



ARAŞTIRMA / RESEARCH

Comparison of clinical and radiological outcomes between extended lateral and sinus tarsi approach in the surgical treatment of displaced intraarticular calcaneal fractures surgery

Deplase eklem içi kalkaneus kırıklarının cerrahi tedavisinde genişletilmiş lateral ve sinüs tarsi yaklaşımlarının klinik ve radyolojik sonuçlarının karşılaştırılması

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Abstract

Purpose: The aim of this stud was to compare the clinical and radiological results between Sinus-tarsi (ST) and Extended-Lateral (EL) approaches in open reduction internal fixation of intra-articular calcaneal fractures.

Materials and Methods: 51 calcaneal fractures of 48 patients surgically treated between 2012 and 2017 were retrospectively analyzed. The patients were divided into two groups. Preoperative CT, early postoperative and postoperative 1st-year radiographs, and The American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score scores were evaluated.

Results: According to the Sanders classification, nine patients in the EL group were type 2(36%), 16 patients type 3 (64%), 8 patients in ST group type 2(34.8%), 13 patients (56.5%) type 3, 2 patients (8.7%) type 4. The mean AOFAS-Hindfoot score was 85(63-100) in the ST group and 83(52-93) in the LE group at one year. Mean preoperative waiting time was shorter, with an average of 2(1-4) days in ST and 6(3-12) days in LE.

Conclusion: ST approach shortens the preoperative waiting time in intra-articular calcaneal fracture surgery, provides a sufficient vision for anatomical restoration, and effectively avoids complications.

Keywords: Calcaneus, sinus tarsi, extended lateral approach

Öz

Amaç: Bu çalışmanın amacı eklem içi kalkaneus kırıklarının açık redüksiyon internal fiksasyonunda Sinüs tarsi(ST) ve Lateral ekstansil(LE) yaklaşımları arası klinik ve radyolojik sonuçların karşılaştırılmasıdır.

Gereç ve Yöntem: Kliniğimizde 2012-2017 yıllarında cerrahi yöntemle tedavi edilen 48 hastanın 51 kalkaneus kırığı retrospektif olarak incelendi. Hastalar iki grup olarak ayrıldı, preoperatif BT, erken postoperatif ve postoperatif 1. yıl grafileri ve The American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score skorları değerlendirildi.

Bulgular: Sanders sınıflamasına göre LE grubunda 9 hasta tip 2(%36), 16 hasta tip 3(%64), ST grubunda 8 hasta tip 2(%34,8), 13 hasta (%56,5) tip 3, 2 hasta(%8,7) tip 4 idi. Takip süresi ST' de 16 ay (12-52), LE' de 37 ay(16-70) idi. AOFAS-Hindfoot skoru 1. yılda ST grubunda 85(63-100), LE grubunda 83(52-93) bulundu. Cerrahi öncesi bekleme süresi ST' de ortalama 2(1-4) gün, LE' de 6(3-12) gün olmak üzere daha kısa bulundu (χ^2 :5.22).

Sonuç: Sinüs tarsi yaklaşımının, eklem içi kalkaneus kırıkları cerrahisinde preoperatif bekleme süresinin kısalttığı, anatomik restorasyon için yeterli görüş sağladığı ve cilt komplikasyonlarından kaçınmak adına etkilidir.

Anahtar kelimeler: Kalkaneus, sinüs tarsi, lateral ekstansil yaklaşım

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INTRODUCTION

Intra-articular fractures of the calcaneus may be expected after high-energy lower extremity trauma. The treatment of displaced intra-articular calcaneal fractures is controversial. Previously, nonsurgical treatment was preferred because of the high risk of complications associated with the surgical treatment of calcaneal fractures. However, the preference for surgical treatment has increased over time because of the incidence of malunion, subtalar arthritis, tibiotalar impingement, and subtalar impingement with nonsurgical treatment¹.

In calcaneal fracture surgery, percutaneous fixation, arthroscopy-assisted fixation, external fixation, transarticular fixation, small medial incision, posterior, lateral, or combined incision techniques have been described in the last ten years. Surgical treatment aims to achieve an anatomic reduction of the articular surface, restore the subtalar articular surface, achieve standard calcaneal width and length, and achieve stable fixation after reduction².

Two exposures are commonly used in the surgical treatment of calcaneal fractures: the extended lateral (EL) approach and the sinus tarsi (ST) approach. The EL approach is the classic approach in which the inside and outside of the joint are easily seen in calcaneal fractures. However, complications such as wound healing problems, sural nerve injury, skin necrosis, and subcutaneous hematoma are more likely to occur with this approach³.

The complications with the EL approach prompted surgeons to find an alternative method. As a result, the ST approach was developed and brought to the literature by Hospodar et al.⁴ ST approach, which is less invasive and can be an alternative to the EL approach in terms of joint fractures. Furthermore, the literature states that this approach provides adequate access to the posterior facet and that neurological injuries and wound problems are less frequent³. In addition, it has been observed that the ST approach effectively achieves anatomical reduction and rigid fixation of the articular surface with a shorter surgical time, a smaller incision, and fewer surgical complications^{3,5}.

In our study, we aimed to compare the fracture types, preoperative waiting times, postoperative wound complications, and radiological and functional aspects of the patients we treated with the classical EL approach, which is known for the prevalence of skin complications, and the ST approach, which we

think is less invasive, in the surgical treatment of intra-articular calcaneal fractures. We hypothesize that the ST approach has some advantages, such as providing an adequate surgical vision of the talocalcaneal articular surface, less preoperative waiting time, and fewer skin complications, as in the classical EL approach.

MATERIALS AND METHODS

The study was carried out with the permission of the Gaziosmanpaşa Training and Research Hospital Clinical Research Ethics Committee (Date: 23.08.2017, Decision No: 74). Patients treated surgically in our clinic receive a clinical scoring questionnaire, widely accepted in the literature of the disease-affected area, before surgery (The American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score is a clinical score for calcaneus fractures). In addition, clinical scores are routinely repeated and recorded in case of follow-up at 1, 3, and 12 months.

Sample

Archival information was obtained from 72 patients who underwent surgical treatment for calcaneal fractures at our hospital between 2012 and 2017. Thirteen patients whose fracture line did not reach the posterior facet and were identified as type 1 by Sanders classification were excluded from the study. Five patients were excluded from the study because they had open fractures. Six patients were excluded from the study because they did not present for follow-up. Thus, data from 51 cases of 48 patients were retrospectively reviewed. Patients were studied in 2 groups: EL and ST. Open reduction with internal fixation was performed in 25 fractures of 23 patients in group 1 (EL) and 26 fractures of 25 patients in group 2 (ST). Patients were followed up for at least 12 months, and clinical and radiological outcomes were compared between the two groups. Age, sex, preoperative length of stay, systemic diseases, neurovascular examinations, fracture type, and trauma in the patients were evaluated clinically.

Radiological evaluations

Direct anteroposterior (AP) and lateral and axial radiographs and computed tomography of the feet were obtained at initial admission to the emergency department.

Sanders classification, Bohler and Gissane angles,

length, height, and width of the calcaneus were determined from preoperative direct radiographs and computed tomography records of patients in both groups. After surgery, Bohler and Gissane angles, length, height, and width of the calcaneus were measured, and the presence of postoperative osteoarthritis was recorded. Calcaneal length and height were measured and recorded by millimeters using the Extreme pacs software.

The Sanders classification system, which helps understand typical calcaneus fracture patterns and predicts the outcome, is used to assess intraarticular calcaneal fractures involving the posterior facet of the calcaneus. This classification is based on the number of intraarticular fracture lines on coronal CT images. The expected outcomes worsen from type 1 to type 4 injuries².

The Gissane and Böhrer angles are used to assess the seriousness of calcaneal fractures, and surgical treatment aims to return these angles to normal values. Therefore, both angles are measured on the lateral radiograph. The Böhrer angle is the angle between a line connecting the highest point of the posterior articular facet with the highest point of the calcaneal tuberosity and a line connecting the highest point of the anterior process of the calcaneus with that point. The Gissane angle is the angle between a line along the lateral margin of the posterior facet and the line anterior to the beak of the calcaneus⁴.

Calcaneal width was calculated as the distance between the lateral cortex of the most lateral calcaneal fracture fragment on the axial radiography and the outer cortex of the medial malleolus. Calcaneal height was calculated as the orthogonal distance between the calcaneus' inferior cortex and the radiograph's highest point on the medial posterior facet.

Clinical evaluation

Skin necrosis, deep infection, and AOFAS-Hindfoot scores were assessed. At the initial emergency department admission, direct anteroposterior (AP) and lateral and axial radiographs of the feet were obtained.

The American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score is a clinical score among the most commonly used tools to measure treatment outcomes in ankle or hindfoot injury patients. Combines a clinician-reported and a patient-reported section².

Surgical technique

Considering the systemic diseases of the patients included in the study and at the patient's request, spinal or general anesthesia was performed. The incision site was examined preoperatively for open wound blister formation. In the EL group, we waited until the wrinkle test was positive. Depending on the age and weight of the patients, antibiotic prophylaxis was administered before surgery and used for 24 hours. Patients were operated on in the lateral decubitus position.

Sinus tarsi approach: Starting from the anterolateral aspect of the distal fibula, along the ST, the fourth metatarsal was aligned, and the skin layers were passed with a 5 cm incision. (Fig. 1) After exploring the fracture line, the lateral stop of the calcaneus was elevated, the collapsed posterior facet was removed and reduced with the periosteum elevator, and the central fragment was temporarily fixed in the medial sustentacular space with 2 K-wires. After temporary fixation, the fracture was fixed with a 4 mm cannulated and partially threaded screw. (Fig. 2)



Figure 1. Marking landmarks in the sinus tarsi approach and incision view after closing the skin folds.

If the anatomy of the fracture required it, more than one screw was used. When deemed necessary after preoperative evaluation, the Steinman pin was inserted perpendicular to the long axis of the foot to reduce the collapse of the talocalcaneal joint from lateral to medial. It was used to correct varus enlargement and shortening of the calcaneus by applying traction. (Fig. 3), a 6.5-mm partially threaded cannulated screw was inserted into the fragment from posterior to the calcaneal tuberosity and lateral to the Achilles tendon, with length controlled under fluoroscopic guidance. Next, a 6.5-mm partially threaded cannulated screw was inserted from the posterior to the calcaneal tuberosity and medial to the Achilles tendon to the anterolateral distal to the calcaneus. Compression was achieved in the fracture

line. After screw insertion, the posterior facet of the subtalar joint was assessed under fluoroscopy. The calcaneus's height, length, and width were assessed under fluoroscopy. Then the skin layers were closed. After applying the dressing, the elastic bandage was wrapped, and the procedure was completed.

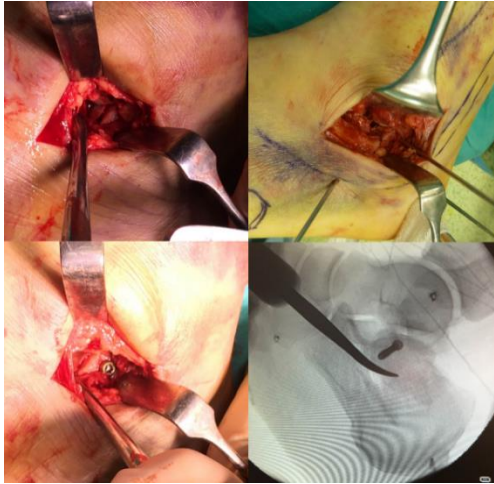


Figure 2. Reduction of the posterior facet collapse with the periosteal elevator and fixation to the sustentaculum with 4 mm cannulated screws.



Figure 3. Schanz pin inserted from the posterior tuberosity and correction of calcaneal alignment with manual traction.

Extended lateral approach

A standard L-shaped, slightly curved skin incision was made in which the posterior arm of the incision was midway between the fibula and the Achilles tendon and the horizontal arm in line with the base of the fifth metatarsal. The full-thickness flap was separated from the periosteum. The calcaneofibular

ligament was sharply detached from the lateral wall of the calcaneus. Despite the injury to the peroneal tendon, the tendon sheath was loosened. The tendons were elevated with a periosteal elevator and retracted with two of three Kirschner wires. After exploring the fracture line, the fragment in the lateral wall was removed with a periosteal elevator. a Steinman pin was placed perpendicular to the long axis of the foot, and traction was performed to correct varus alignment. The talocalcaneal joint was elevated by a periosteum elevator. The reduced portion was temporarily fixed with Kirschner wires and then fixed with a calcaneus plate under fluoroscopy.

Postoperative care

Patients with no additional pathology after surgery were dressed and then wrapped with an elastic bandage. Elevated positioning and cold application were performed in the patient's bed. Sutures were removed on the 15th postoperative day. Passive and active joint movements were initiated. No weight-bearing was recommended for 12 weeks after surgery. Full weight-bearing was allowed after clinical and radiological improvement was noted during clinical follow-up.

Postoperative evaluation

Postoperative clinical evaluation

Postoperative hospital stay, development of postoperative wound infection (deep infection or osteomyelitis), AOFAS-Hindfoot scores, and range of motion were evaluated early postoperative and postoperative first, 3rd, and 12th months. In addition, inversion-eversion restriction in the ankle joint was assessed by comparison with the healthy side.

Postoperative radiological evaluation

The reduction was assessed by lateral, anterior-posterior, and axial radiographs of the foot after surgery. In addition, direct radiographs were taken to check at the 1st, third, and 12th months. Radiologically, reduction loss, Gisanne angle, Bohler angle, length, height, and width of the calcaneus were followed. All radiological measurements were made by the first author twice within one month to reduce the margin of error.

Statistical analysis

The power analysis was performed using G*Power

version 3.1.9.2 (Heinrich-Heine-Universität, Düsseldorf, Germany). Twenty-five cases for the EL group and 26 cases for the ST group were assessed, and the power value was found to be 95%, and the number of patients was sufficient (effect size=0.8, $\alpha=0.05$).

Normality was checked by drawing Shapiro - Wilk test, histogram, Q-Q plot, and boxplot diagrams. Data were expressed as median, minimum, maximum, frequency, and percentage. Radiological measurement parameters and clinical scores between the two groups were analyzed using the Mann-Whitney U test. Nominal variables were evaluated using the Yates-corrected chi-square test (chi-square test with Yates correction) and Fisher's exact probability test. The significance threshold was $p < 0.05$ and was taken bidirectionally. Analyses were performed using the NCSS 10 software program (2015. Kaysville, Utah, USA).

The procedure Benjamini-Hochberg was used to control the possibility of false findings.⁶ The intraclass correlation coefficient with a 95% confidence interval and the Fleiss-Kappa coefficient was used to assess intraobserver reliability. Based on the study by Koo et al., we defined values below 0.5 as indicators of poor reliability, values between 0.50 and 0.75 as moderate reliability, values between 0.75 and 0.90 as good reliability, and values above 0.90 as excellent reliability.⁷

RESULTS

A total of 48 patients, 32 males (65.9%) and 16 females (34.09%), were included in our study. Surgery was performed on 51 feet of 48 patients. The demographic characteristics of the patients are shown in the table (Table 1). In the ST group, eight patients (34.8%) were Sanders type 2, 13 patients (56.5%) were Sanders type 3, and 2 patients (8.7%) were Sanders type 4. In the EL group, nine (36%) had Sanders type 2, and 16 (64%) had Sanders type 3 fractures. No difference was found between the two groups regarding Sanders classification (Table 2).

Clinical results

While the AOFAS-Hindfoot score was calculated to be 83 (52-93) at the 12-month follow-up of patients in the EL group, it was calculated to be 85 (63-100) in the ST group. Patients' mean postoperative follow-up time was 17.5 (12-48) months in the ST group and 34.04 (12-66) months in the EL group.

After surgery, two patients in the EL group experienced necrosis at the incision site, and secondary healing was achieved in both patients with conservative postoperative care. The incidence of skin necrosis was similar between the groups ($p = 1$).

Table 1. Demographic characteristics of the patients

	Sinus Tarsi(ST) (n=23)	Extended Lateral(EL) (n=25)	p
Age	46 (19-68)	42 (14-59)	
Gender(male/female)	14/9	18/7	0.62
Smoking	8 (%34)	10 (%40)	0.94
Diabetes	0	1 (%4)	1
Side			0.40
Right	12 (%52.2)	9 (%36)	
Left	11 (%47)	16 (%64)	
Bilateral	2	1	
Arthrosis	3	8	0.22
Deep infection	0	1	1
Skin Necrosis	0	1	1
Sudeck	2	4	0,66
Extraction	1	3	0.61

Table 2. Distribution of Sanders classification among surgical groups

	Sinus Tarsi(ST)	Extended Lateral(EL)
Sanders type 2	8 (%34.8)	9 (%36)
Sanders type 3	13 (%56.5)	16 (%64)
Sanders type 4	2 (%8.7)	0

The preoperative waiting time of patients was 2 (1-4) days in the ST group and 6 (3-12) days in the EL group. Accordingly, the preoperative waiting time was shorter in the ST group than in the EL group (χ^2 : 5.22; $p < 0.001$).

Radiological results (Table 3):

Before surgery, Bohler and Gisanne angles were similar between the two groups (Bohler; $\chi^2 = 0.89$; $p = 0.38$) (Gisanne; $\chi^2 = 0.51$; $p = 0.61$). Before surgery, the length, height, and width of the calcaneus were similar in both groups (length; $\chi^2 = 0.47$; $p = 0.64$) (height; $\chi^2 = 0.56$; $p = 0.58$) (width; $\chi^2 = 0.505$; $p = 0.614$).

Postoperative changes in Bohler and Gisanne angles were similar between the two groups (Bohler; $\chi^2 = 0.63$; $p = 0.53$) (Gisanne $\chi^2 = 0.93$; $p = 0.35$). Postoperative length difference, height difference, and width difference were similar between the two groups (length; $\chi^2 = 0.99$; $p = 0.32$) (height; $\chi^2 = 0.89$; $p = 0.35$) (width; $\chi^2 = 0.93$; $p = 0.35$).

Table 3. Changes in radiological parameters

Parameter	Preoperative		p	Postoperative	
	ST	EL		ST	EL
Bohler angle (degree)	10.91 (1.82-19)	12.47 (1.42-24.29)	0,58	18.74 (9.64-27.23)	21.39 (9.25-34.56)
Gisanne angle (degree)	112.95 (101.22-133.80)	114.51 (95.37-133.83)	0,61	120.9 (108.56-141.05)	125.56 (114.76-134.72)
Calcaneal length(mm)	81.55 (61.45-88.09)	80.57 (71.72-97.78)	0,64	83.50 (67.35-94.04)	83.49 (67.35-94.04)
Calcaneal Height(mm)	40.66 (30.44-48.51)	40.67 (33.54-55.91)	0.58	44.10 (33.81-50.18)	43.12 (39.25-52.96)
Calcaneal Width(mm)	45.35 (34.64-53.06)	44.80 (38.34-63.72)	0.35	42.47 (34.51-49.26)	43.53 (32.34-55.13)

(Mann Whitney U test, Wilcoxon w) Mm=millimeters

DISCUSSION

Our study compared preoperative waiting times, postoperative complications, and radiological and clinical results between patient groups with displaced intra-articular calcaneal fractures who underwent surgical treatment with sinus tarsi(ST) and extended lateral(EL) surgical approach. It has been observed that the sinus tarsi approach, which provides a smaller surgical incision, shortens the preoperative waiting time in intra-articular calcaneal fracture surgery, provides sufficient vision for anatomical restoration, and is effective in avoiding skin complications.

Intra-articular calcaneus fractures may be expected after high-energy trauma in the back after exposure of the lower extremity to high-energy trauma. Surgical procedures commonly treat displaced intra-articular calcaneus fractures.¹ The goal of surgical treatment is the anatomic reduction of the articular surface, restoration of the subtalar articular surface, the standard width of the calcaneus, and stable fixation after reduction.² Two methods are commonly used in surgical treatment. These are the extended lateral (EL) and sinus tarsi (ST) approaches. Although good exposure in the fracture line is achieved with the EL approach, the possibility of complications such as wound healing problems, injury to the sural nerve, skin necrosis, and subcutaneous hematoma is higher with this approach.³ The complications encountered with the EL approach prompted surgeons to find an alternative method. The ST approach, the most commonly used alternative to the EL approach, was introduced into the literature by Hospodar et al.⁴

When we examine the complications associated with surgical methods, many studies of skin problems and complications following the EL approach stand out in the literature. A meta-analysis of 8 studies and 564 patients found that the complication rate was lower with the ST approach.⁸ In 73 patients who underwent the EL approach, an infection rate of 19% was reported.⁹ In a retrospective study using the EL approach in 148 patients, skin complications occurred in 24%.¹⁰ In a retrospective study involving 190 fractures in 179 patients, the skin complication rate was reported to be 25%.¹¹ Comparing the EL approach and the ST approach, it is noticeable that complication rates are lower with the ST approach than with the EL approach. In their retrospective cohort study (40 patients underwent the EL approach to ST 60 patients) comparing the EL approach and the minimally invasive approach performed with the ST incision in 100 patients with type 2 and 3 calcaneal fractures, they reported that high complication rates, especially skin complications, were observed in the EL group.²

A study comparing the two methods and including 125 patients reported that ST reduced wound complications and shortened the duration of surgery and had these advantages but no adverse effect on fracture reduction.¹² In the systematic review that included 256 patients with 271 calcaneal fractures and eight studies, minor skin complications were reported in 4.1% of patients treated minimally invasively with the ST method. In contrast, the rate of significant skin complications was 0.7%.¹³ In a study using the ST method for Sanders type 2 fractures, it was reported that this method provided an adequate fracture reduction, achieved good clinical scores, and caused a low rate of complications.¹⁴ The studies by

Kline, Xia, and Yao also compared the two methods. The results support that complication rates are lower after the ST method.¹⁵⁻¹⁷

The sural and peroneal nerves are at high risk during surgical treatment of calcaneal fractures because of their proximity to the surgical field. A literature review reveals that nerve injury from surgery is more familiar with the EL approach. In a study of 120 patients who underwent the EL approach, 4 (3.3%) patients experienced permanent paresthesias, and 12 (10%) patients experienced sural nerve discomfort.¹⁸ They applied the EL approach in 59 of 139 patients and reported sural nerve injury in these patients to be 10%.¹⁹ In his anatomic study, Lawrence did not report nerve damage at the ST incision site, although there was a risk of injury to the sural and peroneal nerve.²⁰ In the study of 38 patients treated with the ST approach, it was reported that no nerve damage, entrapment, or complex regional pain syndrome was observed.²¹

In a study that included 237 calcaneal fractures in 214 patients with a follow-up of at least one year, factors that increased the complication rate with the ST approach included patients operated on within one week of trauma, patients with blood loss greater than 150 cc, and patients with an ASA score of 2 or more.²² However, in studying the effect of the surgical timing of the ST approach on neurologic complications and wound complications, it was reported that this method was effective and safe for calcaneal fractures.²³

Our study found wound necrosis in 2 patients in the EL group. Both patients were found to have secondary healing with superficial debridement. No skin complications occurred in the ST group. In our study, no nerve damage was noted in either group.

Operative time in intra-articular calcaneus fractures is one of the factors that should be considered to reduce skin complications. Therefore, it is essential to have a positive fold test, especially in patients treated with the EL approach. In their prospective comparative study, Attilio Basile et al. reported that the operative time was significantly shorter in the ST group.²⁴ Shengli Xia reported in their comparative study that the operative time was shorter in the ST group.¹⁶ Zhikui Zeng et al. reported in their meta-analysis study that the operation time was shorter in the ST group.²⁵ While we waited for the wrinkles to form regarding the surgery timing in our EL patient group, we turned to earlier surgery in the ST group.

In our study, it was found that the surgery time was significantly shorter in the ST group. The short preoperative waiting time is an essential advantage of the ST approach. Besides, the short preoperative waiting time significantly reduces the cost of treatment and hospitalization.

In a study of 109 patients, including type 2 and type 3 Sanders fractures, the ST and the EL approaches were compared. It was reported that both methods were effective. However, the ST approach might be preferred because of the lower analgesic requirement and reduced surgical materials in the postoperative period.²⁶ In the studies by Je-Hyoung Yeo and Hui Yao, it was found that there was no significant difference between the two groups in terms of AOFAS-Hindfoot scores.^{2,17} In the study by Zhikui Zeng, although the ST approach was beneficial in terms of the AOFAS-Hindfoot score in Sanders type 2 fractures, this benefit disappeared in type 3 fractures.²⁵ In our study, the AOFAS-Hindfoot score was 83 in the EL group and 85 in the ST approach. Therefore, it seems that our results are consistent with the literature.

Since the EL approach provides a good field of view in intra-articular calcaneal fractures, it is an excellent aid radiologically to the surgeon in correcting parameters such as Bohler and Gisanne angles, height, length, and width of the calcaneus.²⁷ Using the ST approach, correcting these radiological parameters during surgical treatment is possible. A review of the literature reveals many studies comparing the two methods. In a retrospective cohort study involving 100 patients (40 patients received the ST approach, and 60 patients received the EL approach), it was reported that there was no difference between the rates of improvement in radiological parameters.² In a retrospective study that included 112 patients (79 patients received the EL, 33 patients received the ST approach), it was reported that union was observed radiologically in all patients and that there was no significant difference in the Bohler and Gisanne angles at the end of treatment.¹⁵ The meta-analysis study by Hui Yao et al. reported that the rates of improvement in the Bohler angle were similar between the two groups.¹⁶ The studies by Kikuchi, Basile, and Kline also support that the ST approach effectively achieves adequate radiographic recovery.^{14,24-28}

Our study showed significant improvement in the ST group regarding postoperative Bohler and Gisanne angles, calcaneal height, width, and lengths. There

was no significant difference between the two groups after surgery. The data we obtained are compatible with the literature.

The literature generally found the clinical, functional, and radiologic outcomes of the minimally invasive approach with the ST incision comparable to the EL approach. In addition, common skin complications with the EL approach are less frequent with the ST approach, and preoperative waiting times are shorter with the ST approach. Therefore, the ST approach is a safe and effective surgical treatment of intra-articular calcaneal fractures.

The limitations of our study are that it is retrospective, the follow-up time is short in the groups, and the number of patients in both groups is small. Moreover, screw osteosynthesis was performed in the ST group, while plate-screw osteosynthesis was performed in the EL group. Another limitation of our study is that the same fixation material was not used between the groups.

In our study, similar radiological and clinical results were obtained in our patients with calcaneal fractures who were operated on using the sinus tarsi and extended lateral approach. Our preoperative waiting time and soft tissue complications were observed lower in our cases operated on using the sinus tarsi approach.

In conclusion, the sinus tarsi approach for intra-articular calcaneal fracture surgery reduces the preoperative waiting time, provides adequate visibility for anatomic restoration of the talocalcaneal articular surface, and effectively prevents skin complications. Therefore, we think that conducting prospective randomized clinical studies with large sample groups will contribute to the literature on the surgery of displaced calcaneal fractures, comparing the sinus tarsi approaches, which we think are less invasive and advantageous for the prevention of complications, instead of the classical extended lateral approach, which is known to have more complications related to skin and soft tissue.

Yazar Katkıları: Çalışma konsepti/Tasarımı: UÖ, KŞ; Veri toplama: KŞ, FF, AP, CK, FK; Veri analizi ve yorumlama: KŞ, FF, AP, CK, FK; Yazı taslağı: KŞ, FF, AP, CK, FK; İçeriğin eleştirel incelenmesi: AP, FF, UÖ; Son onay ve sorumluluk: KŞ, AP, FK, CK, FF, UÖ; Teknik ve malzeme desteği: UÖ, CK, FK; Süpervizyon: UÖ, AP, FF; Fon sağlama (mevcut ise): yok.

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