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Screw-only Fixation of Calcaneal Fractures Using the Sinus Tarsi Approach

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ABSTRACT

Objective: Calcaneus is the most commonly fractured tarsal bone. This type of fracture may result from high-energy trauma or axial loading. The ideal treatment method for calcaneal fractures remains controversial in terms of surgical approach and the material that will be used for fracture fixation. This study aims to evaluate the outcomes of screw-only fixation in intra-articular calcaneal fractures using the sinus tarsi approach.

Methods: Patients who were treated between 2014 and 2021 for calcaneal fractures were retrospectively investigated. Functional outcomes were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot-ankle score, and Gissane and Böhler angles were measured and compared.

Results: The study included 32 patients (23 male, 9 female) who underwent screw fixation through the sinus tarsi approach for intra-articular calcaneal fractures. The mean age of the patients was 45.2 years. The fractures were classified according to the Sanders Classification, with 15 patients having type 2 fractures, 12 with type 3 fractures, and five with type 4 fractures. AOFAS hindfoot-ankle score revealed nine patients achieving excellent results, 14 patients achieving good results, and nine patients achieving fair results. AOFAS scores were lower in patients with Sanders type 4 fractures when compared to type 3 and type 2 fractures ($p=0.005$ and $p<0.001$ respectively).

Conclusion: This study provides evidence supporting the favorable results of the sinus tarsi approach using screw-only fixation for treating intra-articular calcaneal fractures.

Keywords: Sinus tarsi, screw-only fixation, mini incision, calcaneus, Sanders type 4

INTRODUCTION

The most commonly fractured tarsal bone is the calcaneus, and this fracture may result from high-energy trauma or axial loading (1). Displaced intra-articular fractures account for 60% to 75% of these fractures. The Sanders Classification, which takes the displacement and number of fragments in the posterior facet into consideration, is commonly used for classifying calcaneal fractures (2). When the posterior facet is fractured, a subtalar intra-articular fracture occurs, and achieving anatomical restoration of the joint surface is crucial in this situation. Open reduction is recommended for restoring normal anatomy and fracture reduction (3). Traumatic arthritis of the talocalcaneal joint, which results from the inability to achieve anatomical restoration of the joint surface, leads to a painful joint that impairs walking (4). However, the ideal treatment method for calcaneal fractures remains controversial,

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and studies advocating conservative treatment also exist due to the high complication rates associated with surgical treatments (5). However, these complications are often associated with the extended lateral approach (6).

While the extended lateral approach can restore the calcaneus geometry and anatomical surface, it can also present problems with the surgical site (6,7). Recently, the sinus tarsi approach, which allows anatomical reduction and fixation of the subtalar joint while encountering fewer wound complications, has become more favorable in the surgical treatment of calcaneal fractures (8-10). This approach enables minimally invasive plate applications, screw osteosynthesis and osteosynthesis using only K-wires (11-13). While standard calcaneal plates are used in the extended lateral approach, modified plates can be used in the sinus tarsi approach, and there is limited research on osteosynthesis without using plates (12-14).

This study evaluated the radiological and functional outcomes of patients with Sanders type 2, 3 and 4 calcaneal fractures, where osteosynthesis was achieved by screws only through the sinus tarsi approach.

METHODS

Patients who were treated between 2014 and 2021 for calcaneal fractures were retrospectively investigated after obtaining approval from University of Health Sciences Turkey, Gaziosmanpaşa Training and Research Hospital Clinical Research Ethics Committee (decision no: 345, date: 06.10.2021). The calcaneus fractures that underwent intra-articular fragment fixation using only screws through the sinus tarsi approach were included in the study. Patients with accompanying tarsal bone fractures or pre-existing pathologies that could cause preoperative mobility limitations were excluded from the study because they could affect the outcomes. In addition, isolated tongue-type fractures and patients who underwent fracture fixation using the extended lateral incision were excluded. Fractures that were treated by plate osteosynthesis were also excluded from the study.

Surgical Technique

After administering prophylactic cefazolin antibiotics, patients with isolated calcaneal fractures were placed in the lateral decubitus position. In contrast, patients with bilateral calcaneal fractures were placed in the supine position, and a pneumatic tourniquet was applied to the thigh. A 4 cm straight incision was made beneath the lateral malleolus leading to the fourth metatarsal base (Figure 1). While preserving the lateral sural cutaneous nerve, the peroneal tendons were retracted posteroinferior and the lateral cortex of the calcaneus was exposed (Figure 2). When the talocalcaneal joint became visible, the posterior facet, usually found collapsed anteroinferior, was reduced with the help of an elevator and temporarily fixated with K-wires. The Achilles tendon should be loosened to facilitate the reduction and the calcaneal tuberosity should be able to advance distally. Therefore, knee flexion is essential. After reduction of the posterior facet, it was stabilized to the constant fragment using one or two 4 mm short-threaded cannulated screws (Figure 3). Varus malalignment of the heel was checked with fluoroscopy (Figure 4), and then two 6.5 mm cannulated screws were placed in the posterior-to-anterior direction for fixation (Figure 5). No graft was applied to the remaining defective area after reduction of the posterior facet. Following anatomical closure, a dressing and a short leg cast were applied, and a drain was inserted. The drain and cast were removed after 24 hours and early mobilization was initiated.

Figure 1. 4 cm straight sinus tarsi incision on a patient in lateral decubitus position

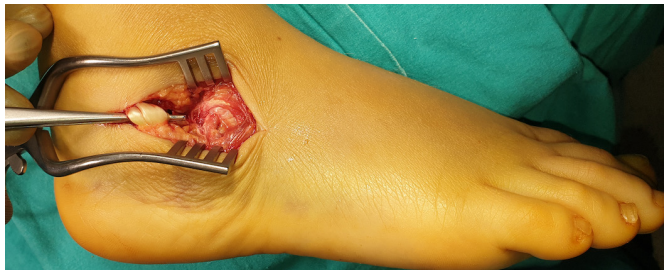

Figure 2. Flexor tendons are protected

Figure 3. Posterior facet is reduced and fixed with one or two canulated screws

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Partial weight bearing was started in the first month, and full weight bearing was allowed in the second month.

Outcomes of Interest

The American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot-ankle score was used to evaluate functional outcomes (15). Boehler and Gissane angles were measured and compared on preoperative and postoperative radiographs. Wound complications and the presence of reflex sympathetic dystrophy were assessed.

Statistical Analysis

Three groups were created according to the Sanders classification, and the normal distribution of the data was assessed by Shapiro-Wilk test for each group by using the SPSS 25.0 (SPSS Inc, IBM, Chicago, IL) software. Mean, standard deviation (SD), median, and interquartile range (IQR) values were used as descriptive analysis when presenting the data. Non-normally distributed (non-parametric) variables were evaluated between groups using the Kruskal-Wallis test, and the Wilcoxon test was used to compare the pre-operative and postoperative calcaneus angles if any of the parameters were nonnormally distributed. However, normally distributed (parametric) variables were compared using the paired sample t-test. AOFAS scores between groups were analyzed using the ANOVA test, and post-hoc (Tukey) test results were given. Results where the p-value was below 0.05 were considered statistically significant.

Figure 4. Fluoroscopy position for the Harris view

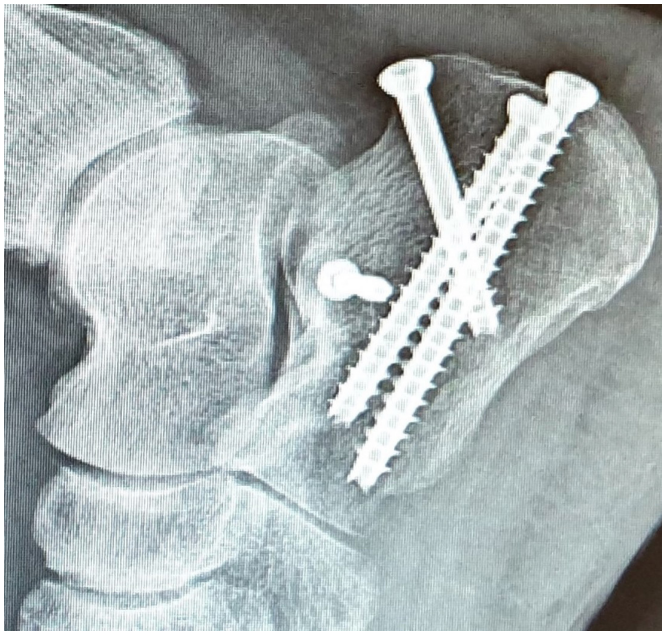

Figure 5. Two 6.5 mm cannulated screws were placed in the posterior-to-anterior direction

RESULTS

A total of 32 patients, including nine (28.13%) females and 23 males (71.88%) who underwent fixation of intra-articular calcaneal fractures using only screws through the sinus tarsi approach, were included in this study. The mean age was 45.2 years (range: 19-68, SD: 11.5). Among the patients, there were 15 Sanders type 2 fractures (46.88%), 12 type 3 fractures (37.50%), and 5 type 4 fractures (15.63%). The mean ± SD values for normally distributed data and median (IQR) values for non-normally distributed data and the comparison of preoperative and postoperative angles for every fracture type are presented in Table 1. Statistically significant differences were observed between the preoperative and postoperative Gissane and Böhler angles in all types of fractures ($p<0.05$).

According to the AOFAS scores, nine patients had excellent results (28.13%), 14 had good results (43.75%), and nine had fair results (28.13%). However, the AOFAS scores were lower in patients with Sanders type 4 fractures when compared with type 3 and type 2 ($p=0.005$, $p<0.001$ respectively) fractures. Type 2 fractures had better results than type 3 fractures, and this difference was found to be statistically significant ($p=0.025$) (Table 2).

DISCUSSION

This study evaluated the outcomes of calcaneal intra-articular fractures that were treated by screws only fixation, using the sinus tarsi approach. The sinus tarsi approach allows for anatomical reduction and fixation of the subtalar joint, and cannulated screws can be used alone for osteosynthesis of calcaneal fractures in selected cases.

After Griffin et al. (16) reported no significant difference in symptoms and functional outcomes between surgical and conservative treatments in 2014, an increased tendency toward conservative treatment emerged. Similarly, Shah et al. (17) reached the same conclusion in 2021. However, both studies used the extensile lateral approach described by Letournel (18). It has been observed that wound complications with this approach

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Table 1. Comparison of pre-operative and postoperative angles

	Sanders type 2	Sanders type 3	Sanders type 4	
	Mean ± SD Median (IQR)	Mean ± SD Median (IQR)	Mean ± SD Median (IQR)	p[1]
Follow-up period as months	24 (8)	28.67±7.89	24.2±6.72	0.390
Böhler angle pre-operative	7.2±3.17	7.08±2.61	3 (6)	0.424
Böhler angle postoperative	31.07±2.94	27.5 (6)	29.2±5.12	0.174
p[2]	**0.017**			
P[3]		**0.002**	**0.043**	
Gisanne pre-operative	110 (14)	105.17±3.76	108.6±7.23	0.684
Gisanne postoperative	116.13±6.08	118.67±6.53	124.6±7.8	
p[2]		**<0.001**	**0.004**	
p[3]	**0.003**			

p[1]: Kruskal-Wallis test, p[2]: paired sample t-test, p[3]: Wilcoxon test (paired sample t-test was used if both groups are normally distributed & Wilcoxon test was used if any one of the groups was not normally distributed). IQR: interquartile range, SD: standard deviation

Table 2. ANOVA test post-hoc analyse for AOFAS scores between groups

	AOFAS	p-value
Sanders type 2	89.8±7.06	0.025
Sanders type 3	83.33±5.31	
Sanders type 2	89.8±7.06	<0.001
Sanders type 4	72.2±3.27	
Sanders type 3	83.33±5.31	0.005
Sanders type 4	72.2±3.27	

AOFAS: American Orthopaedic Foot & Ankle Society

occur at around 25% and are exceptionally high in individuals with risk factors such as smoking and diabetes (19).

The incision described by Palmer (20), which is more limited compared to the extensile approach, was modified by Gupta et al. (21), and it became well-known as the sinus tarsi approach. This approach has recently gained popularity in the surgical treatment of calcaneal fractures (8,22). In addition, it is associated with fewer wound complications compared with the extended lateral approach (6,23). Subsequently, several studies compared the sinus tarsi approach to the lateral extensile approach and demonstrated that the rates of wound complications with the sinus tarsi approach have lowered (24-26).

Although the sinus tarsi approach is widely used today, there is an ongoing search for suitable fixation materials for this incision because the plate used in the extensile approach is incompatible. In this regard, Eltabbaa et al. (12) used K-wires, Huang et al. (22) used a modified calcaneal plate, Xia et al. (4) used a combined locking plate, and Kikuchi et al. (8) used a one-third tubular plate, locking/non-locking plate, and in some cases, only cannulated screws. The sinus tarsi approach without plating has been studied less, with limited research on the outcomes of such fixation methods (8,12,13). In our study, we achieved osteosynthesis using only screws and initiated early mobilization.

Guo et al. (27) compared a less invasive plate with the screw fixation method. They found no significant difference in functional outcomes but emphasized that screw fixation alone is more cost-effective. In another study where only screws were used, Abdelazeem et al. (28) concluded that screw-only fixation is sufficient for Sanders type 2 and 3 fractures. Our results also demonstrated significant improvements in the Gissane and Böhler angles after surgery, indicating successful anatomical restoration of the subtalar joint surface. These findings suggest that the sinus tarsi approach with screw fixation can effectively achieve anatomical reduction and restoration of the subtalar joint surface.

Most of the patients in this study achieved excellent or good results according to the AOFAS scores, indicating satisfactory functional outcomes following surgery. These results demonstrate the positive impact of the sinus tarsi approach with screw fixation on functional recovery.

Abdelazeem et al. (28) stated that there was no significant difference between the AOFAS score and Sanders type, but they did not include any type 4 fracture. Alajmi et al. (29) concluded that Sanders type 4 fractures are more prone to complications than other types, even when the sinus tarsi approach is used. We observed a correlation between the Sanders Classification and AOFAS scores, with type 4 fractures associated with poorer AOFAS scores ($p<0.001$). This finding highlights the importance of considering fracture severity and displacement when assessing functional outcomes in calcaneal fractures.

Regarding complications, we encountered no wound-related issues in our patient cohort. In addition, there were two reflex

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sympathetic dystrophies, that were resolved after partial weight bearing. These data suggest that the sinus tarsi approach with screw-only fixation has a low risk of wound complications.

Study Limitations

It is essential to acknowledge the limitations of our study. The relatively small sample size may have affected the generalizability of our findings as this was a retrospective study. Additionally, the lack of a control group limited our ability to directly compare the outcomes of the sinus tarsi approach with other surgical techniques or conservative management.

CONCLUSION

Our study provides evidence supporting the sinus tarsi approach using screw-only fixation for treating intra-articular calcaneal fractures. Our study suggests that the sinus tarsi approach is effective and safe for treating calcaneus fractures without using plates. This technique allows the anatomical reduction of the subtalar joint and demonstrates favorable outcomes.

Ethics Committee Approval: Obtained approval from University of Health Sciences Turkey, Gaziosmanpaşa Training and Research Hospital Clinical Research Ethics Committee (decision no: 345, date: 06.10.2021).

Informed Consent: Retrospective study.

Peer-review: Externally and internally peer-reviewed.

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