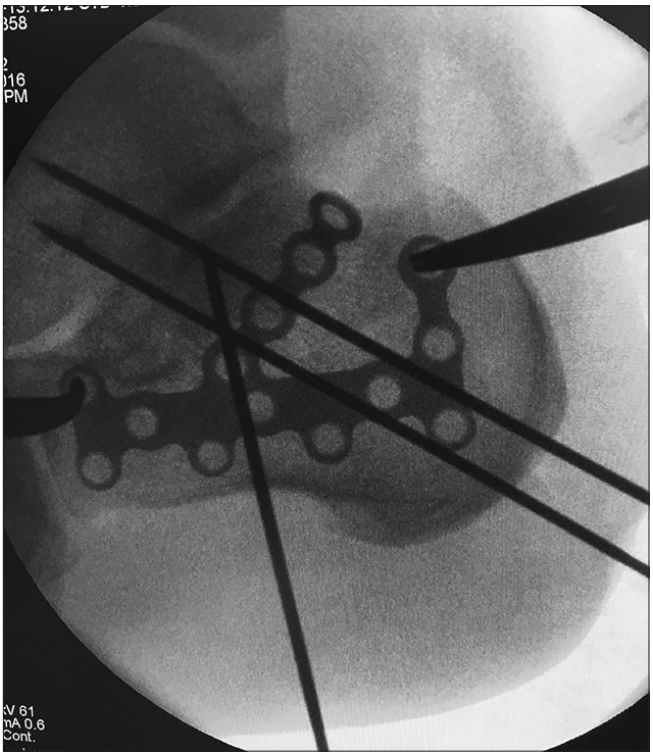

Figure 6: Fluoroscopic lateral view of ankle joint showing holding of reduction provisionally with K wires and sliding the plate

fixed with K-wires while 19 underwent plate fixation. The patients were operated as soon as possible without waiting for the "wrinkle sign" to appear. However, 10 patients had a delay of > 7 days from injury due to either associated comorbidities (*n*=3) or prior management of other injuries (*n*=7).

The most common associated fractures were spine injuries (*n*=8), pelvic fractures (*n*=3), tibial pilon fractures (*n*=2), medial malleolus fracture (*n*=2), tibial shaft fracture (*n*=5), proximal tibia (*n*=1), shaft humerus fracture in (*n*=2), and a radial head fracture (*n*=1). The most common mode of injury was fall from height (*n*=26) with road traffic accident (*n*=4).

Overall, the Bohler angle improved from a preoperative mean of 14.3° (range 0°–28°) to a postoperative mean of 32.46° (range 22° –42°). The Gissane angle improved from a preoperative mean of 135.83° to a postoperative mean of 128.33°. The postoperative improvement in Bohler and Gissane angles was highly significant ($P < 0.001$). The AOFAS scores at 6 months were excellent in nine patients, good in 15 patients, and fair in six patients. Three patients had residual valgus deformity of the heel. One patient had superficial pin tract infection requiring K-wire removal at 6 weeks. Another patient, a chronic smoker, had his sutures removed at 7 days with excision of scab by a local practitioner. Luckily, the plate was not exposed. Vacuum-assisted closure (VAC) application for 2 weeks resulted in healing of the wound. A third patient presented 8 months after the surgery with swelling and collection at

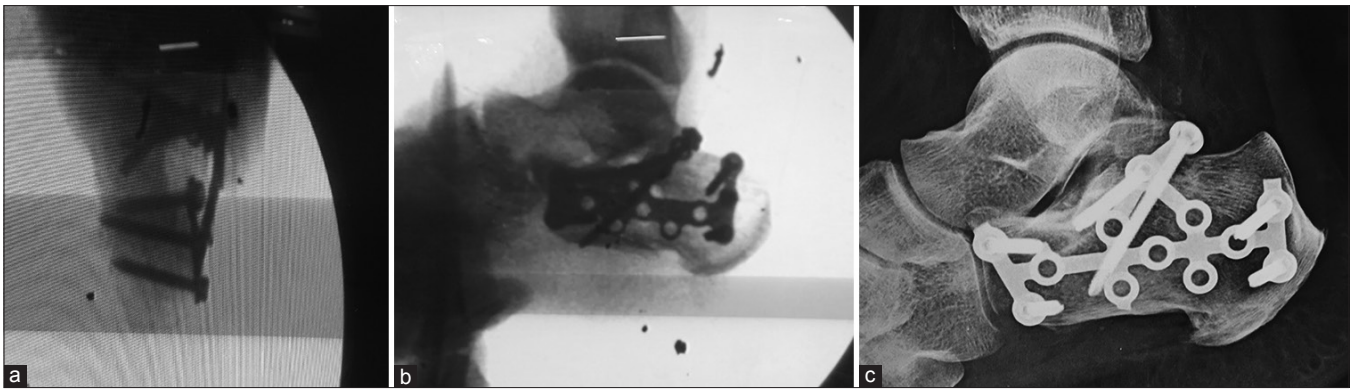

Figure 7: (a and b) Fluoroscopic views showing fracture well reduced and implant *in situ* (c) Postoperative x-ray ankle joint lateral view showing fracture fixed with plate and screws

the incision site requiring debridement. He was diagnosed to be an uncontrolled diabetic. Blood sugars were controlled with insulin and no further intervention was required.

Discussion

While the sinus tarsi approaches have been gaining popularity, longitudinal approaches to the calcaneus are less commonly reported.

Gallie[18] first described his approach in 1973 for subtalar fusion and a modified Gallie's approach was described in 1977 as a posterior approach to the subtalar joint. Through an incision lateral to the tendoachilles, the posterior subtalar joint was approached. The flexor hallucis longus was retracted and the joint capsule excised to reveal the subtalar joint.

Park *et al*.[19] (2000) used the Gallie's approach for fractures of the calcaneus and reported good results. They however used the approach to expose only the subtalar joint posteriorly. No attempt was made to elevate tissues of the lateral wall. A compression device was used to reduce the lateral wall, and K-wires were then used to hold the reduction in place.

Wu *et al*.[20] (2012) compared the results of ORIF with a minimally invasive approach for calcaneal fractures. They described a technique of reduction under a C-arm using a Steinmann pin. They also described creating a subcutaneous tunnel on the lateral side to slide a plate. They used compression bolts tightened through another medial incision as well. The fracture site was either reduced closed or a small sinus tarsi incision was used to reduce the fractures with equivalent functional outcomes when compared to the extensile approach. Zhang *et al*.[21] (2014) published an extension of the same study as Wu *et al*.[20] and reported similar outcomes between the longitudinal approach and the sinus tarsi approach. This despite the fact that the longitudinal approach had been used by the authors only to slide a plate while the reduction was done fluoroscopically. Furthermore, if the joint was required to be opened it was done via the sinus tarsi approach.

The "open-envelope" approach has evolved into a dual incision, limited open approach for calcaneal fracture fixation. The proximal longitudinal limb combines the Gallie's approach with the longitudinal limb of the classical extensile approach. The subperiosteal lifting off of the soft tissue envelope till the calcaneocuboid joint with incision of the subtalar joint capsule permits excellent visualization of the subtalar joint, allows direct manipulation of the displaced fragments under vision, and also allows the lateral wall fragments to be addressed. This ensures restoration of the articular surface under vision. The visible void in the calcaneus body after reduction of the articular fragments can also be addressed if required. The approach allows direct manipulation of the depressed articular fragment. The fragment can be removed, cleaned, and repositioned at the correct angle. Furthermore, removal of the lateral fragment allows access to the medial fragment, which is clearly visible. If required, a curved osteotome can be used to reduce the tuberosity under the medial fragment under vision. This is held by a K-wire from the tuberosity into the medial fragment. The lateral fragment is then repositioned, and the reduction held temporarily by more K-wires.

The fasciocutaneous flap that is lifted does not have an angular margin as in the extensile approach, which minimizes the risk of wound complications. There is no need to wait for the "wrinkle sign to disappear." Furthermore, the entire vascular arcade on the lateral aspect of the heel remains intact. The incision is just lateral to the Achilles tendon and thus does not endanger the sural nerve or the peroneal tendons which also remain in the elevated soft tissue flap. Furthermore, the approach can be carried out with the patient in the lateral or prone position, thus enabling bilateral fracture fixation without re-draping or as a combined procedure with spine fixation if required in the same setting.

The smaller 1.5 cm distal vertical incision over the anterior end of the calcaneus enables addressing fractures of the anterior end of the calcaneus. It permits insertion of a periosteum elevator to help in the reduction of a long displaced articular fragment. Furthermore, a curved hemostat introduced from this incision, under the peroneal tendons, facilitates sliding of a calcaneal plate and ensures

that the peroneal tendons are not trapped under the plate. As the incision is made only skin deep with a blunt hemostat for deeper dissection, there is no risk of injury to the sural nerve as it curves around the ankle.

The initial fixation used in the approach was K-wires. As our experience with the approach evolved, we felt the need for a second access point to the fracture. Thus, though the posterior incision afforded an excellent view, it was not sufficient to slide a plate in without adequate distal control. Furthermore, it would not have been possible to put anterior screws in the calcaneal plate with the posterior incision. With the introduction of the small anterior incision, a second access point to the fracture was created. This enabled sliding a blunt curved hemostat under the peroneal tendons to help slide the plate. It also allowed reduction of fractures of the anterior process and screw placement in the anterior holes of the calcaneal plate. In tongue-type fractures, the small anterior incision facilitated the introduction of a small elevator to lift and reduce the articular surface, while a bone hook was used from the posterior longitudinal incision to pull the tuberosity down.

As already discussed, another advantage of the excellent exposure afforded by the approach is in comminuted articular fractures. The articular fragments can be retrieved under vision from the posterior incision and reassembled and reinserted to reconstitute the articular surface. Thus, the posterior longitudinal incision allows addressing the lateral wall fragments, intraarticular depressed fragments, direct visualization of the medial fragment while removing and repositioning the lateral fragment, and repositioning the calcaneal tuberosity. The incision provides an excellent view of the posterior and lateral aspects of the subtalar joint. The void created by proper reduction of the articular fragment is also visible and can be addressed if required [Figure 4f].

The "open-envelope" approach does appear to offer a lower wound complication rate. This is evident from the fact that in the patient with the superficial K-wire infection requiring early K-wire removal, the superficial infection can be attributed to leaving K-wires protruding from the skin and not to the approach itself. The second patient, a smoker, actually had excision of the healing suture line scab and suture removal of the posterior incision at 7 days postoperative by an "indigenous practitioner." Luckily, the plate was not exposed and the wound healed with VAC application in 2 weeks. This wound breakdown was thus iatrogenic and not due to the approach. The third patient was a delayed presentation at 8 months post surgery with uncontrolled sugars requiring debridement. Thus, though the wound complication rate appears to be lower than the reported recently in a large meta analysis of up to 16.5% in a conventional extensile approach,[22] a longer followup with a larger patient cohort would be required to confirm this apparent benefit in wound management.

The limitations of the study include its non randomized nature, selection bias for patients with associated injuries (24 patients out of 30), relatively small sample size, and lack of comparison to the extensile approach. Furthermore, no patients presenting later than 3 weeks were operated on by the "open-envelope" technique. The authors do not recommend limited incision approaches as a method for treating late presenting calcaneal fractures, wherein a conventional extensile approach would be beneficial.

Conclusions

The "open-envelope" approach combines the excellent fracture visualization offered by the standard extensile approach with the advantage of a limited open incision, thus helping to avoid wound complications. A larger study with a longer followup period will help to accurately assess long term outcomes.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Dhillon MS, Bali K, Prabhakar S. Controversies in calcaneus fracture management: A systematic review of the literature. MusculoskeletSurg 2011;95:171-81.
2. Khurana A, Dhillon MS, Prabhakar S, John R. Outcome evaluation of minimally invasive surgery versus extensile lateral approach in management of displaced intra-articular calcaneal fractures: Arandomised control trial. Foot (Edinb) 2017;31:23-30.
3. Schepers T. The sinus tarsi approach in displaced intra-articular calcaneal fractures: A systematic review. IntOrthop 2011;35:697-703.
4. Carr JB. Surgical treatment of intra-articular calcaneal fractures: A review of small incision approaches. J Orthop Trauma 2005;19:109-17.
5. Essex-Lopresti P. The mechanism, reduction technique, and results in fractures of the oscalcis. Br J Surg 1952;39:395-419.
6. Schepers T, Schipper IB, Vogels LM, Ginai AZ, Mulder PG, Heetveld MJ, *et al.* Percutaneous treatment of displaced intra-articular calcaneal fractures. J OrthopSci 2007;12:22-7.
7. Magnan B, Bortolazzi R, Marangon A, Marino M, Dall'Oca C, Bartolozzi P, *et al.* External fixation for displaced intra-articular fractures of the calcaneum. J Bone Joint Surg Br 2006;88:1474-9.
8. Stulik J, Stehlik J, Rysavy M, Wozniak A. Minimally-invasive treatment of intra-articular fractures of the calcaneum. J Bone

Joint Surg Br 2006;88:1634-41.
9. Holm JL, Laxson SE, Schuberth JM. Primary subtalar joint arthrodesis for comminuted fractures of the calcaneus. J Foot Ankle Surg 2015;54:61-5.
10. Howard JL, Buckley R, McCormack R, Pate G, Leighton R, Petrie D, *et al.* Complications following management of displaced intra-articular calcaneal fractures: A prospective randomized trial comparing open reduction internal fixation with nonoperative management. J Orthop Trauma 2003;17:241-9.
11. Sharr PJ, Mangupli MM, Winson IG, Buckley RE. Current management options for displaced intra-articular calcaneal fractures: Non-operative, ORIF, minimally invasive reduction and fixation or primary ORIF and subtalar arthrodesis. A contemporary review. Foot Ankle Surg 2016;22:1-8.
12. Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int 1998;19:856-61.
13. Dhillon MS, Gahlot N, Satyaprakash S, Kanojia RK. Effectiveness of MIS technique as a treatment modality for open intra-articular calcaneal fractures: A prospective evaluation with matched closed fractures treated by conventional technique. Foot (Edinb) 2015;25:134-40.
14. DeWall M, Henderson CE, McKinley TO, Phelps T, Dolan L, Marsh JL, *et al.* Percutaneous reduction and fixation of displaced intra-articular calcaneus fractures. J Orthop Trauma 2010;24:466-72.
15. Arastu M, Sheehan B, Buckley R. Minimally invasive reduction and fixation of displaced calcaneal fractures: Surgical technique and radiographic analysis. IntOrthop 2014;38:539-45.
16. Park CH, Lee DY. Surgical treatment of sanders type 2 calcaneal fractures using a sinus tarsi approach. Indian J Orthop 2017;51:461-7.
17. Kline AJ, Anderson RB, Davis WH, Jones CP, Cohen BE. Minimally invasive technique versus an extensile lateral approach for intra-articular calcaneal fractures. Foot Ankle Int 2013;34:773-80.
18. Kalamchi A, Evans JG. Posterior subtalar fusion. A preliminary report on a modified Gallie's procedure. J Bone Joint Surg Br 1977;59:287-9.
19. Park IH, Song KW, Shin SI, Lee JY, Kim TG, Park RS, *et al.* Displaced intra-articular calcaneal fracture treated surgically with limited posterior incision. Foot Ankle Int 2000;21:195-205.
20. Wu Z, Su Y, Chen W, Zhang Q, Liu Y, Li M, *et al.* Functional outcome of displaced intra-articular calcaneal fractures: A comparison between open reduction/internal fixation and a minimally invasive approach featured an anatomical plate and compression bolts. J Trauma Acute Care Surg 2012;73:743-51.
21. Zhang T, Su Y, Chen W, Zhang Q, Wu Z, Zhang Y, *et al.* Displaced intra-articular calcaneal fractures treated in a minimally invasive fashion: Longitudinal approach versus sinus tarsi approach. J Bone Joint Surg Am 2014;96:302-9.
22. Yao H, Liang T, Xu Y, Hou G, Lv L, Zhang J, *et al.* Sinus tarsi approach versus extensile lateral approach for displaced intra-articular calcaneal fracture: A meta-analysis of current evidence base. J OrthopSurg Res 2017;12:43.