ORIGINAL ARTICLE

Comparison of sinus tarsi approach versus extensile lateral approach in the management of displaced intra-articular calcaneal fractures: A single-center study

Mehmet Ersin, M.D.,[1] **Mehmet Demirel, M.D.,**[2] **Mehmet Ekinci, M.D.,**[1] **İbrahim Sungur, M.D.,**[1] **Murat Yilmaz, M.D.,**[1]

[1]Department of Orthopaedics and Traumatology, Haseki Training and Research Hospital, Istanbul-*Türkiye*
[2]Department of Orthopaedics and Traumatology, İstanbul University, İstanbul Faculty of Medicine, İstanbul-*Türkiye*

ABSTRACT

BACKGROUND: Controversy still exists for optimal treatment for displaced intra-articular calcaneal fractures (DIACFs). Conventionally, the extensile lateral approach (ELA) has been the most preferred approach. Although ELA provides excellent fracture access and direct evaluation of the depressed posterior facet, this approach has a high rate of serious complications, such as hematoma, superficial/deep infection, and wound healing issues. To overcome such complications, more minimally invasive techniques including external fixation, percutaneous fixation, arthroscopic assisted fixation, and sinus tarsi approach (STA) have been recently described. The primary aim of this study was to compare STA and LEA in the treatment of DIACFs.

METHODS: Patients who were operated for DIACFs in our clinic were included in the study. Patients with closed DIACFs of Sanders Type II, III, IV, and over 18 years of age were identified. Physical examinations and radiological evaluations of the patients were performed, and clinical scores were filled. Patients were divided into subgroups according to the Sander's classification and comparisons were made again according to these subgroups.

RESULTS: There were 37 patients (four female and 33 male) in STA group and 44 patients in LEA group (six female and 38 male). The mean age was 44.42±13.57 years (range, 18–61) for STA group and 37.32±11.09 years (range, 18–56) for the LEA group. In clinical outcomes, except for short-form survey (SF-12)/MCS-12 (Mental Score) and visual analog scale score, all the parameters were significantly better in STA group compared to LEA group. No significant difference was observed between the two groups in radiographic results, except for the Böhler angle. Significantly less infection occurred in the STA group compared to LEA group (P=0.021). According to Sander's classification, American Orthopedic Foot and Ankle Society, foot and ankle disability index, and SF-12/PCS-12 and foot function index scores, no significant differences were determined between STA and LEA groups for Sanders Type 2, whereas the values were considerably higher in STA group than in LEA group for Sanders Type 3 and 4.

CONCLUSION: In DIACFs, STA is considered a safe and effective method for restoring the width, height, and length of the calcaneus and reconstruction of joint alignment and has now become our standard technique for all calcaneal fractures requiring operative treatment.

Keywords: Displaced intra-articular calcaneal fractures; sinus tarsi approach; the extensile lateral approach.

INTRODUCTION

Displaced intra-articular calcaneal fractures (DIACFs) represent disabling injuries that often occur in young, active individuals and thus have a significant socioeconomic impact.[1] Malunion, subtalar arthritis, and sub-fibular impingement are common complications following both conservative and surgical treatment of these fractures.[2] To minimize these compli-

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Address for correspondence: Mehmet Ersin, M.D.
Haseki Training and Research Hospital, İstanbul, Türkiye
E-mail: drmehmetersin@gmail.com

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cations, open reduction and internal fixation of the posterior facet of the calcaneus and restoration of the subtalar joint become mandatory. However, the optimal treatment for such fractures is still a matter of debate.[1,3,4]

Historically, the extensile lateral approach (ELA) has been considered the gold standard for the fixation of DIACFs.[5] Although ELA provides excellent fracture access and direct evaluation of the depressed posterior facet, this approach has a high rate of serious complications, such as hematoma, superficial/deep infection, sural nerve injury, and wound healing issues, despite the meticulous attention to soft-tissue management.[5,6] To overcome such complications, more minimally invasive techniques, including external fixation, percutaneous fixation, arthroscopic assisted fixation, and sinus tarsi approach (STA) have been recently described.[1-3,7] Despite limited exposure for fracture fixation, STA could ensure direct reconstruction of the posterior facet and strong fixation with screws as well as satisfactory functional outcomes.[5,8]

In recent years, there has been an increasing interest in the STA in calcaneal fractures. There are comparative studies on the treatment of calcaneal fractures with STA and ELA in the literature, but different results have been reported about the success of these methods.

The primary aim of this study was to compare the clinical and radiographic results of patients treated by either STA or ELA for DIACFs in a single tertiary referral center. The secondary aim was to conduct subgroup analyses of surgical outcomes for Types II, III, and IV calcaneal fractures according to Sander's classification.

MATERIALS AND METHODS

This study was approved by the institutional review board and conducted in accordance with the Helsinki Declaration's principles. The medical records of 119 patients with Sanders Type II, III, or IV intraarticular calcaneal fractures were diagnosed and surgically treated by either STA or ELA from 2011 to 2021 at our institution and were retrospectively identified. The inclusion criteria for the study were: (1) Patients aged 18 years old and above; (2) a diagnosis of Sanders Types II, III, or IV DIACFs, (3) closed fractures, (4) complete clinical and radiographic data, (5) a minimum follow-up of 24 months, and (6) being willing to participate in the study. Exclusion criteria were: (1) Patients who underwent revision surgery, (2) lost to follow-up, (3) inadequate medical records, and (4) revision surgery being unwilling to participate in the study.

Based on the above eligibility criteria, after excluding 38 patients (29 were lost to follow-up, and nine had inadequate medical records), the remaining 81 patients (89 feet) were included in the study and invited to a final follow-up appointment. Patients were informed that medical records would be used for scientific purposes only, and their informed consent was obtained.

The patients included in the study were invited to the clinic for this study and their physical examinations were performed. Standard anterior-posterior, lateral, oblique, and axial foot x-ray evaluations of the patients were performed, and their clinical scores were filled.

Study Protocol

Part I: Comparison of clinical and radiographic outcomes between STA versus LEA groups.

All the patients were initially divided into two groups based on the surgical approach (STA and LEA). Then, the two groups were compared in terms of following clinical and radiographic outcome measures.

Demographic and clinical data were collected from the hospital electronic database and the medical records, including age at the time of surgery, gender, follow-up duration, and involvement side as well as the need for revision surgery. Intra and post-operative complications were recorded. Patients who underwent revision surgery were noted.

In the clinical assessment, the American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, foot and ankle disability index (FADI), the 12-item short form survey (SF-12), foot function index (FFI), and visual analog scale (VAS) during daily activities were measured at the final follow-up. All clinical outcome measures were obtained by a single orthopedic surgeon who did not participate in the treatment of patients.

In the radiographic evaluation, calcaneal anatomical parameters including Gissanne angle, Böhler angle, calcaneal length, height, and width were measured on the weight-bearing anteroposterior and lateral radiographs of the foot at the final follow-up by a single orthopedic surgeon with a particular interest in foot and ankle surgery, using Osirix software (University of Geneva, Geneva, Switzerland).

Part II: Subgroup analyses

Subgroup analyses were conducted according to Sander's classification between STA versus LEA groups in terms of the aforementioned clinical and radiographic outcome measures. Clinical and radiographic results for Sanders 2, 3, and 4 were analyzed in detail.

We have traditionally performed ELA for DIACFs, particularly Sanders Type 3 and 4. Then, in line with changing assumptions and attitudes regarding STA in the literature, our surgical strategy changed, and we began performing minimally invasive surgery on such fractures, even for Sanders Type 4.

Operative Techniques

ELA

The incision originates between the fibula and Achilles tendon and extends horizontally to the fifth metatarsal's base. After exposing the lateral wall of the calcaneus and the subtalar joint, a full-thickness skin flap was created and retracted using multiple Kirschner wires. Open reduction was then

performed, and an anatomic, low-profile plate designed specifically for the calcaneus was used for internal fixation. An absorbable stitch was used for the apposition of subcutaneous tissue with great attention to avoid excessive tension on the distal corner of the incision. An interrupted Allgöwer-Donati stitch was used for the skin closure.

STA

A 4 cm incision was made between the end of the fibula and the base of the fourth metatarsal. To reveal the sinus tarsi and posterior facet, the extensor digitorum brevis was retracted. A Schanz pin was inserted from lateral to medial in the calcaneal tuberosity to reduce the tuberosity fragment, and the varus deformity was corrected with a Schanz pin in the axial heel image under fluoroscopic control. After reducing the posterior facet with a lamina spreader or Hinterman distractor, two screws were inserted laterally to medially to engage the sustentacular and support facet. To correct and maintain the axial length of the calcaneus, one or two large fully threaded screws were placed from posterior to anterior. The procedure was finished after rigid fixation was achieved. The post-operative protocol was similar for both patient groups. All the feet were placed in a below-knee cast postoperatively and followed for wound care. The overall duration of non-weight-bearing was generally 6–8 weeks, followed by gradual protected weight-bearing.

Statistical Analysis

Statistical analysis was performed using SPSS version 21.0 (IBM Corporation, Armonk, NY, USA). Verification of the normality of the distributions of quantitative variables was performed using the Shapiro–Wilk method. The Chi-squared test was used to compare categorical data and proportions, while continuous variables were analyzed using the t-test and Mann–Whitney test. Differences with P<0.05 were considered to be statistically significant.

Table 1. Descriptive statistic

	STA group	LEA group
Number of patients/feet	37/41	44/48
Age (years)	44.42±13. 57	37.32±11.09
Gender (Female/Male)	4/33	6/38
BMI (kg/m²)	27.53±3.45	27.94±3.55
Follow-up period (months)	31.73±7.65	61.35±27.58

RESULTS

Overall, 89 feet of 81 patients (ten females and 71 males) were analyzed eight patients presented with bilateral calcaneal fractures, while 73 sustained a unilateral fracture. Forty-one calcaneus were included in the STA group, while 48 calcaneus were included in the LEA group.

Part I: Comparison of surgical outcomes between STA versus LEA groups

There were 37 patients (four female and 33 male) in STA group and 44 patients in LEA group (six female and 38 male). The mean age was 44.42±13. 57 years (range, 18–61) for STA group and 37.32±11.09 years (range, 18–56) for the LEA group. The mean follow-up was 31.73±7.65 months (range, 24–51 months) and 61.35±27.58 months (range, 24–106 months) for the STA group and LEA group, respectively. The mean BMI was similar between the groups. (STA group, 27.53±3.45 kg/m², LEA group, 27.94±3.55 kg/m², and P=0.522) (Table 1).

There was a significant difference between the two groups in clinical outcomes in all parameters except SF-12/MCS-12 (Mental Score) and VAS score. The mean AOFAS was 87.88±10.84 and 73.68±16.95 in STA group and LEA group, respectively. The mean FADI was 92.51±9.54 and

Table 2. Clinical outcomes

Groups		Mean	SD	P-value
VAS	STA group	0.96	1.13	
	LEA group	2.08	2.10	0.076
AOFAS	STA group	87.88	10.84	
	LEA group	73.68	16.95	<0.001*
FADI	STA group	92.51	9.54	
	LEA group	79.89	17.37	<0.001*
SF 12 / PCS-12 (physical score)	STA group	50.96	5.85	
	LEA group	42.37	8.02	<0.001*
SF 12 / MCS-12 (mental score)	STA group	60.98	5.38	
	LEA group	57.05	8.96	0.214
FFI	STA group	16.48	16.09	
	LEA group	38.15	22.37	<0.001*

Table 3. Radiographic outcomes

Groups		Mean	SD	P-value
Böhler angle (°)	STA group	22.67	8.37	
	LEA group	32.74	10.93	<0.001*
Gisanne angle (°)	STA group	124.62	10.13	
	LEA group	125.94	13.91	0.360
Calcaneal length (mm)	STA group	80.25	6.61	
	LEA group	82.89	6.41	0.078
Calcaneal height (mm)	STA group	49.48	4.58	
	LEA group	51.97	4.17	0.006*
Calcaneal width (mm)	STA group	37.17	3.85	
	LEA group	36.09	3.86	0.362

79.89±17.37 in STA group and LEA group, respectively. The mean SF-12/PCS-12 (Physical Score) and the mean FFI score were 50.96±5.85, 42.37±8.02, and 16.48±16.09, 38.15±22.37 in STA and LEA groups, respectively. There were no significant differences in SF-12/MCS-12 (Mental Score) and VAS scores between the groups. The mean SF-12/MCS-12 was 60.98±5.38 and 57.05±8.96 in STA group and LEA group, respectively. The mean VAS was 0.96±1.13 and 2.08±2.10 in STA group and LEA group, respectively (Table 2).

In radiographic outcomes, a significant difference was observed in Böhler angle between the two groups, (the mean value = 22.67±8.37 for STA group and 32.74±10.93 for LEA group; P<0.001), whereas there was no significant difference in Gissane angle (the mean value = 124.62±10.13 for STA group and 125.94±13.91 for LEA group; P=0.360). The mean calcaneal length was 80.25±6.61 and 82.89±6.41 in STA group and LEA group, respectively (P=0.078). The mean calcaneal width was 37.17±3.85 and 36.09±3.86 in STA group and LEA group, respectively (P=0.362). Although no significant differences were found in the calcaneal length and width between the two groups, the mean calcaneal height was significantly higher in LEA group than in STA group (P=0.006) (Table 3).

No intraoperative complication was observed in both groups. In terms of post-operative complications, there was superficial infection in two patients in both groups, osteomyelitis in one patient in STA group, and three patients in LEA group.

Table 4. STA and LEA groups according to Sander's classification

Sander's classification	STA group	LEA group
Type 2	n=10	n=8
Type 3	n=21	n=22
Type 4	n=10	n=18
Total	n=41	n=48

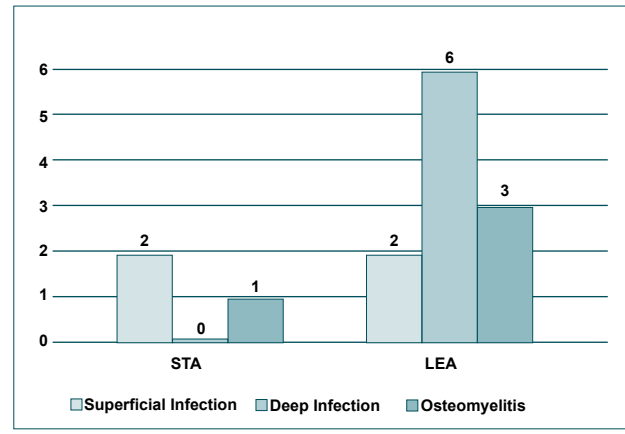

Figure 1. Infection prevalence in patient groups

While six patients suffered from deep infection in LEA group, none of the patients have such a complication in STA group. Significantly less infection occurred in the STA group compared to LEA group (P=0.021) (Fig.1).

Part II: Comparison of groups according to Sander's classification

Table 4 details patient subgroups according to Sander's classification. Table 5 outlines comparative results of outcome measures among subgroups.

In terms of AOFAS, FADI, SF-12/PCS-12, and FFI scores, no significant differences were determined between STA and LEA groups for Sanders Type 2, whereas the values were considerably higher in STA group than in LEA group for Sanders Type 3 and 4. For SF-12/MCS-12 score, while there were no significant differences between STA and LEA groups in Sanders Type 2 and 3, the LEA group showed higher results compared to STA group in Sanders Type 4.

DISCUSSION

When making clinical decisions regarding the treatment of

Table 5. Comparison of groups according to sander's classification

Groups		Sanders Type 2		Sanders Type 3		Sanders Type 4	
		Mean±SD	P	Mean±SD	P	Mean±SD	P
VAS	STA group	1.18±1.10		0.83±1.08		0.25±0.46	
	LEA group	1.46±1.27	0.581	2.55±1.54	<0.001*	3.18±2.05	0.001*
AOFAS	STA group	85.81±7.21		87.16±12.98		91.75±3.80	
	LEA group	86.05±10.01	1.000	74.56±12.90	<0.001*	67.74±16.53	<0.001*
FADI	STA group	91.62±8.19		91.40±10.74		98.50±4.37	
	LEA group	93.39±9.53	0.788	80.49±11.83	0.001*	73.87±18.16	<0.001*
PCS-12	STA group	49.33±4.63		50.75±6.59		55.02±2.86	
	LEA group	45.92±2.85	0.052	43.43±6.37	<0.001*	39.63±8.37	<0.001*
MCS-12	STA group	62.81±2.49		60.20±6.90		61.57±1.52	
	LEA group	62.44±3.77	0.947	59.18±5.92	0.149	52.23±8.78	0.018*
FFI	STA group	18.75±12.22		17.66±18.96		7.50±6.25	
	LEA group	23.47±10.43	0.461	38.04±20.15	0.001*	44.01±20.01	0.001*

calcaneal fractures, there are debates about which surgical approach should be preferred. After the initial injury, researchers have emphasized the importance of restoring the articular surface level, calcaneal height, shape, and alignment.[3,9,10] We hypothesized that this could be accomplished with STA, a less invasive technique, at least as effectively as with LEA.

In accordance with the literature, radiological measurements revealed that the length and width of the calcaneus and Gissane angles were comparable between groups.[2,11] Measurements of the Böhler angle and calcaneal height revealed statistically significant differences between groups. When these differences are examined in detail, however, the values found in statistically significant differences fall within normal ranges. These differences, which are within normal parameters, were deemed insignificant.

In terms of pain and functional scores, while there was no statistically significant difference between the groups regarding the VAS, the STA group demonstrated superior performance on the AOFAS, FADI, SF/PCS-12, and FFI. VAS was comparable between the two groups, in accordance with the literature.[1,3,11] There are different results in the literature about functional evaluation parameters. While in many studies, there was no difference in functional evaluation scores between the groups,[1-3,12] a recently published meta-analysis reported that the results of the STA group were superior, as was the case in our study.[13]

Infections and wound complications are among the most significant complications associated with calcaneal fractures. Yao et al. conducted a systematic review and meta-analysis to compare the outcomes of the two approaches in seven studies involving a total of 784 patients. The authors discovered that LEA was associated with a higher incidence of wound complications.[14] In the present study, even though severe complications such as osteomyelitis were observed in the STA group, the LEA group had significantly higher rates of complications.

Although these two groups have been compared many times in the literature, the clinical results of the subgroups according to Sanders 2, 3, and 4 have not been adequately studied. In the current study, In Sanders Type 2 fractures, there was no difference between the two approaches in both functional scores and radiological evaluations. In Sanders Type 3 fractures, the two methods showed similar results in radiological evaluations and functional scores except for AOFAS. The AOFAS scores of the STA group were significantly better. These results were generally compatible with the literature.[6,8]

Particularly, DIACFs of Sanders Type IV have a poor prognosis and are treated conservatively to avoid the risks of surgical intervention, frequently due to unsatisfactory outcomes.[11,15] Consequently, Sanders Type 4 fractures were precluded from the majority of studies.[1,3,7] In the literature, extended approaches are recommended over minimally invasive procedures for Sanders Type 4.[16] On the other hand, Lin et al. reported that STA and LEA approaches yielded comparable results even in Type 4 cases.[11] In contrast to the literature, findings from the present study have shown that STA could confer similar radiological results with better functional scores for Sanders Type 4 calcaneal fractures.

The present study's findings must be interpreted in light of its potential limitations. The most significant limitation of the study was its retrospective nature, limited sample size, and lack of a case series for comparison. Furthermore, multiple surgeons were involved in the operations. Despite these limitations, the present investigation possessed several strengths. It is one of the few studies that analyze functional scores and

radiological parameters according to Sanders Types 2, 3, and 4 subgroups in such detail. Only senior surgeons conducted all surgeries at a single tertiary referral center. Future prospective, randomized, and comparative studies are required to elucidate the differences in clinical outcomes between these two methods.

CONCLUSION

Despite the fact that the STA and the lateral extensile approach have comparable radiographic and clinical outcomes, the wound complication rates in STA were significantly lower. The STA is a minimally invasive technique that provides adequate exposure of the subtalar joint and posterior facet of the calcaneus with less soft-tissue injury. STA is considered a safe and effective technique for restoring the width, height, and length of the calcaneus and reconstructing joint alignment in DIACFs. Consequently, STA has become our standard treatment for all calcaneal fractures requiring surgical intervention.

Ethics Committee Approval: This study was approved by the University of Health Sciences Haseki Training and Research Hospital Ethics Committee (Date: 11.05.2022, Decision No: 90-2022).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Deplase eklem içi kalkaneal kırıkların tedavisinde sinüs tarsi yaklaşımı ile ekstansil lateral yaklaşımın karşılaştırılması: Tek merkezli çalışma

Dr. Mehmet Ersin,[1] Dr. Mehmet Demirel,[2] Dr. Mehmet Ekinci,[1] Dr. İbrahim Sungur,[1] Dr. Murat Yilmaz[1]

[1]Haseki Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, İstanbul, Türkiye
[2]İstanbul Üniversitesi, İstanbul Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, İstanbul, Türkiye

AMAÇ: Deplase eklem içi kalkaneal kırıkların (DEİKK) optimal tedavisi için tartışmalar devam etmektedir. Geleneksel olarak, ekstensil lateral yaklaşım (ELY) en çok tercih edilen yaklaşım olmuştur. ELY, mükemmel kırık fragmana erişim ve çökmüş posterior fasetin doğrudan değerlendirilmesini sağlasa da, bu yaklaşımın hematom, yüzeysel/derin enfeksiyon ve yara iyileşme sorunları gibi yüksek oranda ciddi komplikasyonları vardır. Bu tür komplikasyonların üstesinden gelmek için, eksternal fiksasyon, perkütan fiksasyon, artroskopik yardımlı fiksasyon ve sinüs tarsi yaklaşımı (STY) gibi daha minimal invaziv teknikler yakın zamanlarda tanımlanmıştır. Bu çalışmanın birincil amacı, deplase eklem içi kalkaneus kırıklarının tedavisinde STY ve ELY'yı karşılaştırmaktı.

GEREÇ VE YÖNTEM: Kliniğimizde deplase eklem içi kalkaneus kırığı nedeniyle ameliyat edilen hastalar çalışmaya dahil edildi. Sanders tip II, III, IV, kapalı deplase eklem içi kalkaneus kırığı olan ve 18 yaş üstü hastalar belirlendi. Hastaların fizik muayeneleri ve radyolojik değerlendirmeleri yapılarak klinik skorları dolduruldu. Hastalar Sanders sınıflamasına göre alt gruplara ayrıldı ve bu alt gruplara göre tekrar karşılaştırmalar yapıldı.

BULGULAR: STY grubunda 37 hasta (4 kadın, 33 erkek), ELY grubunda 44 hasta (6 kadın, 38 erkek) vardı. STY grubu için yaş ortalaması 44.42±13.57 (18-61 arası), ELY grubu için 37.32±11.09 (18-56 arası) idi. Klinik sonuçlarda, SF-12/MCS-12 (Mental Score) ve VAS skoru dışındaki tüm parametreler STY grubunda ELY grubuna göre anlamlı olarak daha iyiydi. İki grup arasında radyografik sonuçlarda Böhler açısı dışında anlamlı bir fark gözlenmedi. STY grubunda ELY grubuna göre anlamlı olarak daha az enfeksiyon meydana geldi (p=0.021). Sanders sınıflamasına göre, AOFAS, FADI ve SF-12/PCS-12 ve FFI skorlarındaa Sanders tip 2 için STY ve ELY grupları arasında anlamlı fark saptanmazken, Sanders tip 3 ve 4 için STY grubundaki değerler ELY grubuna göre oldukça yüksekti.

SONUÇ: Deplase eklem içi kalkaneus kırıklarında STY, kalkaneusun genişliğini, yüksekliğini ve uzunluğunu eski haline getirmek ve eklem dizilimini yeniden yapılandırmak için güvenli ve etkili bir yöntem olarak kabul edilir ve artık operatif tedavi gerektiren tüm kalkaneal kırıklar için standart tekniğimiz haline gelmiştir.

Anahtar sözcükler: Deplase eklem içi kalkaneal kırıklar; ekstansil lateral yaklaşım; sinüs tarsi yaklaşımı.

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