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Functional and radiographic outcomes after surgery for displaced intraarticular calcaneal fractures: Comparison between the sinus tarsi approach and the extensile lateral approach

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Abstract

The sinus tarsi approach (STA) is a relatively novel and minimally invasive procedure that reduces soft tissue complications during surgery for displaced intra-articular calcaneal fractures (DIACF). We aimed to evaluate the effectiveness of this approach by comparing the functional and radiographic outcomes obtained after the STA and the extensile lateral approach (ELA) in DIACF. The medical records of 73 patients underwent surgery for displaced intra-articular calcaneal fractures between 2013 and 2018 were retrospectively analyzed. The cases were divided into two groups. The first group classified as STA (n: 39) and the second one classified as ELA (n: 34). Pre-Post-operative Boehler-Gissane angle, calcaneal length, height and width, postoperative AOFAS scores, and postoperative complication rates for each case were recorded and statistically compared. The AOFAS score was 82.5±4.4 points in the STA group whereas it was 79.5±5.4 points in the ELA group (p: 0.01). According to AOFAS scoring, 74.4% of patients in the STA group had an excellent-good outcome, whereas it was 55.9% in the ELA group. The postoperative Boehler angles were 28.5±8.4 degrees in the STA group and 26.3±8.3 degrees in the ELA group (p: 0.26). The postoperative Gissane angles were 122.2±8.9 degrees in the STA group and 128.7±10.5 degrees in the ELA group (p:0.005). Superficial infection was observed in one patient in STA group. Wound infections and necrosis in four patients and non-union was seen in one patient in ELA group. Minimally invasive surgery with STA is a feasible and effective surgical treatment method that provides adequate postoperative radiological alignment and functional results and minimizes soft tissue dissection in DIACFs.

Keywords: Sinus tarsi approach, extensile lateral approach, calcaneal fractures, minimally invasive

Introduction

The calcaneus is the most commonly fractured bone among the tarsal bones. Approximately 75% of foot fractures are consist of calcaneal fractures. Falling from a height is the leading cause of approximately 3/4 of displaced intra-articular calcaneal fractures (DIACF). DIACF are usually associated with chronic pain and long-term loss of function [1-3]. These injuries are associated with osteoarthritis of the subtalar joint, malunion, and poor functional outcomes, and surgical treatment options are preferred in the treatment of displaced intra-articular fractures [4-6]. The surgical method acceptable by clinicians should be when calcaneal geometry is preserved and soft tissue dissection is minimized while an anatomic reduction is performed. The Extensile Lateral Approach (ELA), a classic procedure, has been preferred for many years [7-9]. Nutrition of the skin flap may be impaired after extensive skin dissection with this approach; this can lead to wound infections and other soft tissue complications [10,11]. Soft tissue complications and the comminuted area of the joint make treatment of these fractures more challenging. As a result, high rates of complications may be observed, including superficial infections (19.7%), deep infections (5.6%), and osteomyelitis (1%) [12,13].

On the other hand, the Sinus Tarsi Approach (STA) is one of the minimally invasive methods developed to avoid complications of open surgery with the ELA [14-16]. The minor incision could theoretically reduce sural nerve damage and soft tissue complications [17].

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Problems at the wound site and possible infections can have devastating consequences and it is very difficult to address these situations. Determining which surgical method is more effective in reducing complications can minimize such complications and provide the basis for effective treatment [17]. Our hypothesis is that minimally invasive surgical treatment of displaced intra-articular calcaneal fractures using the sinus tarsi approach is an effective method providing high-quality fracture reduction as well as the extensile lateral approach, and decreasing complication rates. Therefore, our aim was to compare the postoperative radiographic and functional outcomes of patients who underwent minimally invasive surgery with STA and patients who underwent open surgery with ELA for the surgical treatment of displaced intraarticular calcaneal fractures.

Materials and Methods

The files of 87 patients underwent surgery due to DIACF between the years of 2013-2018 were analyzed retrospectively. Open fractures, pathologic fractures, preoperative neurovascular deficits, neuropathic feet, and patients under the age of 18 were excluded from the study. Fracture characterization according to the Sanders classification was performed by 2 surgeons who did not perform the surgeries. The surgeons reached a consensus in cases with different fracture typing. Cases that cannot be agreed on were not included in the study. According to the exclusion criteria, 73 patient files over 18-year-old age who underwent surgery for DIACF were included in the study. 34 patients who underwent surgery with extensile lateral approach were grouped as ELA group and 39 patients who underwent surgery with tarsi sinus approach were grouped as STA group.

All cases underwent surgery in the lateral decubitus position and under spinal anesthesia. In cases with minimally invasive STA, a 4-6 cm straight incision was made, extending from the tip of the fibula to the base of the fourth metatarsal bone. The posterior facet was made visible by retracting the extensor digitorum brevis proximally and the peroneal tendons distally. The displaced posterior facet fragment was reduced with the elevator and reduction clamps and temporarily fixed with Kirschner wires (k-wires). A Steinman screw was then sent posteriorly to the calcaneal tuberosity to restore varus and heel height. After confirmation of calcaneus length, height, and width, as well as Gissane and Böhler angles, fracture fixation was performed with a C-arm fluoroscopy-guided and anatomically locked minimally invasive calcaneus plate in the appropriate position (Figure 1). After application of negative pressure drainage, all layers were anatomically closed. A short-leg plaster splint was applied.

In the cases where ELA was used, an oblique L-incision was used, starting from the lateral Achilles tendon 3-4 cm above the lateral malleolus and extending to the base of the 5th metatarsal. Subsequently, a subperiosteal flap was formed by preserving the soft tissues through dissection of the sural nerve and sharp dissection. This flap was retracted using a 1.5 mm K-wire sent to the talus neck, distal fibula and cuboid bone, which allowed a wide area of view in the surgical field. Reduction of the displaced posterior facet was achieved and temporary fixation with K-wires was obtained. Varus and height were restored with a Steinman screw from the tuber calcanei. After confirmation with intraoperative fluoroscopic images, fixation was performed with an anatomic calcaneus plate and 3.5 mm cortical screws (Figure 2). The tourniquet was released and bleeding was controlled. The layers were closed with negative pressure drainage, and a short leg splint was applied.

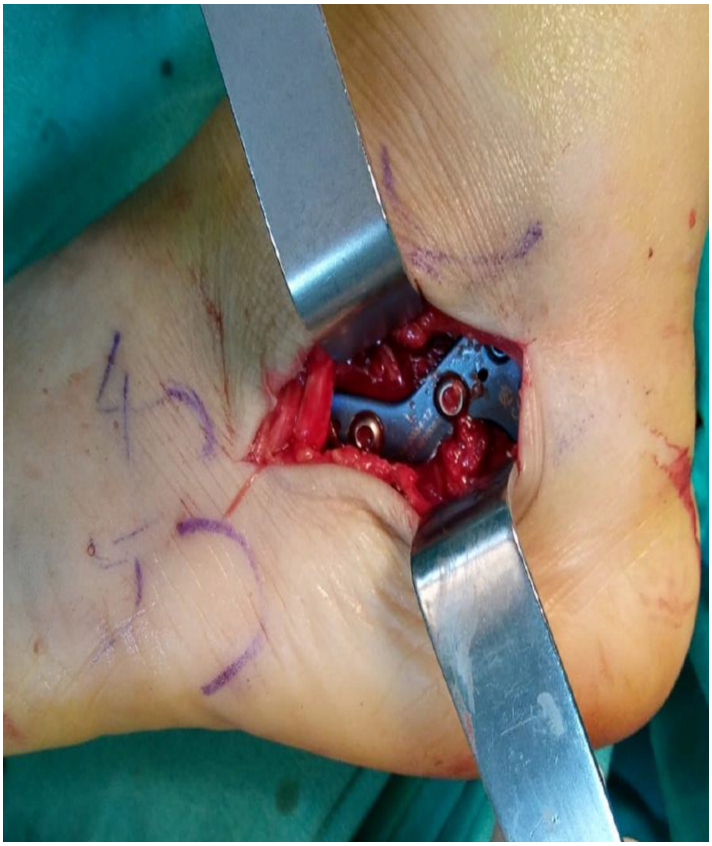

Figure 1. Application of minimally invasive anatomic calcaneal plate via sinus tarsi approach

Figure 2. Application of anatomic calcaneal plate via extensile lateral approach

Surgical drains were removed within 24 hours postoperatively. Short leg braces were removed in the second postoperative week and ankle exercises were initiated. Patients received nonweight-bearing exercise as well. At postoperative week 6, patients received partial weight-bearing and weight-bearing was increased over time as they tolerated it. Full weight-bearing was initiated after union results were seen on radiographs at week 12.

AOFAS scores were evaluated [18]. The normal value for the Gissane angle was accepted as 100-133 degrees, and the normal value for the Boehler angle was accepted as 20-46 degrees [19]. Postoperatively, the length, height, and width of the calcaneus

were recorded. These measurements were performed at the postoperative 6th month in the outpatient visit. The measurements were performed with the INFINITT PACS (Picture Archiving and Communication Systems) (INFINITT Healthcare, Seoul, South Korea) program used in our hospital. Fractures were grouped according to the Sanders classification from the preoperative computed tomography images [20]. The operations were performed by 3 different surgeons with more than 5 years of experience in trauma surgery.

The age, gender, smoking status, trauma history, mechanism of injury, extremity side of fracture, Sanders classification, surgical method, calcaneus length, height, preoperative and postoperative Gissane and Böhler angles on X-Ray images, CT scans and American Orthopedic Foot and Ankle Society (AOFAS) scores were recorded. The data obtained were statistically compared between the STA group and the ELA group.

The study was conducted under the Declaration of Helsinki by obtaining the approval of our local ethics committee.

SPSS 21.0 (Statistical Package for the Social Sciences) (SPSS Inc., Chicago, IL, USA) and Microsoft Excel 2016 programs were used for statistical analysis. Central and prevalence criteria such as number, percentage, minimum and maximum values, mean, standard deviation, and median were used to generate descriptive statistics. Conformity of variables to the normal distribution was examined by visual (histogram and probability plots) and analytic methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Comparison of independent categorical data was compared with Pearson's chi-square; normally distributed independent numerical variables were compared with the t-test for independent samples. Independent numerical variables that were not normally distributed were compared using the Mann-Whitney U test. A statistical p-value of less than 0.05 was considered significant in the study.

Results

A total of 73 patients were included in the study. Of the patients, 39 underwent minimally invasive surgery with STA and 34 underwent open surgery with ELA. The mean follow-up period was 14.47 ± 7.44 (8-36) months. Patient demographic characteristics such as age, sex, smoking status, and fracture injury mechanism, fracture site statistical analyses, and Sanders classifications are summarized in Table 1.

The distribution of radiological and clinical outcomes according to the surgical method used in the patients participating in the study is shown in Table 2.

Pain and clinical assessment were performed using the AOFAS hind-foot score (Table 3). Patients with a score of 90 and above were grouped as excellent outcomes, 80-89 points as good outcomes, 70-79 points as moderate outcomes, and 69 and below as poor outcomes. There were no poor outcomes whereas individuals in both groups had excellent outcomes, 27 (69.2%) had good outcomes, 10 (25.6%) had moderate outcomes in patients who underwent minimally invasive surgery, 17 (50%) had good outcomes in patients who underwent open surgery, and 15 (44.1%) had moderate outcomes.

Table 1. Demographic characteristics of patients and distribution of fracture characteristics by group

		STA Group n=39 n(%)	ELA Group n=34	p value
Age	**mean±SD**	43.8±11.2	39.4±10.8	0.09*
Gender	**Male**	34 (%87.2)	26 (%76.5)	0.23**
	Female	5 (%12.8)	8 (%23.5)	
Smoking condition	**Smoking**	22 (%56.4)	18 (%52.9)	0.77**
	Non-smoking	12 (%43.6)	16 (%47.1)	
Mechanism of injury	**Simple trauma**	7 (%17.9)	7 (%20.6)	0.86**
	Traffic accident	15 (%38.5)	11 (%32.4)	
	Falling from high	17 (%43.6)	16 (%47.1)	
Fracture side	**Right**	19 (%48.7)	18 (%52.9)	0.70**
	Left	17 (%43.6)	12 (%35.3)	
	Bilateral	3 (%7.7)	4 (%11.8)	
Sanders classification	**Type 2**	7 (%17.9)	2 (%5.9)	0.06**
	Type 3	22 (%56.4)	15 (%44.1)	
	Type 4	10 (%25.6)	17 (%50)	

* Independent Sample t Test
**Pearson Chi square

Table 2. Distribution of postoperative radiological measurements and AOFAS scores of the patients by groups

	STA Group (n=39)	ELA Group (n=34)	t	p*
Variables	**Aver.±SS**	**Aver.±SS**		
Calcaneal measurements (mm)				
Length	77.1±5.0	79.9±5.9	2.2	0.03
Height	45.5±4.5	43.6±4.5	1.8	0.08
Width	47.9±4.7	45.6±5.1	2.0	0.05
Gissane angle (degrees)				
Pre-operation	106.0±13.1	102.7±9.7	1.2	0.2
Post-operation	122.2±8.9	128.7±10.5	2.9	0.005
Boehler angle (degrees)				
Pre-operation	11.9±6.1	9.9±6.6	1.4	0.18
Post-operation	28.5±8.4	26.3±8.3	1.1	0.26
AOFAS score	82.5±4.4	79.5±5.4	2.6	0.01
Wound-Site Complication	1	4		0.12**

*Independent Sample t Test, **Pearson chi-square test

Table 3. AOFAS hindfoot scale

PAIN (40 points)			
None (40p)	Mild, occasional (30p)	Moderate, daily (20p)	Severe, almost always present (0p)
FUNCTION (50 points)			
Activity limitations, support requirement			
No limitations, no support (10p)	No limitation of daily activities, limitation of recreational activities, no support (7p)	Limited daily and recreational activities, cane (4p)	Severe limitation of daily and recreational activities, walker, crutches, wheelchair, brace (0p)
Maximum walking distance, blocks			
Greater than 6 (5p)	4-6 (4p)	1-3 (2p)	Less than 1 (0p)
Walking surfaces			
No difficulty on any surface (5p)		Some difficulty on uneven terrain, stairs, inclines, ladders (3p)	Severe difficulty on uneven terrain, stairs, inclines, ladders (0p)
Gait abnormality			
None, slight (8p)		Obvious (4p)	Marked (0p)
Sagittal motion (flexion plus extension)			
Normal or mild restriction (30o or more) (8p)		Moderate restriction(15o-29o) (4p)	Severe restriction (less than 15o) (0p)
Hindfoot motion (inversion plus eversion)			
Normal or mild restriction (75%-100% normal) (6p)		Moderate restriction (25%-74% normal) (3p)	Marked restriction (less than 25% normal) (0p)
Ankle-hindfoot stability (anteroposterior, varus-valgus)			
Stable (8p)		Definitely unstable (0p)	
ALIGNMENT (10 points)			
Good, plantigrade foot, ankle-hindfoot well aligned (10p)		Fair, plantigrade foot, some degree of ankle. hindfoot malalignment observed, no symptoms (5p)	Poor, nonplantigrade foot. severe malalignment, svmptoms (0p)

In patients who underwent STA, complications occurred in a total of 3 patients; 1 patient had superficial wound site infection treated with oral ab and dressing and 1 patient had wound site infection requiring surgical debridement and intravenous antibiotic therapy. In patients who underwent ELA, complications occurred in a total of 8 patients; 3 patients had superficial wound-site infection resolved with oral ab and dressing, 1 patient had wound site infection requiring surgical debridement and intravenous antibiotic therapy, 3 patients had reflex sympathetic dystrophy requiring physical therapy, and 1 patient had nonunion. There was no statistical significance between wound-site infections ($p > 0.05$).

Discussion

Calcaneal fractures are the most common tarsal bone injuries [21]. There has not been a single approach universally applied to all calcaneal fractures until today. The aim of the treatment for these fractures is to provide possible anatomic reduction, stable fixation for early functional rehabilitation, and avoid potentially destructive soft tissue complications. A surgical approach should allow adequate imaging and allow adequate fracture reduction [22]. The main objective of surgery for calcaneal fractures can be summarized as regulating the subtalar articular surface, especially the posterior articular surface, and providing the height and width of the calcaneus [23]. In our study, there was no statistical difference between the results obtained with ELA in the postoperative parameters of Gissane, Boehler angle, calcaneal height, and width after STA. The values for calcaneal length were significantly higher with ELA than with STA only. Nevertheless, these values were similar to postoperative calcaneal length values measured in studies in the literature [24, 25]. Based on these results, we believe that the sinus tarsi approach is a feasible method to achieve effective fracture reduction.

Regarding the evaluation of the outcomes of calcaneal fractures, we used AOFAS hindfoot scoring, a scoring system with high validity and reliability that has been frequently preferred [26]. Studies comparing open surgery and minimally invasive surgical approaches in the literature have found that complications are generally reduced, pain is minimized with the minimally invasive approach, and there is no significant difference in AOFAS scores between the two surgical methods [17, 27-29]. In contrast to these studies, two cohort studies found higher scores in the AOFAS score of patients who received a minimally invasive approach, but no significant difference was found [30, 31]. In our study, the AOFAS hindfoot score was 82.5 points in STA and 79.5 points in ELA. It was found that the AOFAS hindfoot score was better, even if it was not very high, in patients who underwent minimally invasive surgery. Furthermore, as the number of fragments containing the joint increases, functional outcomes are expected to get worse. In fact, there are publications reporting good pain and functional outcomes with primary arthrodesis for Sanders type 4 calcaneal fractures [32, 33]. Although STA is minimally invasive, it may be a method that can be used in the surgery of displaced intra-articular calcaneal fractures other than Sanders type 4 with good functional results.

Although the extensile lateral approach is a widely used technique for intra-articular calcaneal fractures, it has been associated with serious complications. Surgical site infections and wound problems are the most common complications [10, 34]. Wound problems with ELA are seen at a rate of up to 25% [35, 36]. A review of the literature shows that these complications are lower in minimally invasive sinus tarsi cases. [37- 39]. Although it was not statistically significant in our study, similar to the literature, wound-site infection rates were higher in the ELA group than in the STA group.

Limitations of this study include the retrospective design of the study, the use of surgical procedures by more than one surgeon, the short follow-up periods, and surgery on different dates. Considering these results, much better results can be obtained by conducting prospective randomized controlled studies with homogenous groups, higher number of patients, and with long-term results.

Conclusion

The sinus tarsi approach for displaced intra-articular calcaneal fractures is an effective and feasible surgical treatment method that provides adequate fracture reduction, having good functional results, and minimizing soft tissue dissection and complications thanks to its minimally invasive nature.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
All authors declare no financial support.

Ethical approval
The study was approved by the Institutional Review Board of Okmeydani Training and Research Hospital numbered: 48670771-514.10.

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