ORIGINAL ARTICLE

Minimally invasive sinus tarsi approach in Sanders II-III calcaneal fractures in high-demand patients

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ABSTRACT

Aim To evaluate if the sinus tarsi approach treated with open reduction and internal fixation (ORIF), without using plate fixation, provided good functional results in active adult population. The hypothesis was that the sinus tarsi approach with limited incision provided good results comparable to other approaches.

Methods A total of 78 patients (81 feet) surgically treated for articular calcaneus fracture were reviewed according to inclusion criteria: Sanders fracture type II-III, minimum follow-up of 2 years, patients aged 18-65 years. Exclusion criteria were smokers, diabetics, non-collaborative patients and patients with Sanders fracture type I and IV. A mean follow-up was 52.6 months. Radiographic changes of the Bohler's angle were reported. For the clinical evaluation, Visual Analogue Scale (VAS) for calcaneal fractures, American Orthopaedic Foot and Ankle Society (AOFAS) score and Maryland Foot Score (MFS) were used.

Results A statistically significant restitution of Böhler's angle from preoperative to postoperative (13.5°-27°; p<.001) was found. The AOFAS and MFS showed pain relief and good/excellent functional activities at the final follow-up in 65 of 78 (83.3%) patients. In eight (out of 81; 10%) feet a superficial wound infection was observed. In three (3.8%) patients a subtalar arthrodesis was performed.

Conclusion The mini-invasive sinus tarsi approach for active adult population is a valid and reproducible technique with a low rate of major complications, but it is mandatory advice to patients regarding the expectation of the results.

Key words: foot and ankle trauma, hindfoot surgery, mini-invasive surgery, outcome scoring

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INTRODUCTION

Calcaneal fractures present a significant challenge to orthopaedic surgeons. Calcaneal fractures are the most frequent tarsal fractures (approximately 60% of all tarsal fractures) and represent 2% of all adult fractures; in the most cases they involve young adults (1-4). ORIF is routinely performed especially for displaced intra-articular calcaneal fractures (5,6).

There are various approaches for calcaneal fracture fixation in the literature (2-4). Surgical approach is one of the factors affecting outcomes of the surgical treatment (7,8).

The most commonly used approach is the extensile lateral approach described by Letournel (9).

Soft tissue complications affect success of the surgery (7,8). Percutaneous techniques are developed in order to reduce the complications of the extensile approach but reduction of the articular surface could be difficult and may be considered the main problem of percutaneous techniques (10,11). Soft tissue problems may accompany calcaneal fractures due to high-energy trauma. Particularly severe oedema may cause corruption of the soft tissue, fracture blisters and compartment syndrome (12,13).

The aim of this study was to evaluate if the sinus tarsi approach fixed with k-wires or screws provided good functional results in active adult population. The hypothesis was that the sinus tarsi approach with limited incision provided good results comparable to other approaches.

PATIENTS AND METHODS

Patients and study design

Ninety-seven patients (109 feet) surgically treated for articular calcaneus fracture in SM Misericordia Hospital - Orthopaedic and Traumatology Department (Perugia, Italy) in the period 2007-2018 were retrospectively analysed.

Inclusion criteria were: Sanders fracture type II-III, minimum follow-up 2 years, patients aged 18-65 years, workers and/or recreational sports, with a Tegner Activity Level ≥4 before injury. Exclusion criteria were open fractures and polytrauma, chronic smokers (more than 10 years), diabetics (with clinical manifestations), non-collaborative patients and patients with Sanders fracture type I and IV. All surgeries were performed by surgeons who had considerable experience in foot and ankle surgery.

After applied exclusion criteria 78 patients (81 feet) were eligible for an analysis.

All fractures were classified according to the CT Sanders classification system (4). The study only included Sanders II (48 feet) and Sanders III (33 cases feet) fractures. The average final follow-up was 52.6 (range 24-120) months.

The mean age of the patients was 44.8 (range 22-63) years. Of the 78 patients, 21 (27%) were females and 57 (73%) were males; 41 had right feet injury and 37 left one (three cases were bilateral).

This study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki, and an informed consent was obtained from all patients. Data used in this retrospective study were recorded as part of a usual clinical evaluation in the Orthopaedic and Traumatology Department (Perugia, Italy), and consequently approved by a local review board.

Methods

Radiographic modifications of the Bohler's angle (pre-operative, immediately after surgery and at final follow-up) were reported. For the clinical evaluation, Visual Analogue Scale (VAS) for calcaneal fractures (12 questions, 0 was the worst possible result and 10 was no pain), American Orthopaedic Foot and Ankle Society (AOFAS) score (it includes both subjective and objective, or physician-assessed items, and is scored from 0 to 100, with a higher score representing a better outcome) for ankle/hindfoot and Maryland Foot Score (MFS) were used (in MFS 100 marks are possible with pain, function and movements each carrying 45, 50 and 5 marks respectively; less than 50 marks suggest failure, 50-74 fair, 75-89 good and 90-100 excellent results) (2, 14-17).

CT scans were performed to confirm Sanders classification preoperatively.

The radiographic evaluations included anterior-posterior (AP), lateral view of the calcaneus and Broden's view in all patients. The Böhler's angle was measured before surgery, one-day post-operative, and at the time of the final follow-up.

Radiographic measurements of the calcaneus were also measured retrospectively, according to Abdelgaid and Kikuchi, pre-operative, after 6 weeks and at the final follow-up (11,18). Osteoarthritic changes of the subtalar joint were evaluated at the final follow-up using Paley and Hall scoring system (14).

The functional and radiographic results were evaluated by an orthopaedic surgeon who was blinded to the study and who was not involved in the surgical treatment.

In all patients, surgery was performed via sinus tarsi approach in lateral decubitus position and the fragments are fixed either temporarily with a Kirschner (K)-wire, or definitively with one or more screws. No plate fixation was used in patients (Figure 1).

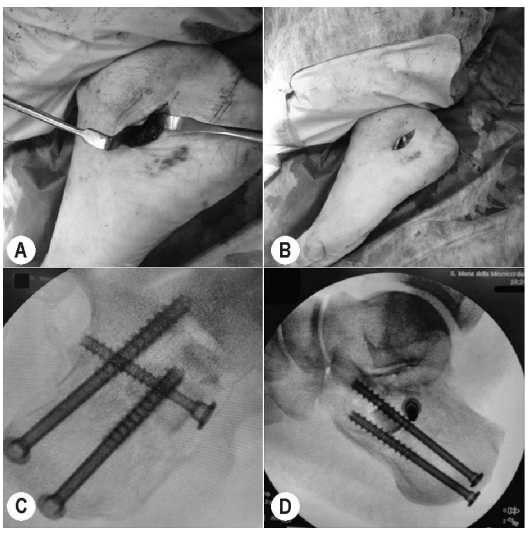

Figure 1. Surgical technique for reduction of calcaneal fractures with limited sinus tarsi approach. A) Sinus tarsi approach; B) after open reduction and internal fixation; C) axial view: direction of the screws and fracture reduction; D) lateral view: Bohler's angle reduction can be observed after Open Reduction and Internal Fixation (ORIF) (Ceccarini P, SM Misericordia Hospital, 2019)

The average time from the trauma to surgery was 7.8 days (range 2-16 days) (Table 1).

Table 1. Characteristics of the study population

No of patients/feet	**78/81**
Age (years)	44.8 (22-63)
Gender (No, %)	
Female	21(27)
Male	57 (73)
Side of injury (No, %)	
Right	41 (52)
Left	37 (44)
Bilateral	3 (4)
Time to surgery (days)	7.8 (range 2-16)
Sander's classification (No, %)	
II	48 (61)
III	33 (39)
Follow-up duration (months)	52.6 (24-120)
Complications (No, %)	
Deep infection	/
Wound dehiscence	8/81 (10)
Subtalar fusion	3/81 (4)
Sural nerve symptoms	6/81 (7)
Non-union	/

Post-operative. After surgery a cast below the knee without weight-bearing was placed for 6 weeks. After this time hydro kinesitherapy and partial weight bearing was encouraged. Full weight-bearing was possible after 8 weeks. Sutures were removed approximately after 3 weeks and after a meticulous wound check.

Statistical analysis

The nonparametric Wilcoxon test for paired data was used to compare scores before and after the surgery. Statistical significance for $p < 0.05$ was used.

RESULTS

A total of 78 (fifty-seven males and twenty-one females, with a mean age of 44.8 years) met the inclusion criteria. The average length of follow-up time was 52 (range 24-120) months.

Preoperatively all patients were high demand workers and/or active in daily living (at least sport activities two times a week).

All patients reported severe pain at the VAS dedicated for calcaneus fractures (in the pre-operative, with an average of 1.6 (range 0-3). At the final follow-up the mean VAS for calcaneus fractures was 7.58 ($p<0.0001$).

According to the Sander's CT classification for calcaneus intra-articular fractures, 48 (out of 81; 59%) fractures were classified as grade II and 33 (41%) as grade III.

None of the patients improved his/her activity level and the most of them, 80 (%) practiced non-contact sports after trauma.

For the clinical evaluation Maryland Foot Score (MFS) and AOFAS score were used, reporting a mean score of 85.28 and 86.34 at the final follow-up, respectively. A total of 65 (83.3%) of 78 patients showed excellent/good result (range 80-100), seven (8.9%) fair (range 70-80) and six (7.6%) poor (score <70).

The patients with Sanders II and III fractures reported an MFS of 88.1 and 82.46 respectively ($p>0.005$) (Table 2, Figure 2).

Median Böhler's angle in the pre-operative was 7.1° (range -11°-17°), on the day 1 after the surgery it was 21.5° (min. 6°, max. 34°), and at the final follow-up it was 20° (min. 2°, max. 33°), with mean improvement of 14° between pre-operative and last follow-up (7°-20.1°) ($p<0.001$). No

Table 2. Clinical and radiographic results of calcaneal fractures surgically treated

Clinical results	**Pre-operative**	**Post-operative** (final follow-up)			**p**
VAS for calcaneus fractures	1.61	7.16			<0.0001
Maryland foot score					
Pain		38.57			
Walked distance		8.85			
Stability		3.71			
Support		3.92			
Limp		3.71			
Shoes		8.86			
Stairs		3.64			
Terrain		2.42			
Cosmesis		7.28			
Motion		4.01			
Total		85.28			
Radiographic results	**Pre-operative**	**1 day after surgery**	**After 6 weeks**	**Final follow-up (52 months)**	**P (post-operative)**
Böhler angle (°)	7.1	21.5	21.16	20	>0.05
Mean length (mm)	78.6	84.26	84.01	83.72	>0.05
Mean width (mm)	58.6	48.92	48.75	50.63	>0.05
Mean height (mm)	47.6	51.51	51.53	49.89	>0.05
Paley and Hall score for subtalar joint					
Grade 0				11	
Grade 1				18	
Grade 2				10	
Grade 3				2	/

Significant (p<0.001) improvement of VAS was observed after the surgery. No loss of correction of Bohler's angle was observed at the final follow-up (p>0.05)

VAS, visual analogue scale; NA, non-applicable; WB, weight-bearing radiographs

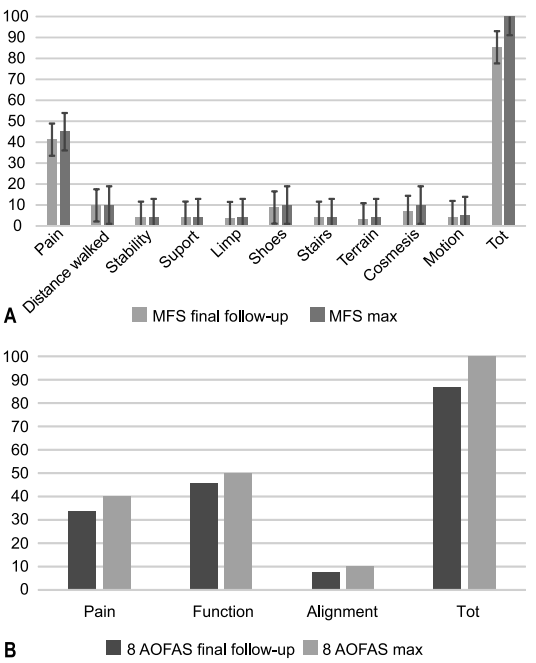

Figure 2. A) Maryland Foot Score (MFS) and B) American Orthopaedic Foot and Ankle Society (AOFAS) for ankle-hindfoot score at the final follow-up (52.6 months)

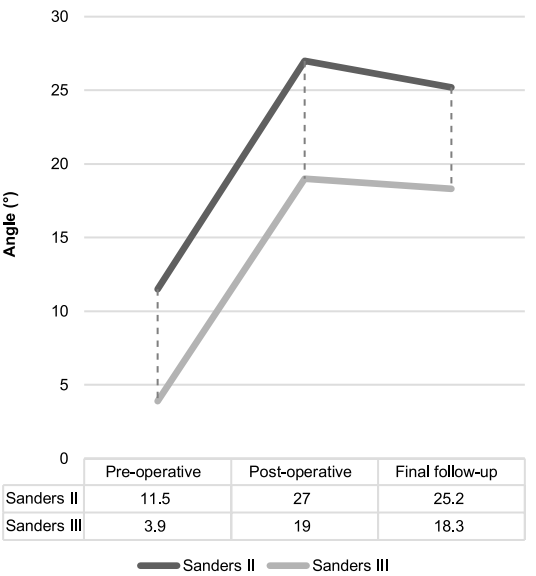

Figure 3. Changes in Bohler's angle for Sanders II and III at the time of trauma, after surgery and at final follow-up

statistical difference between post-operative results was observed (p>0.05). The patients with Sanders II fractures showed better results of the Bohler's angle, however without statistical differences (p>0.05) (Figure 3).

Radiographic outcomes of calcaneal measurements (height, width and length) were not significantly different from 6 weeks post-operatively to the final follow-up (p>0.05) (Table 2).

Complications

In eight of 81 (9.8%) fractures a superficial wound infection was observed, all healed with conservative treatment. In three (3.8%) of 78 patients a subtalar arthrodesis was performed due to

post-traumatic subtalar arthritis 2 years after the surgery (Sanders III in all cases). In six (7.6%) cases, patients reported sural nerve symptoms in the first year; no patient required exploration or sural neuroma excision. One patient reported malunion. There were no reported cases of osteomyelitis, deep infection and non-union. There were no cases of displacement of hardware.

DISCUSSION

The surgical treatment for the calcaneal fractures has been advocated for years; in general, open reduction and internal fixation is indicated as a gold standard in the young and active population, but the debate is still open on the best surgical treatment, with many surgical approaches proposed in the last years, each with its advantages and disadvantages (3,6,19-21).

In 2011 Schepers et al. performed a systematic review on the sinus tarsi approach in intra-articular calcaneal fractures, examining eight case series of the last decade (2000-2010) with 271 calcaneal fractures. The author concluded the review asserting that the results of the sinus tarsi approach compare similar or favourable to the extended lateral approach, and in the process of tailoring the best treatment modality to the right patient and the right fracture type the sinus tarsi approach might be a valuable asset (6). Moreover, the author suggested to use in all cases Sanders classification and more uniformity in the outcome scores.

There are also other studies published after this systematic review in order to evaluate the results of the sinus tarsi approach.

In a prospective study Zhang et al. reported similar clinical (with AOFAS score) and radiographic outcomes of two mini-invasive approaches in 130 patients with Sanders II-III intra-articular fractures of calcaneus (22). Kikuchi et al. reviewed 22 calcaneal fractures treated with ORIF with limited sinus tarsi approach and found a statistically significant restoration of Böhler's angle and calcaneal width; however, a clinical evaluation with dedicated scores was not performed. The authors reported no cases of osteomyelitis, deep infection, malunion or non-union and three out of 22 cases of superficial wound infection (18). Kline et al. found similar results in a retrospective comparative case series of 112 displaced intra-articular calcaneal fractures treated with minimally invasive technique and extensile lateral approach, of 33 who were treated through the sinus tarsi approach,

6.6% required repeat surgery for infection and 94% of patients were satisfied versus 20% and 84%, respectively, in the extensile lateral approach cohort. The study showed the minimally invasive approach had a significantly lower incidence of wound complications and secondary surgeries (23). In a retrospective cohort study Yeo et al. compared 100 calcaneal fractures Sanders II and III treated with sinus tarsi approach (40 cases) or extensile lateral approach (60 fractures) and found comparable clinical and radiographic results for both approaches, with a lower complication rate for sinus tarsi approach (24).

Our study showed that the articulation subtalar joint can be restored without the use of plates and more invasive approaches. The infection rate and major complications appear to be lower than classic L-shaped approach. The prevalence of deep infection with this approach varies significantly between different studies, suggesting that a larger patient cohort would be required to better assess the true incidence of this complication (23). The patients should therefore be explicitly advised preoperatively of this risk.

The clinical and radiographic results of our study in active population with high functional requests are very interesting and at midterm are comparable and, in some cases, superior to other approaches though a long-term outcome of subtalar arthrosis with this technique rests unidentified.

Limitations of this study include the retrospective study design, a relatively small patient cohort, the absence of a control group and direct comparison with other approaches. A comparison radiographs of the contralateral calcaneum were not performed and also weight bearing X-rays were not routinely done at the final follow up.

To our knowledge this study reporting the results of the sinus tarsi approach in active adult population could be an important reference for more accurate studies for the treatment of the intra-articular calcaneus fractures.

In conclusion, the sinus tarsi approach for adult active population is a valid and reproducible

technique with a low rate of major complications, but is mandatory advice to patients regarding the expectation of the result.

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TRANSPARENCY DECLARATION

Conflict of interest: None to declare.

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