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Surgical treatment of displaced intraarticular calcaneal fractures by a minimally invasive technique using a locking nail: A preliminary study

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ABSTRACT

Background: The aim of this retrospective study was to evaluate the outcome of patients with intra-articular calcaneal fractures treated using a minimally invasive locking nail (Calcanail®).
Methods: Between January 2016 and April 2017, 15 patients (9 men and 6 women) with a calcaneal fracture were consecutively treated with Calcanail®. The Böhler angle was recorded on standard X-rays pre- and post-operatively. The articular reduction of the posterior facet was evaluated with the Goldzak index in a CT scan 3 months post-operatively. The mean age of the patients was 53 years (range, 24–78). Mean final follow-up was 18 months (range, 12–24).
Results: Six fractures were classified as Sanders II, 7 as Sanders III and 2 as Sanders IV. In 13 out of the 15 patients treated, the post-operative Böhler angle was of more than 20°. Goldzak index was deemed as excellent in 73.5% of the cases (11 patients), good in 20% of cases (3 patients), and poor in 6.5% (1 patient). Post-operative mean AOFAS score was 85 (range, 60–96).
Conclusions: The Calcanail® provides good restoration of the subtalar joint and the calcaneal angles with the advantages of a minimally invasive approach. It was effectively used in Sanders types II and III, even in the presence of poor cutaneous conditions.

1. Introduction

The surgical treatment of displaced articular calcaneal fractures is still controversial. Historically open reduction and internal fixation (ORIF) using a plate through a surgical lateral approach has been considered the gold standard for Sanders type II and III fractures and still proposed as such by some [1–3]. However, a high complication rate is associated to ORIF techniques due to delayed wound healing, skin necrosis and infection [4,5]. Wound complications with an extensile lateral approach were reported in up to 33% of cases in a retrospective study and 16% in a prospective randomized trial [4,5].

To avoid these complications minimally invasive techniques have been proposed such as percutaneous K wire pinning or screws, minimally invasive plates and external fixation [6–12]. The Calcanail® (FH Orthopedics SAS, Heimsbrunn, France) implant is a novel locking nail that is introduced through a minimally invasive posterior approach allowing intra-focal reduction of the thalamic portion and internal fixation [13,14].

The aim of this study was to evaluate a group of consecutive patients affected by intra-articular calcaneal fractures treated with the Calcanail® implant and technique.

2. Methods

Between January 2016 and April 2017, 15 patients (9 men and 6 women, with a mean age of 53 years, range 24–78) with a displaced intraarticular calcaneus fracture were consecutively treated with Calcanail®. Preoperative CT scans and plain radiographs were obtained to analyze the subtalar joint congruity and to classify fractures according to Sanders' classification. All patients were evaluated clinically and with X-rays after 6 weeks, 12 weeks, 6 months and at final follow-up. A CT scan was obtained 3 months after surgery. The final follow-up was at a mean of 18 months (range, 12–24) after surgery. At final follow-up patients were assessed with the American Orthopedic Foot and Ankle Society (AOFAS) score.

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The Böhler angle was recorded on standard X-rays preoperative and postoperative. The accuracy of the posterior facet's articular reconstruction was evaluated with Goldzak index in the CT scan obtained 3 months after surgery [14]. The reconstruction was considered excellent for types A or B, good for type D or E and poor for type C.

The postoperative protocol consisted of three weeks of immobilization with a cast, allowing for partial weight-bearing at 6 weeks and full weight-bearing at approximately 12 weeks after surgery.

2.1. Surgical technique

Despite descriptions of the technique in a lateral position, for this case series it was the authors' preference to place the patients in a prone position. The surgery was performed under spinal anesthesia and tourniquet was not used.

A 3 mm K-wire with stopper was firstly placed in the posterior tuberosity and its position checked with fluoroscopy in the lateral and axial views: this was a crucial point for the success of the procedure, particularly in fractures with severe hindfoot varus displacement. An authors' tip is to place the K-wire right under the posterior subtalar surface in the lateral view and aiming at the IV interdigital space (Fig. 1). Then two 3 mm K-wires were placed as adjuncts for an external distractor: the first in the posterior tuberosity at least 10 mm above and perpendicular to the K-wire with stopper. The second K-wire at the center of the talar dome and perpendicular to it. By applying distraction, the varus of the hindfoot can be corrected and the posterior subtalar surface can be raised and reduced, thus restoring Böhler's angle. A 10 mm hollow reamer was introduced over the K-wire and the bone was reamed up until the undersurface of the depressed articular fragments. The hollow reamer and the K-wire with stopper were removed, and a 2–3 cm bone plug was harvested from the inside of the hollow reamer. This cancellous bone could be used at the end of the procedure. The intrafocal reduction of the thalamus and of the subtalar surface was completed under fluoroscopy control with straight and curved instruments inserted through the hole drilled in the posterior tuberosity (Fig. 2). Once the congruence of the subtalar joint was restored, the length of the nail was determined. The Calcanail® is available in three lengths (45, 50 and 55 mm) of a unique diameter (10 mm). The nail was inserted with its jig and locked with two 5 mm cannulated screws (Fig. 3). Final lateral and axial views were performed with fluoroscopy and a cast in neutral ankle position was applied (Fig. 4).

3. Results

Fifteen patients (15 fractures) underwent surgical treatment with Calcanail® for a displaced intraarticular calcaneus fracture. Six were classified as Sanders II (3 IIA and 3 IIB), 7 as Sanders III (4 IIIAB, 2 IIIBC and 1 IIIAC) and 2 as Sanders IV. All fractures were closed but the 2 Sanders IV presented soft-tissue compromise classified as Tscherne type III. The mean time from injury to operation was of 5 days (range, 3–10 days) and the mean surgical time was 60 min (range, 30–90 min). Patient's data and results are summarized in Table 1.

Preoperative mean Böhler's angle was 0° (range, –15° to +7°). Postoperative images showed a mean Böhler's angle of more than 20° in 13 out of 15 patients (Fig. 5). For the remaining two patients the Böhler's angle was between 10° and 20°. These values did not change in subsequent follow-up. Based on the 3 months CT scan the Goldzak index was deemed as excellent (type A or B) in 73.5% of the cases (11 patients), good (type D or E) in 20% of the cases (3 patients), and poor (type C) in 6.5% (1 patient) (Fig. 6).

During clinical follow-up, no superficial or deep infections were observed. At final follow-up the AOFAS score reached a mean of 85 (range, 60–96). When analyzing the pain section within the AOFAS score, 14 out of 15 patients reported no functional limitations, none or occasional pain, no gait abnormality, normal hindfoot alignment and normal or mild restriction of eversion and inversion. One patient (Sanders IV type fracture) complained of daily pain, severe limitations, gait abnormality and marked restriction of hindfoot motion. This patient presented a mild complex regional pain syndrome (CRPS) after 6 months and required removal of the implant and conversion to subtalar arthrodesis 11 months after the primary surgery. This was the only case requiring re-operation and secondary subtalar arthrodesis.

4. Discussion

The most important finding of the present study was that the Calcanail® device is a reliable technique to treat intraarticular calcaneal fractures including Sanders II and III.

Intraarticular calcaneal fractures are oftentimes complex fractures, hence, difficult to reduce, even for expert surgeons and with the use of an open approach and a locking plate. The main concern with ORIF techniques is the risk of complications related with wound-healing and infection [4]. A retrospective review compared the outcomes of displaced intra-articular calcaneal fractures treated with ORIF via an extensile approach versus a minimally invasive sinus tarsi approach [15]. Clinical results were similar for the 2 approaches, but the minimally invasive approach had a significantly lower incidence of wound complications and secondary surgeries [15]. To avoid these complications minimally invasive techniques have been proposed such as percutaneous K wire pinning or screws, balloon systems and external fixations [6–12]. Recently, Goldzak et al. proposed a locking nail that allows both intrafocal reduction of the thalamic surface and internal fixation through a minimally invasive posterior approach [13,14]. In a prospective study of 69 cases form the designer center this system showed satisfactory midterm results with a minimal complication rate, and a satisfactory reduction of intraarticular fractures [14]. In addition, it gives the surgeon the opportunity,

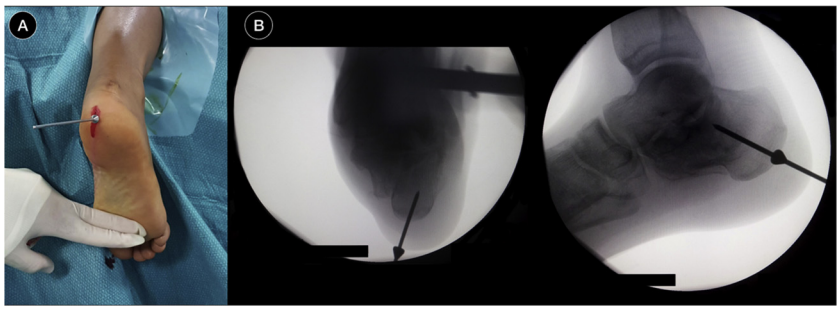

Fig. 1. Intraoperative positioning of the K-wire with stopper in the posterior tuberosity (A). Position is then checked in the lateral and axial views with fluoroscopy (B).

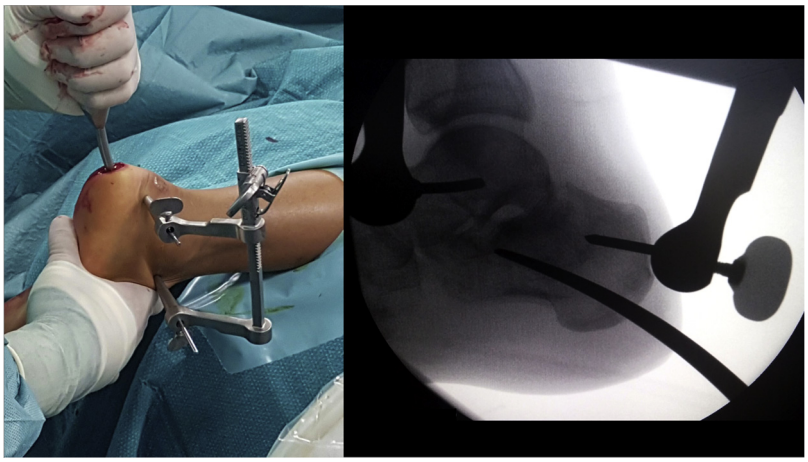

Fig. 2. Reduction of the thalamus and subtalar joint surface under fluoroscopic control with the use of straight and curved instruments through the posterior tuberosity.

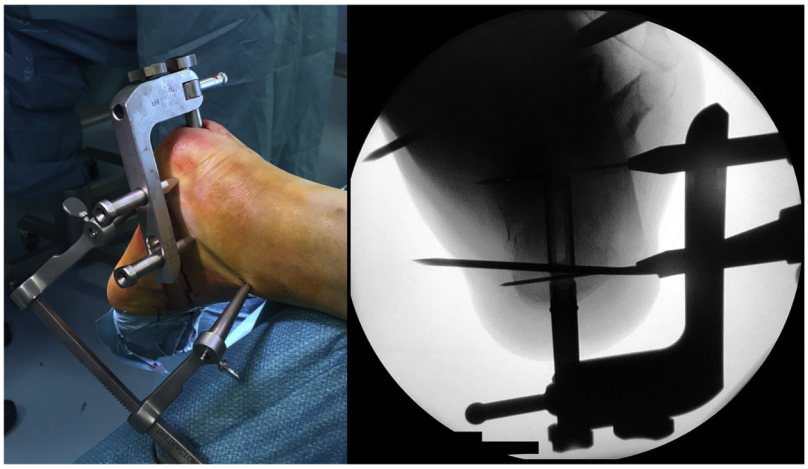

Fig. 3. The nail is inserted with the jig and blocked with two 5 mm cannulated screws.

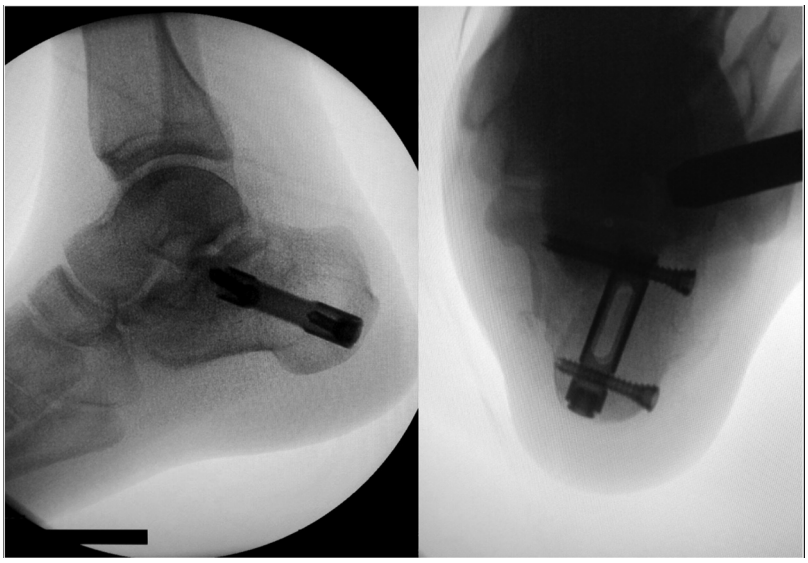

Fig. 4. Lateral and axial final views after nail insertion.

Table 1
Patient's data and results.

Pt	Age (y)	Final follow-up (months)	Sanders type	Surgical time (min)	Time injury to surgery (days)	Pre Böhler's angle (α)	Post Böhler's angle (α)	Goldzak index	AOFAS
1	30	24	III AB	90	5	α −3°	>20°	B	90
2	47	24	IV	90	7	α −15°	10°<α>20°	C	60
3	56	22	II A	70	3	α +7°	>20°	A	90
4	50	22	IV	90	10	α −8°	10°<α>20°	E	70
5	57	20	III BC	75	6	α −3°	>20°	B	90
6	67	20	III AB	70	5	α +3°	>20°	A	92
7	43	18	III BC	75	6	α 0°	>20°	B	88
8	24	18	II B	55	3	α +5°	>20°	A	92
9	30	18	III AB	60	8	α +3°	>20°	A	90
10	69	18	II A	40	4	α 0°	>20°	A	96
11	47	16	II B	30	3	α +2°	>20°	B	88
12	78	16	III AB	45	7	α −3°	>20°	D	82
13	59	14	II B	40	3	α 0°	>20°	B	86
14	70	12	II A	30	3	α +7°	>20°	A	88
15	63	12	III AC	45	7	α −2°	>20°	D	80
Mean	53 y	18 months		60 min	5 days	α 0°			85

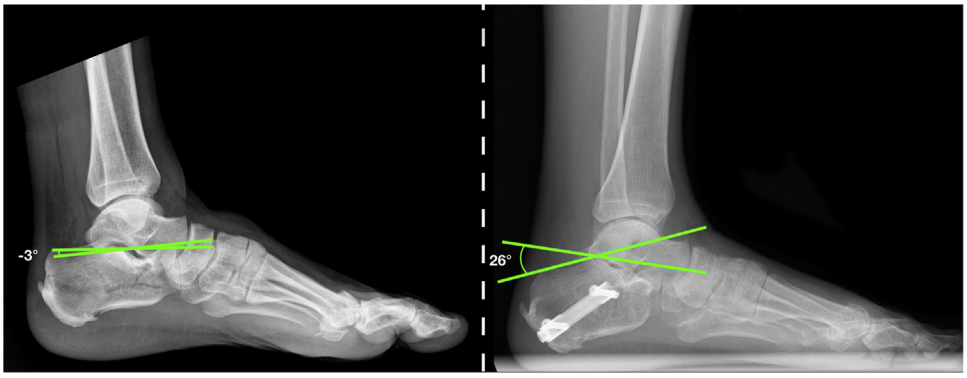

Fig. 5. Preoperative lateral non-weight bearing view showing an inverted Böhler's angle (−3°) (*left side*). The weight bearing X-rays 6 months after surgery showing a complete restoration of Böhler's angle (26°) (*right side*).

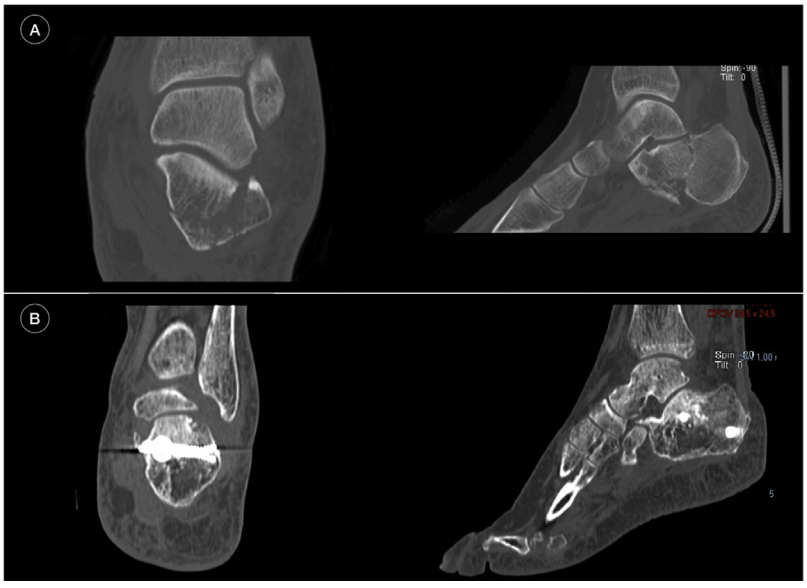

Fig. 6. Preoperative CT scan of a Sanders 2A calcaneal fracture in coronal and sagittal view (A). Postoperative CT scan showing good reduction (Goldzak A) and fracture healing.

when necessary, to switch to a subtalar arthrodesis in cases of irreducible severely damaged posterior facets (Sanders IV) using a longer nail. Several biomechanical studies were performed to quantify primary stability of minimally invasive calcaneal interlocking nail systems in comparison to variable-angle interlocking plates [16]. Both systems reported sufficient primary stability and no differences were observed between the two [17,18].

Surgical treatment of displaced intra-articular calcaneal fractures aims to restore calcaneus height and width and to reconstruct the subtalar articular surface. When these goals are met, functional outcomes are best with a decreased risk of developing subtalar arthrosis and an increased chance of resuming preinjury work [19]. In this study this system has been proved to be effective in restoring both Bohler angle and reduction of articular subtalar surface. No cases of subfibular impingement or lateral wall compression were seen as a result of insufficient width restoration.

In addition, despite the inherent complexity of these fractures this device has proven to simplify the procedure while resulting in a reduction of the surgical time. Once the learning curve was overcome, surgery took less than an hour. According to the original technique, patients are placed in a lateral position [13,14]. In this case series patients were placed in a prone position, as the authors believe that fracture reduction is facilitated and fluoroscopic views easily obtained. No complications related to early or late infection, skin necrosis, neurovascular injury, malreduction or nonunion were observed. A benefit of the percutaneous approach is that surgery can be performed even in patients with compromised soft tissues as seen in this series (Tscherne type II and III). Theoretically the early restoration of bony anatomy would decrease the tension applied to soft tissues and facilitate their recovery.

The treatment of Sanders type IV fractures is still debated and primary subtalar arthrodesis is considered a reasonable option for many authors [20–23]. Ideal indications proposed for locking nails are Sanders type II and III fractures. In this study the indication was extended to fix 2 cases of Sanders IV fractures. The reason behind it was the young age of patients and every attempt was made to restore the articular surface while preserving the subtalar joint. We caution about its use in these highly comminuted fractures as the reduction maneuvers may be difficult and sometimes the restoration of congruity suboptimal. In 1 case a good reconstruction of the subtalar articular surface was obtained (Goldzak E) resulting in satisfactory clinical outcome whereas in the other the reduction achieved was insufficient (Goldzak C) and led to poor clinical outcome requiring subtalar arthrodesis about 1 year after surgery. A good posterior facet reduction is important to achieve satisfactory outcomes and should be always pursued. When not obtained, after preparing the subtalar joint through a minimally invasive approach the Calcanail system can be used as the method of fixation for primary subtalar arthrodesis and this should be carried out. Although the presented small numbers are not enough to draw definitive conclusions, the potential for satisfactory subtalar reduction with minimal soft tissue disruption is a good enough reason to justify the initial attempt of joint sparing intervention when good reduction is obtained.

The present study was limited by the lack of a control group and the retrospective analysis. Another limitation of the study was the use of AOFAS score to assess clinical outcomes, which is not a validated questionnaire [24]. The relatively short follow-up at completion of our report was an additional weakness.

In conclusion, intraarticular calcaneal fractures can be successfully treated with a locking nail. The Calcanail® has proven to be a reproducible and safe technique when used in Sanders type II and III fractures, even in patients with poor cutaneous conditions (Tscherne type II and III). Its minimally invasive approach allowed for good restoration of Böhler's angle and subtalar articular congruence. In Sanders type IV, it could be used as long as good joint reduction is obtained.

Conflict of interest

None.

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