



Original Article

Outcomes of Mini-open Sinus Tarsi Approach for Displaced Calcaneal Fractures Sanders Type I and Type II

Mohammad H. Hassan^{1*}, Bassam M. Ouda¹, Mohamed M. A. Bakr¹

¹Orthopedic Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt

*Corresponding author:

Mohammad Hassan Abd-
Ellatif Hassan

E-mail:

Mhmdhassan1515@gmail.
com

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ABSTRACT

Background: The goal of the ongoing research aimed mainly to assess clinical and radiological outcomes of the mini-open sinus tarsi surgical technique in reduction and fixation management of intra-articular displaced calcaneal bone fractures, which are frequently caused by high-energy trauma.

Methods: 23 participants with intra-articular displaced calcaneal bone fractures were managed surgically using mini-open sinus tarsi technique. Plain X-ray films included lateral, anteroposterior, and axial heel views for all patients. CT scan was done to the studied participants preoperatively. The classification of fractures according to Sanders was II and III.

Results: According to AOFAS score 6 cases were having excellent results, 15 cases were good, one case was fair and one case with poor result. Nine patients responded no pain, 12 patients complained mild pain, one patient presented with daily moderate degree of pain while only one patient complained from severe pain.

Conclusions: the mini-open sinus tarsi surgical approach is valuable for reduction and fixation of intra-articular calcaneal bone fractures. It is highly efficient with in Sander's II & III calcaneal fractures.

Key words: Mini-open; Displaced; Fractures; Sanders.

INTRODUCTION

Intra-articular calcaneal bone fractures usually incurred following high-energy trauma, and numerous treatments are available for anatomical reduction and surgical fixation [1]. It was evidenced that 75% of calcaneal fractures are classified as displaced intra-articular calcaneal fractures (DIACFs). Computerized tomography (CT) evaluation results classify calcaneal fractures into 4 different subtypes, with Sanders types II and III being more prevalent. Conservative management frequently leads to subtalar arthrosis, malunion, and suboptimal functional outcomes [3]. The open reduction and internal fixation (ORIF) using an extensile L-shaped method has been widely favored due to its efficacy in restoring the

anatomical alignment of the calcaneus, ensuring congruity of the posterior subtalar joint, and achieving stable osteosynthesis. Extensive exposure is associated with soft tissue problems such as infections either superficial or deep infections and wound dehiscence, which evidenced among 1.8% to 27% of patients [4]. Mini-open sinus tarsi ORIF has been performed to address displaced calcaneus fractures, aiming to minimize complications and enhance recovery when surgical intervention is warranted, demonstrating lower complication rates and favorable clinical and radiographic outcomes in specific fracture patterns, particularly in patients at elevated risk for soft tissue complications [5].

METHODS

The current research was applied on 23 participants (21 males 91.3% & two females 8.7%) with intra-articular displaced calcaneal fractures managed surgically with operative fixation through mini-open sinus tarsi approach and were selected depending on the predetermined inclusion and exclusion criteria, in the Orthopedics and Traumatology Department of Zagazig University Hospitals from 2020 to 2023 with an average follow up period of nine months after acquiring a local institutional review board (IRB) approval (Number: 804/ 13-Nov-2024).

Inclusion criteria: Age more than 18 years old. Displaced intra-articular calcaneal fractures (type II and III Sanders classification). Fracture with posterior facet minimal comminutions on CT scan. Closed fracture calcaneus. Fractures within two weeks from date of trauma

Exclusion criteria: Non or Minimally displaced calcaneal fractures (Sanders type I). Type IV fractures (Crushed calcaneus). Fractures older than two weeks. Open injuries. Infected skin condition.

General examination: To reveals any associated injuries as fracture spine, pelvis, upper limb or lower limb fractures. For any associated systemic disease or patient fitness for surgical intervention. **Local examination:** Foot deformity. Degree of edema and exclude compartmental syndrome. Skin condition: blister, appearance of skin wrinkle and presence of wound. Peripheral neuro-vascular condition. **Laboratory investigations:** CBC, LFT, KFT, PT, PTT, INR and random blood sugar.

Timing of surgery: after subsidence of edema, skin bullae and appearance of skin wrinkle usually it takes from 5 to 10 days according to degree of injury

Surgical technique:

Prior to the operation, all the participants received antibiotics as a prophylaxis. The

operation was done while the patient in a lateral decubitus position with either spinal or general anesthesia. The pneumatic tourniquet was increased. A linear skin incision is performed started from the tip of the lateral malleolus down to the fourth metatarsal bone base, approximately four cm in length. The extensor digitorum brevis muscle is retracted cephalically to expose the sinus tarsi and the calcaneocuboid joint. A Stienen pin is inserted through a small stab wound above the posterior calcaneal tuberosity under C-arm guidance, facilitating the distraction of fracture fragments, restoring length, and correcting varus by manipulating the posterior calcaneal tuberosity. Using a tiny periosteal elevator, the depressed posterior facet fragments are lifted under C-arm guidance, and temporary K-wires are inserted from lateral to medial to stabilize the position of the decreased pieces. Two sets of cancellous screws are obtained. One or two 4 mm cancellous screws are inserted from lateral to medial to secure the lateral piece to the fixed medial segment, using fully threaded 6.5 mm screws from posterior to anterior. Cancellous screws are inserted through small stab wounds to preserve length, and axial heel images are performed to assess the correction of heel varus and calcaneal widening. In certain instances, fully threaded screws are utilized from inferior to superior to assist in stabilizing the position of the decreased posterior facet fragment. In certain instances, low-profile plates (small T plates) or specially designed plates, if available, can be inserted through the skin incision to stabilize fracture fragments. Displaced anterior process fragments over 25% are reduced and stabilized using either K-wire or screw fixation. Layered wound closure (Figure 1).

Postoperative: Continuing on antibiotic medication and analgesic, Anticoagulant in high risk patients, Posterior ankle splint is

made, Sutures are removed after 2 weeks and Patients are put in cast for about 4 weeks and Gradual weight bearing after cast removal.

Functional outcomes:

Radiological: (calcaneal height, length, width, Bohler and Gissane angles) were done after surgical intervention, at suture removal and monthly interval until complete Clinical and radiological healing and thereafter in 3 months' interval.

Clinical: According to AOFAS, VAS score and subtalar motion.

Statistical analysis :

All studied participants informations were gathered, organized, and underwent statistical analysis utilizing Microsoft Office Excel 2010 for Windows (Microsoft Corp., Redmond, WA, USA) and SPSS 22.0 for Windows (IBM Inc., Chicago, IL, USA). Continuous quantitative data were represented as the mean \pm SD and median (range), whereas categorical qualitative variables were represented as absolute frequencies (number) and relative frequencies (%). Continuous data were assessed for normalcy using the Shapiro-Wilk test. The Wilcoxon signed-rank test was employed to compare two dependent groups of non-normally distributed data. All tests were bilateral. A p-value of < 0.05 was deemed statistically significant (S), a p-value of < 0.001 was regarded as highly statistically significant (HS), and a p-value of ≥ 0.05 was classified as statistically insignificant (NS).

RESULTS

Bohler's and Gissane angles:

Pre-operative analysis shows mean difference between intact contralateral and injured sides:

A statistical significant variation of Bohler's angle (mean difference (MD)= 19.42 ± 4.81 , t-test=15.097, P <0.001)

Also a significant difference Gissane's angle (MD= 13.4 ± 22.8 , t-test= -2.506 , P=0.2).

Post-operative analysis

Bohler's mean angle of operated side was $29.1^\circ \pm 5.9$ and it was ranged from 16 degrees up to 34 degrees with mean $30 \text{ degrees} \pm 1.2$.

Gissane's mean angle of operated side was $132.3 \text{ degrees} \pm 16.1$ and it was ranged from 125 degrees to 145 degrees.

Mean difference between operated sides and intact contralateral sides:

Post-operative mean difference in Bohler's angle was $3.9 \text{ degrees} \pm 5.9$, t-test= 2.5, P=0.5 which was not statistically significant. Post-operative mean difference in Gissane's angle was $-2.4 \text{ degrees} \pm 16.6$, t-test= -0.6 and P=0.5, which also not statistically significant.

Mean difference between pre-operative and post-operative angular measurement of operated side:

Bohler's angle it was 15.5 ± 3.08 , t-test was -18.8 and the p-value was 0.001 which was considered significant.

Gissane's angle it was 11.05 ± 19.7 , t-test was 2.38 and the p-value was 0.029 which was considered significant.

- 1) **Posterior facet inclination angle:** post-operative mean of calcaneal PFIA was 63.3 as compared to 55.3 mm pre-operative mean
- 2) **Height of calcaneus (mm):** post-operative mean of calcaneal height was 45.8 mm as compared to 40.6 mm pre-operative mean
- 3) **Length of calcaneus (mm):** post-operative mean of calcaneal length was 61.6 mm as compared to 56 mm pre-operative mean
- 4) **Width of calcaneus (mm):** post-operative mean of calcaneal width was 47.9 mm as compared to 53.6 mm pre-operative mean

Table 1: AOFAS score results among the patients.

N	Mean	Std. Deviation	Median	Minimum	Maximum
23	83.9565	11.54626	85.0000	35.00	95.00
		No.	%	Valid %	Cumulative %
Valid	Poor	1	4.3	4.3	4.3
	Fair	1	4.3	4.3	8.7
	Good	15	65.2	65.2	73.9
	Excellent	6	26.1	26.1	100.0
	Total	23	100.0	100.0	

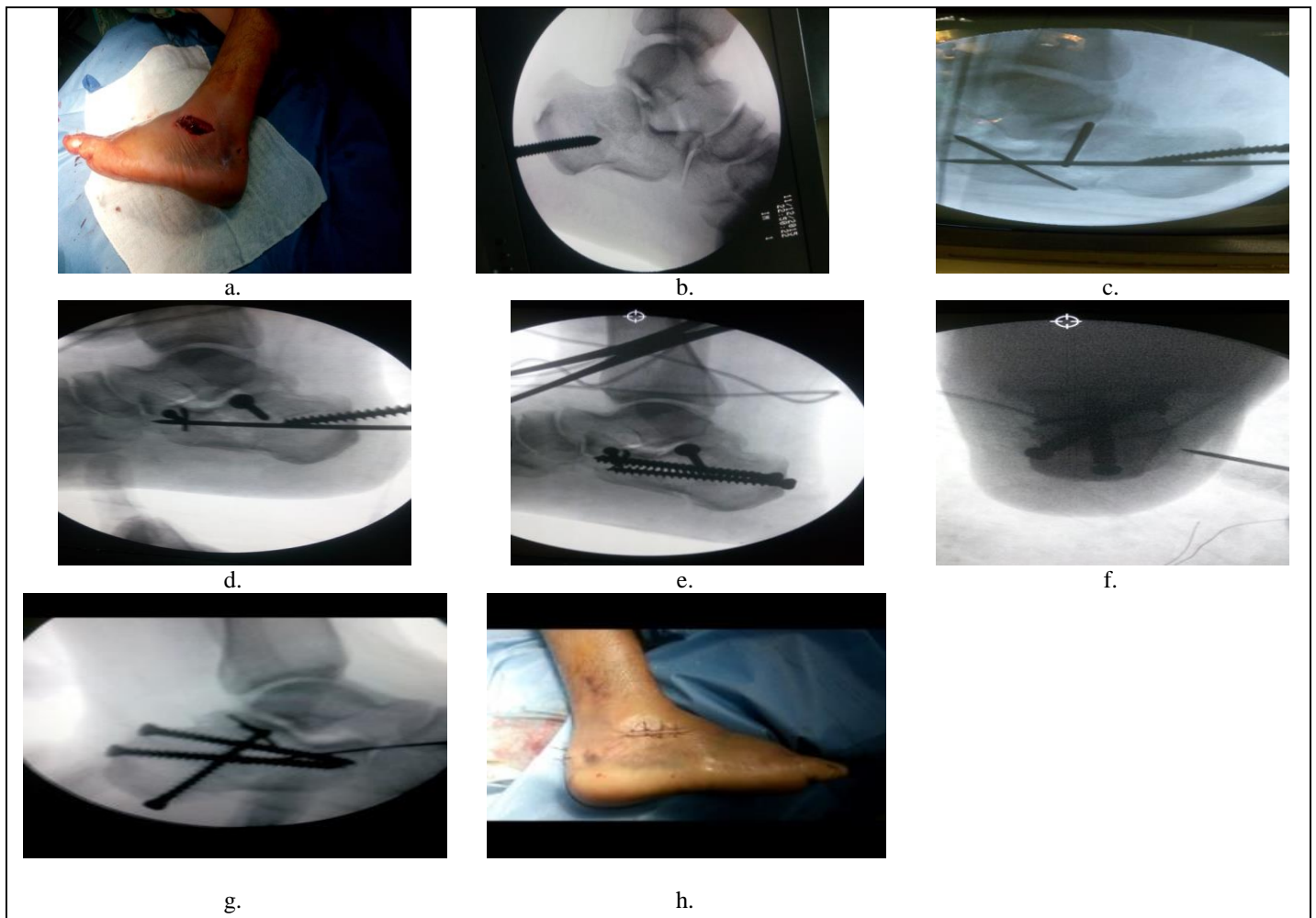
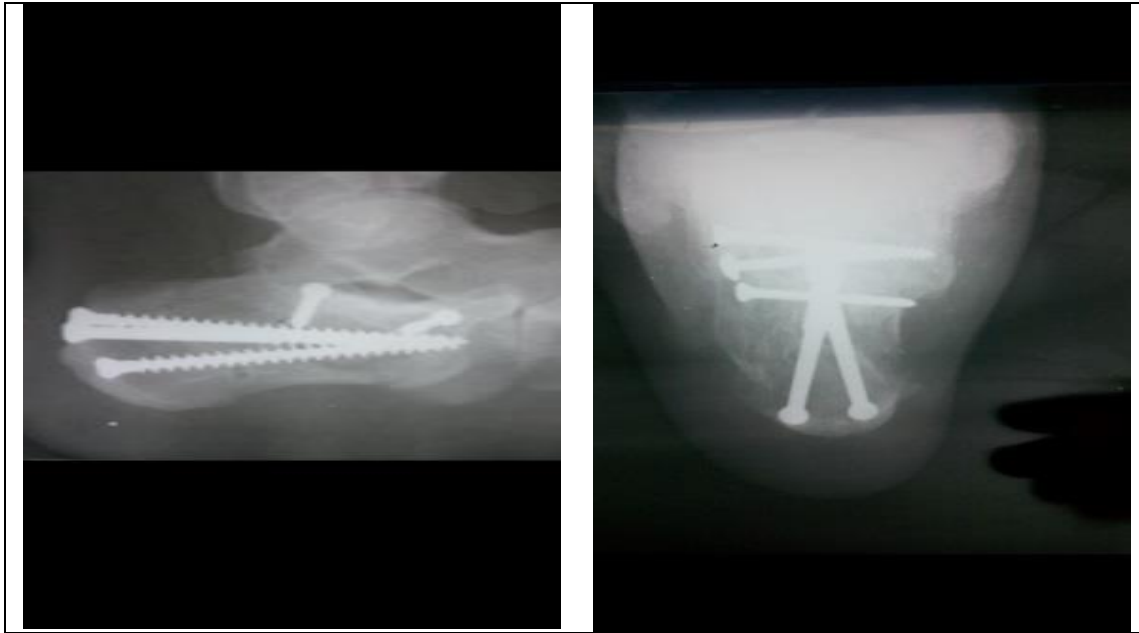


Figure 1: Mini-open Sinus Tarsi Approach. (a): skin incision from tip of lateral maleolus toward base of 4th metatarsal about 4 cm. (b): schanz pin is introduced into posterior calcaneal tuberosity for manipulation of the posterior fragment. (c): temporary fixation of elevated posterior

calcaneal facet by K-wire. (d): lateral to medial screws are used for fixation of the elevated posterior facet. (e): posterior to anterior screws are used to maintain calcaneal height and length. (f): axial views to assure correction of varus and broadening. (g): inferior to superior is used to support

posterior facet fragment. (h): closure of skin incision.



Figure(2): post opetative X-ray showing good reduction of posterior facet.

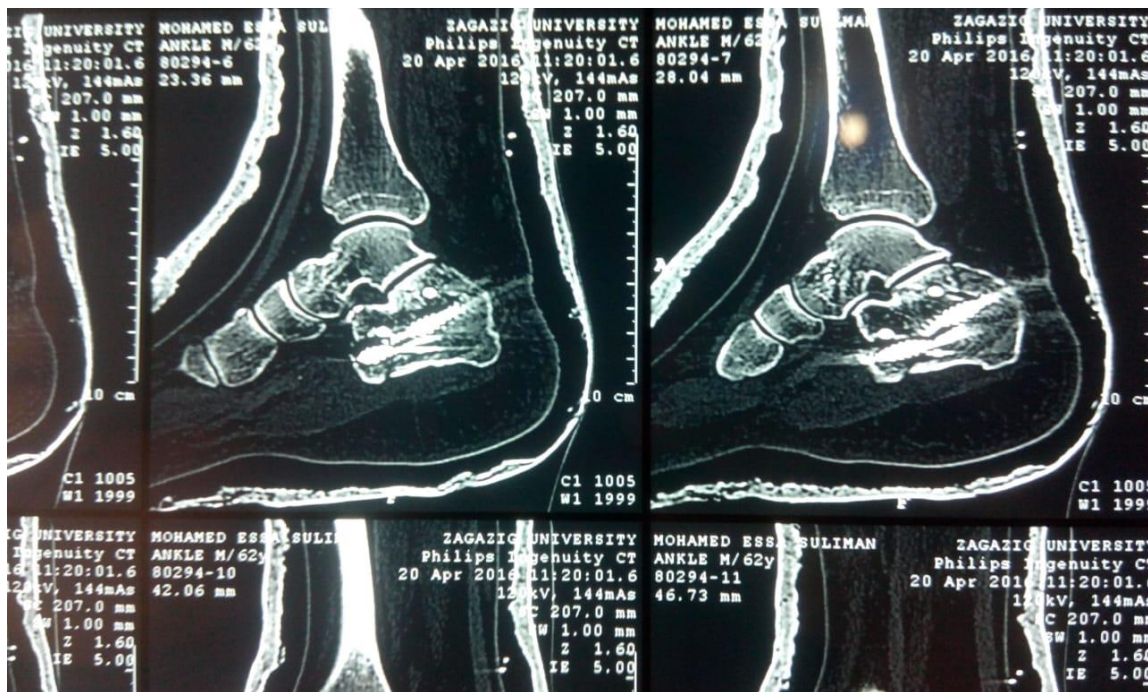


Figure (3): post opetative CT scan with adequate restoration of articular surface.



Figure (4): Clinical photo with mobile subtalar joint.

DISCUSSION

The extensile lateral technique is commonly employed for the majority of intra-articular fractures [6] [7]. The increased occurrence of surgical wound complications associated with the extensile lateral approach is ascribed to the delicate and susceptible lateral sub-periosteal flap created during surgery [8] [9]. This mini-open sinus tarsi technique provides excellent fracture exposure similar to an extensile lateral approach, while minimizing skin and soft tissue complications [10] [11]. As it offers an effective method for the reduction and stabilization of posterior facet fractures, particularly those with limited comminution (Sanders type II & III) [12].

In comparison to the extensile lateral approach, the mini-open sinus tarsi method yields comparable clinical and radiological outcomes with minimal skin and soft tissue complications [13] [14] [15]. In this study, 10 cases were operated on the 5th day, 6 cases on the 10th day, 4 instances on the 13th day, and 3 cases on the 15th day. Our

findings indicate that the earlier the operation is performed (after the enhancement of local soft tissue state), the more facile the reduction and fixing are accomplished. Although there is no definitive timeline for surgical intervention in displaced calcaneal fractures, a delay exceeding two weeks complicates reduction due to soft tissue contraction and bone fibrous union [16] [17].

In our study, we employ the rafting screw approach and/or kickstand screw to preserve the decrease of the posterior facet and avert its collapse. Cho, J et al. (2021) utilized allogenic bone grafts to fill the hole created by the elevation of the depressed posterior facet, preserve calcaneal height, and avert post-operative collapse [18].

Clinical evaluation:

This study indicated that, according to the AOFAS score, six cases exhibited exceptional results, fifteen cases demonstrated good outcomes, one case was rated as fair, and one case resulted in poor performance. In this investigation, the

subtalar range of motion indicated that the mean inversion-eversion arc of the subtalar joint, relative to the normal side, was 87.32% (ranging from 100% to 70%). Concerning pain, the AOFAS questionnaire indicates that 9 patients experienced no pain, 12 patients reported light pain, one patient suffered from significant (daily) pain, and one patient endured severe pain.

Seletti M et al. (2023) documented that the clinical outcomes from the operative management of 54 fractures via the sinus tarsi technique yielded 12 excellent results, 25 good, 12 fair, and 5 poor outcomes. According to the AOFAS scale, the combined rate of excellent and good outcomes was 68.5%, which aligns with the findings of the mini-open sinus tarsi approach [19].

Sadek S. I. et al. (2020) conducted a study involving 26 patients (30 calcaneal fractures) with displaced intra-articular calcaneal fractures treated using minimally invasive techniques. They reported improved clinical outcomes based on the AOFAS score, with satisfactory results observed in 90% of cases (40% classified as excellent and 50% as good) [20].

Radiological evaluation:

The mean difference in angular measurements of the fractured side of Gissane's angle pre-operatively and post-operatively was 12.06 ± 18.8 , with a t-test value of 2.4 and a p-value of 0.028, deemed significant. For Bohler's angle, the mean difference was 16.7 ± 3.06 , with a t-test value of -19.7 and a p-value of 0.001, also considered significant. In this study utilizing the sinus tarsi method, we successfully attained all calcaneal parameters, with posterior facet inclination angles improving from a pre-operative mean of 55.3 to a postoperative mean of 63.3. The calcaneal height (45.8 post-operative mean versus 40.6 pre-operative mean), length (61.6 post-operative mean versus 56.6 pre-operative

mean), and width (47.9 post-operative mean versus 53.6 pre-operative mean) were effectively reduced in comparison to the pre-operative measurements.

Seletti M et al. (2023) The Bohler angle increased from $10.8^\circ \pm 10.4$ pre-operatively to $30.77^\circ \pm 8.24$ at the final follow-up [19].

Schepers T (2011), in his systematic assessment of the sinus tarsi method for displaced intra-articular calcaneal fractures from 2000 to December 1, 2010, determined that precise reduction of both Bohler and Gissan angles was achieved in all cases, with a success rate of 72%-100% [21].

Evaluation of the subtalar joint: Subtalar osteoarthritic alterations were assessed utilizing the Paley and Hall technique. Grade 0: 9 cases, Grade 1: 12 cases, Grade 2: 1 case, and 1 patient with Grade 3. Seletti M et al (2023) report that nearly all patients experienced a reduction in subtalar motion, with 16.7% exhibiting mild restriction, 72.2% moderate restriction, and 11.1% severe restriction. Additionally, 3.8% of patients had grade III subtalar osteoarthritis, 7.4% had grade II, and 44.4% had grade I; however, these findings are not correlated with the AOFAS score [19].

Sadek S. I. et al. (2020) revealed that the mean subtalar motion was favorable at 86.42% in comparison to the normal side. Based on the AOFAS questionnaire, 40% of cases reported no pain, 50% experienced mild pain, 6.6% reported moderate pain, and 3.4% experienced severe pain. Concerning subtalar arthritis, there are 12 cases classified as grade 0, 15 as grade 1, 2 as grade 2, and one case as grade 3 according to the Paley and Hall method [20].

Complications: This study employed the mini-open sinus tarsi method for the surgical management of displaced intra-articular calcaneal fractures to reduce soft tissue problems and enhance patient recovery. Four instances reported post-operative problems. Two cases had problematic

hardware; in one instance, the screws were removed after six months, and in the other, after eight months.

One example experienced a surgical site infection after 2.5 months, which did not respond to conservative therapy for two weeks, necessitating surgical debridement and removal of screws. One case was suffering from subtalar osteoarthritis and subtalar fusion was done after 9 months

Seletti M et al (2023) discovered that around 9.3% of patients experienced problematic hardware necessitating removal due to infection or peroneal discomfort. 3.7% of cases required subtalar fusion due to chronic pain from subtalar osteoarthritis, 5.6% experienced varying degrees of wound complications among the 54 calcaneal fractures, and 3 cases exhibited temporary sural nerve impairment, all of which improved during the follow-up period [19].

Schepers (2011) indicated that the incidence of wound complications varies from 0 to 15.4%, encompassing superficial infections to wound dehiscence. Hardware removal was documented in four studies, with rates between 10% and 40%. Sural nerve involvement was noted in five studies, one of which reported spontaneous recovery. Secondary subtalar arthrodesis was mentioned in three studies [21].

In their comprehensive study, Nosewicz et al. (2018) revealed that post-operative skin problems were limited when utilizing the sinus tarsi, showing a reduction of around 80% compared to the extensile lateral route.

CONCLUSIONS

This mini-open sinus tarsi technique is an effective method for achieving satisfactory reduction and stabilization of displaced intra-articular calcaneal fractures while minimizing soft tissue complications.

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Conflict of Interest: Nil.

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