A Modified Sinus Tarsi Approach for Treatment of Displaced Intra-articular Calcaneal Fractures Sanders type I or II Compared to Extended Lateral Approach

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Research article

Keywords: calcaneal fracture, Sanders I or II, extended lateral approach, modified sinus tarsi approach

Posted Date: August 21st, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-54607/v1>

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Abstract

Background: We have designed a modified sinus tarsi approach (MSTA) to treat sanders type II or III intra-articular calcaneal fractures, providing sufficient surgical field exposure and operation space, and significantly reducing the rate of wound complications. We compared the radiologic results, clinical outcomes, and complications of patients operated on via the MSTA and the extended lateral approach (ELA) for treatment of displaced intraarticular calcaneal fractures Sanders type II or III.

Methods: We retrospectively studied the utility of the ELA (32 patients, 34 feet) and the MSTA (33 patients, 36 feet) operated on from January 2013 to January 2018. The average follow-up time of the two groups was 58 months. We assessed the preoperative and final x-rays, clinical outcomes and complications at the last follow-up. Clinical outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) score and visual analog scale (VAS).

Results: In both groups, the average final width, height, Bohler angle were significantly restored compared with the preoperative width, height, and Bohler. The last follow-up calcaneal length, width, height, Bohler angle, Gissane angle did not differ significantly between the 2 groups. In terms of the clinical outcomes, the average AOFAS score of the ELA group checked to 82.1 points, yielding a 77.8% excellent or good rating, and the average VAS score was 1.76 points. In contrast, the average AOFAS score of the MSTA group checked to 81.0 points, yielding a 79.4% excellent or good rating, and the average VAS score was 1.68 points. There was no significant difference in AOFAS score and VAS score between the 2 groups. The wound-healing complication rate was 2.9% in MSTA group and 22.2% in ELA group ($p = .040$). 4 cases of sural nerve injury occurred in ELA group, and 2 in MSTA group. 1 cases of peroneal tendon complication only occurred in ELA group.

Conclusion: Compared with ELA, MSTA provides similar and favorable radiological and clinical results, and is associated with fewer wound complications. We believe the MSTA is more appropriate in the treatment of Sanders II and III calcaneal intra-articular fractures.

Background

Calcaneal fractures comprise 1% to 2% of all fractures and 75% of calcaneal fractures involving the subtalar joint^[1]. Surgical treatment of displaced intra-articular calcaneal fractures (DIACFs) has been widely accepted^[2–3–4]. Among all the approach, the extended lateral approach (ELA) has been recognized as the gold standard of treatment for intra-articular calcaneal fractures^[5–6–7]. This approach can fully expose the calcaneal fracture, reduce it under direct vision, and provide enough space to insert the plate and screws. The reduction effect and functional recovery of this approach are satisfactory, but the high rate of wound complications has become a troublesome problem for clinicians^[8–9].

In order to limit the wound complications, various minimally invasive approaches have been proposed, including Palmer approach^[10], Olier approach^[11], and sinus tarsi approach (STA)^[12]. The minimally

invasive approach to treat Sanders type I or II displaced intra-articular calcaneal fractures can achieve a clinical effect comparable to that of the ELA, and the wound complications rate is significantly reduced [13]. The STA is the most widely used minimally invasive approach. This approach is limited incision, the dissection of soft tissue is mild, and the incidence of wound complications is low [14,15,16,17,18]. This approach can reduce the subtalar joint under direct vision, but the body of the calcaneal fractures cannot be fully exposed, so reduction and placement of the plate and screws are difficult. It requires experienced surgeons and a longer learning curve.

In attempt to overcome the high incidence of wound complications in ELA and the difficult operation of STA, we designed a modified sinus tarsi approach (MSTA). The approach is only about 5cm, and the soft tissues including the peroneal tendons, the sural nerve, and the lateral calcaneal artery are pulled together and protected as a whole, then the calcaneal fracture is fully exposed through the anterior and posterior windows. This approach combines the advantages of ELA whose operation field was fairly visible and STA whose wound complications rate is low. We have retrospectively analyzed and reported the operative times, radiographic results, and clinical outcomes of 29 patients with Sanders type I or II intra-articular calcaneal fractures treated with MSTA. It showed adequate fracture reduction and satisfactory functional recovery. Also, the wound complications rate was significantly reduced [19]. However, there was no conclusive conclusion about the comparison between MSTA and ELA. This investigation aims to solve this problem. This investigation retrospectively analyzed the 65 patients (70 feet) of Sanders type I or II intra-articular calcaneal fractures treated in our hospital from January 2013 to January 2018, using MSTA or ELA. Our primary goals were to compare the operative time, radiographic results, and clinical outcomes afforded by MSTA and ELA.

Methods

From January 2013 to January 2018, 96 patients with displaced intra-articular calcaneal fractures were admitted to the hospital. Inclusion criteria were patients (1) diagnosed with closed displaced intra-articular calcaneal fractures of Sanders type I or II (2) age more than 18 years and less than 65 years at the time of surgery. Exclusion criteria were patients (1) Patients who refused surgery or follow-up, (2) diagnosed with closed displaced intra-articular calcaneal fractures of Sanders type I or II (3) Patients with severe medical diseases who cannot tolerate surgery. 14 patients were Sanders type I. 9 patients refused or lost follow-up. 1 patient was younger than 18 years old, and 2 patients were older than 65 years old. 3 patients decided to treat conservatively after preoperative conversation. 2 patients were open fractures. Finally, 65 people were included. 65 people were included in this retrospective study, consisting of 33 patients (36 feet) in the ELA group, and 32 patients (34 feet) in the MSTA group. All surgeries including hardware removal were performed by the same senior surgeon who is proficient in both techniques. The minimum follow-up for each technique was 24 months. This study was approved by our institutional review board.

Preoperative Management

Calcaneal lateral and axial radiographs and CT were taken before operation. The calcaneus length, width, height, Böhler angle, and Gissane angle were measured on calcaneal lateral and axial radiographs, and Sanders classification was performed according to the CT. All operation was not performed until the swelling diminished, which depended on the doctor's opinion that the planned approach can be applied. The duration between injury and operation were recorded for both groups.

Operative Techniques

Modified sinus tarsi approach

After general or spinal canal anesthesia, the patient was placed in a lateral position (bilateral calcaneal flipped, secondary disinfected) and tourniquet was used for the injured limb. An approximately 5-cm incision was made from 1.5 cm inferior to the fibular tip, paralleling to the sole of the foot, and ended at the base of the fourth metatarsal. The incision spanned the peroneal tendons and sural nerve, and these soft tissues need to be properly protected. After sharp dissection of the skin and subcutaneous tissue, the peroneal tendons was defined as the boundary, the exposed area in front of the tendon sheath was defined as the anterior window of the surgical field, and the exposed area in the rear of the tendon sheath was defined as the posterior window of the surgical field. First, the skin of the anterior window was pulled, and the lower part was exposed as extensor digitorum brevis tendon. The calcaneal anterior tuberosity and the calcaneocuboid joint could be exposed by dissecting from the attachment point of the extensor digitorum brevis tendon along the bone surface. The posterior facet could be exposed by pulling the skin of the peroneal tendon sheath and the sinus tarsi to both sides, opening the posterior joint capsule and cleaning up the soft tissue and blood clots. Then the skin of posterior window was pulled and the deep fascia was cut along the back of the peroneal tendons. The posterior edge of the tendon sheath was dissected sharply and the soft tissue was separated along the bone surface. Finally, the anterior and posterior edges of the tendon sheath were sharply dissected, deep to the bone surface, the tendon sheath was isolated from the bone surface. The operation field was exposed by using ribbon gauze to pass under the tendon sheath and the sural nerve and pulling up these tissues to protect them. Through above operations, the calcaneal anterior tuberosity, the calcaneocuboid joint, the posterior facet, the lateral wall and the calcaneal posterior tuberosity could be exposed.

Fracture reduction followed the sequence from medial to lateral. First, the ribbon gauze was pull forward, so the anterior window was exposed. The fracture segments of the lateral wall were opened and the blood clot was cleaned to expose the deep medial fracture segment. The calcaneal varus deformity was corrected by using a periosteal stripper to insert the medial fracture line combined with a 3.5 mm Steinman pins inserted through the calcaneal tuberosity to pull downward. Meanwhile, the calcaneal tuberosity was reduced to the medial sustentacular fragment and was temporary fixed with 1.5 mm K-wires to restore the calcaneal height, Böhler angle and Gissane angle. Then, the ribbon gauze was pulled backward, so the posterior facet could be viewed directly through the posterior window. After the

reduction of the posterior facet, a 1.5 mm K-wire was temporarily fixed from the medial to the lateral. Finally, the lateral wall was reduced. The fracture reduction and the bone defect were observed with intraoperative fluoroscopic and determined whether the bone graft was needed. The plate could be placed from the anterior window by pulling up the ribbon gauze. After placing the plate and confirming it to be in the proper position, the screws was fixed on it. Then, the incision was washed and closed by layers over a drain. ☐Figure 1☐

Extended Lateral Approach

The ELA was the standard approach ^[20,21]. The reduction technique and the implants used for fixation were the same as MSTA. (Figure 2)

The operative times were recorded for both groups.

Postoperative Management

All patients were treated with antibiotics for 1 day after operation. Antibiotics was not stopped until the wound was dry. The wound dressing was changed 24 hours after the operation. The drain was removed when the volume was less than 30ml / 24h. The subtalar circle motion exercises and the active extension and flexion of the ankle and toes were guided under the condition of analgesia, 48 hours after the operation. The wound dressing was changed once every 2 or 3 days, and the sutures were removed 2 or 3 weeks after operation. Partial weight bearing began gradually at 6 weeks after operation. Full weight bearing began when the radiological results showed that the fracture had healed.

Follow-up Evaluation

Wound healing of patients after operation were recorded. Postoperative follow-up was at 6 weeks, 3, 6, and 12 months after operation, and every six months thereafter. Early complications were recorded 3 months after operation. Measurement of calcaneus length, width, height, Böhler angle, Gissane angle were at the last follow-up. Meanwhile, the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score was used to assess the efficacy, the visual analog scale (VAS) score was used to assess pain relief and the complications were recorded. All measurements and scoring were performed by two clinicians.

Statistical Analysis

Statistical analysis was performed using IBM SPSS version 23 software for Windows. The distributions of age, duration between injury and operation, operation time, calcaneal length, width, height, Bohler angle, Gissane angle of pre-operation and final follow-up, and AOFAS scores of the two groups were

normal, and the independent t test was employed to compare these data between the 2 group. The paired t test was performed to compare the preoperative and final length, width, height, Bohler angle, Gissane angle angles and calcaneal widths of both groups. The Mann-Whitney U test was used to compare follow-up duration, VAS scores between the 2 groups. Pearson's chi-square test or Fisher's exact test was performed to compare gender, other fracture complications, injury severity, prevalence of complications between the 2 groups. $P < .05$ was considered significant.

Results

The 2 groups did not differ in terms of age, gender, or injury severity. However, the duration between injury and operative differed significantly. Also, there was significant difference in the operation time. (Table 1)

Table 1
Demographic data of the study

General information	ELA (N=36)	MSTA (N=34)	P Value
Age (year)	43.3 (21-61)	41.4 (21-62)	0.507
Gender (male/female)	28:5	26:6	0.830
History			
Tobacco (n%)	5 (15.2%)	4 (12.5%)	1.000
DM (n%)	0 (0%)	1 (3.1%)	0.988
other fracture complications	9	8	0.835
Lumbar vertebra or thoracic vertebra	5	2	
Femoral neck	0	2	
Tibial plateau	3	3	
Ankle	1	1	
Sanders classification, Type I/Type II	16/20	14/20	0.782
Duration between injury and operation, day	10.4 (4-18)	7.8 (3-13)	0.001
Operative time, min	116.9 (80-168)	101.1 (51-128)	0.001
Follow-up duration, month	60.4 (24-72)	55.7 (28-72)	0.751
Abbreviations: ELA, Extended Lateral Approach; MSTa, Modified Sinus Tarsi Approach.; DM (diabetes mellitus)			
Values are expressed as the mean (range) unless otherwise indicated.			

Radiologic Results

The mean preoperative calcaneal length, width, height, Bohler angle, Gissane angle did not differ significantly between the 2 groups. In both groups, the mean final width, height, Bohler angle were significantly restored compared with the preoperative width, height, and Bohler. The last follow-up calcaneal length, width, height, Bohler angle, Gissane angle did not differ significantly between the 2 groups. (Table 2)

Table 2
Radiographic data of the study

Outcome	ELA	MSTA	P Value
Bohler angle, degree			
Preop	11.5 (-14.6-48.5)	11.6 (-12.9-32.5)	0.956
Final follow-up	25.0 (13.6–42.5)	26.2 (14.2–42.4)	0.507
P Value	0.000	0.000	0.767
Gissane angle, degree			
Preop	122.6 (94.5–152.0)	121.9 (101.8-139.7)	0.909
Final follow-up	123.8 (107.0-142.8)	124.0 (110.1-137.5)	0.606
P Value	0.530	0.193	0.266
Length, mm			
Preop	74.5 (65.8–81.2)	73.9 (63.3–87.3)	0.213
Final follow-up	75.4 (65.3–85.1)	74.0 (63.8–88.1)	0.550
P Value	0.109	0.887	0.924
Width, mm			
Preop	40.3 (34.3–49.9)	39.2 (30.8–47.7)	0.696
Final follow-up	40.3 (34.3–49.9)	39.2 (30.8–47.7)	0.696
P Value	36.7 (30.1–47.8)	36.2 (29.0–44.0)	
Height, mm			
Preop	0.000	0.000	
Final follow-up	40.1 (34.6–47.1)	40.2 (27.9–47.7)	
P Value	43.6 (37.0–51.0)	43.9 (34.8–52.2)	
Values are expressed as the mean (range).			
Abbreviations: ELA, Extended Lateral Approach; MSTa, Modified Sinus Tarsi Approach.			

Clinical Results

At the last follow-up, the average AOFAS score of ELA was 82.1 points. The result was excellent in 12 cases (33.3%), good in 16 cases (44.4%), fair in 8 cases (22.2%) and no poor case. The average AOFAS score of MSTa was 81.0 points. The result was excellent in 10 cases (29.4%), good in 17 cases (50.0%), fair in 7 cases (20.6%) and no poor case. There was no significant difference in AOFAS score and VAS score between the 2 groups (Table 3).

Table 3
Clinical outcomes of the study

Outcome	ELA	MSTa	P Value
AOFAS	82.1(61–97)	81.0 (61–94)	0.644
VAS pain during weightbearing	1.76(0–3)	1.68(0–3)	0.788
Abbreviations: ELA, Extended Lateral Approach; MSTa, Modified Sinus Tarsi Approach.			
Values are expressed as the mean (range).			

Complications

In the MSTa group, only 1 case of superficial wound infection occurred, no deep infection and skin necrosis occurred. However, in the ELA group, 8 cases of wound complications occurred, including 3 cases of superficial infections, and 5 cases of skin necrosis, but no deep infections occurred. All patients with superficial infections were healed by dressing changes and intravenous application of antibiotics. Also, all patients with skin necrosis had wound healing after delayed removal of sutures. Sural nerve injury occurred in 2 cases of the MSTa group and 4 cases of the ELA group. Local numbness healed at 6 months follow-up. 1 case of the peroneal tendon complication occurred in the ELA group, but none occurred in the MSTa group. The condition was relieved after resting by plaster casts and taking the NSAIDs orally. During the follow-up period, all patients did not experience loosening of internal fixation, nonunion of fracture and traumatic subtalar arthritis. All patients returned to their original job types. (Table 4)

Table 4
Postoperative complications of the study

Complications	ELA	MSTA	P Value
Wound complication	8(22.2%)	1(2.9%)	0.040
Superficial infection	3	1	0.723
Deep infection	0	0	1.000
Skin necrosis	5	0	
Sural nerve injury	4(11.1%)	2(5.9%)	
Peroneal tendon complication	1(2.8%)	0(0%)	
Abbreviations: ELA, Extended Lateral Approach; MSTA, Modified Sinus Tarsi Approach.			
Values are expressed as the mean (range) unless otherwise indicated.			

Discussion

This study compared the radiographic results, the clinical outcomes and the complications of the MSTA group with the ELA group in the treatment of Sanders I or II intra-articular calcaneal fractures. The radiographic results, the clinical outcomes of the MSTA group were comparable to that of the ELA group. The preoperative waiting time and operation time of the MSTA group were shorter, and the rate of wound complications and complications were lower than that of the ELA group.

The ELA is the most commonly used surgical approach for intra-articular calcaneal fractures. This approach is completely exposed, and the fracture can be reduced under direct vision and insertion of the plate is simple and practicable. Therefore, Satisfactory radiographic results and clinical outcomes can be achieved through this approach [22]. The mean postoperative Böhler angle and width were significantly restored compared with the preoperative Böhler angle and width in both groups. Also, the postoperative and the last follow-up Böhler angles and calcaneal widths did not differ significantly between the 2 groups. These results indicate that the MSTA can obtain radiographic results comparable to the ELA. In terms of the clinical outcomes, the average AOFAS score of the ELA group checked to 82.1 points, yielding a 77.8% excellent or good rating, and the average VAS score was 1.76 points. Roberto Buzzi et al. reported 44 cases of ELA for intra-articular calcaneal fractures, with an excellent or good rating of 72.7% [23], whose results are similar to that of ours. In this study, the average AOFAS score of the MSTA group checked to 81.0 points, yielding a 79.4% excellent or good rating, and the average VAS score was 1.68 points. This was not significantly different from the ELA group, achieving the same good clinical outcomes.

Compare to ELA, MSTA can achieve equivalent radiographic results and clinical outcomes in the treatment of Sanders II and III intra-articular fractures. The reasons are as follows. Although the incision of MSTA is small, the calcaneal anterior tuberosity, the calcaneocuboid joint, the posterior facet are

exposed via anterior window and the lateral wall, the calcaneal tuberosity are exposed via posterior window to obtain a sufficient operative field by pulling up the soft tissues including the peroneal tendons, the sural nerve, and the lateral calcaneus artery as a whole. For the reason that there are only two or three fracture segments in Sanders II or III intra-articular calcaneal fractures, this approach can provide enough space for reduction. Insertion of the plate is also simple and practical by putting one side of the plate through the anterior window, pulling up the ribbon gauze, and dragging the other side of the plate into the incision. Therefore, MSTa can completely replace the ELA in the treatment of Sanders II or III intra-articular calcaneal fractures. A significant advantage of MSTa over other minimally invasive approaches is simple operation and short learning curve.

Although the ELA can provide a good operation field, the biggest problem is that the soft tissue is stripped too much, making the rate of wound complications reached about 30% [8]. In order to solve this problem, various minimally invasive approaches have been proposed in recent years, of which the STA is the most widely used. In a retrospective study, Je-Hyoung Yeo et al. reported that overall incidence of the wound complications was 5% and 13.3% in STA and ELA respectively [16]. The wound complication rate of the STA was very low. In our study, 8 case of the wound complication occurred in the ELA group, yielding a 22.2% wound complication rating, while only 1 case of the wound complication occurred in the MSTa group, yielding a 2.9% wound complication rating. The rate of wound complications in the MSTa was much lower than the ELA, which is comparable to the STA in previous studies by others. The MSTa is only about 5 cm in length, which is equivalent to the length of the STA and has less damage to soft tissues. The blood supply of the lateral calcaneal flap is mainly derived from the lateral calcaneal artery which is the branch of the peroneal artery [24,25]. The MSTa can avoid damage to the lateral calcaneal artery by pulling up the lateral calcaneal artery together with the tendon sheath and the sural nerve to protect them, coupled with a smaller incision and less damage to the surrounding soft tissues, so the MSTa significantly can reduce the risk of skin necrosis and infection of the lateral calcaneal flap.

In addition to the low rate of wound complications, MSTa have some advantages in reducing other complications. Operation field is achieved by pulling up the soft tissues with the ribbon gauze in MSTa instead of retracting the lateral flap with the K-wires in ELA, doing much less damage to the peroneal tendons and the sural nerve, so that vascular and neurological complications may reduce. The pain after MSTa was much slighter than that after ELA due to shorter incision, milder soft tissue damage and new exposure method. Therefore, patients with MSTa may have greater range and intensity of early subjective exercise and lower rate of late subtalar joint stiffness.

In addition, the average duration between injury and operation for ELA group was 10.4 d and the average operation time was 116.9 minutes. While the average duration between injury and operation for MSTa group was 7.8 d and the average operation time was 101.1 minutes. The duration between injury and operation and the operation time were shorter in MSTa than that in ELA and the differences were significant.

ELA requires completely diminishment of swelling, which is confirmed by positive wrinkle sign ^[26]. However, the incision of the MSTA is short and the requirements for the degree of swelling diminishment are lower, so the duration between injury and operation of MSTA is also lower than that of ELA. The ELA need full-thickness subperiosteal flap, deep wound closure with the interrupted figure-of-eight technique, and skin closure with the Allgöwer-Donati technique to minimize the rate of wound complications, which require more time than the MSTA. The ELA takes longer operation time and cause more damage to soft tissues, and soft tissue swelling and exudation risks are greater after surgery and recovery time is longer. Therefore, the duration between injury and operation, the operation time and the hospital time of MSTA are shorter than that of ELA, and the hospitalization cost is lower.

The MSTA can completely replace the ELA in the treatment of Sanders I or II intra-articular calcaneal fractures, whose radiographic results and clinical outcomes are comparable to the ELA, and the rate of complications is significantly lower. Compared with other minimally invasive approaches, the MSTA can provide sufficient surgical field, and the reduction of fracture and insertion of plates are more convenient, with simpler operation and shorter learning curve. Therefore, the MSTA is more suitable as a conventional approach for Sanders I or II intra-articular calcaneal fractures.

As for Sanders III intra-articular calcaneal fractures, due to severity of fracture, more fracture segments and obstruction of a soft tissue sheath, the MSTA is difficult to reduce the fracture well. Therefore, it is more appropriate for Sanders III intra-articular calcaneal fractures to choose the ELA. In the surgical treatment of intra-articular calcaneal fractures, the indications of various approaches should be carefully selected. The most appropriate surgical approach should be selected according to the fracture classification to reduce the pain and financial burden of patients as much as possible.

This study also had some limitations, including retrospective studies, too short follow-up time, and too few cases. In addition, the reduction of the posterior facet evaluated by CT is closely related to the clinical outcomes ^[27]. This study lacked postoperative CT and failed to evaluate the reduction of the posterior facet after surgery. Further research is needed to clarify these issues.

Conclusion

In summary, the MSTA can combine the sufficient operation field of ELA and low wound complication rate of STA, achieving satisfactory radiographic results and clinical outcomes comparable to ELA, and having the advantage of simple operation and short learning curve. The MSTA is more appropriate in the treatment of Sanders II and III calcaneal intra-articular fractures.

Abbreviations

MSTA: modified sinus tarsi approach; STA: sinus tarsi approach; ELA: extended lateral approach ; AOFAS: American Orthopaedic Foot and Ankle Society; VAS: visual analog scale

Declarations

Acknowledgments

Not applicable.

Authors' contributions

YH, JZ and CM contributed to this work equally as first author. Study design: YH, JZ, JJ. Surgery performance: JZ,NZ. Data collection: YH, ZM. Data analysis and data interpretation:YH,CM. Drafting manuscript: YH. Revising manuscript content: JZ. Approving final version of manuscript: JJ. JJ takes responsibility for the integrity of the data analysis. The authors read and approved the final manuscript.

Funding

The research has no source of funding.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding authors on reasonable request.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Second Affiliated Hospital of Anhui Medical University, and written consent was obtained from all patients.

Consent for publication

Not applicable.

Competing interests

None of the authors have competing interests to disclose.

Author details

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Figures

Figure 1

Displaced intra-articular calcaneal fractures Sanders type $\geq$ 3 or $\geq$ 4 operated on via ELA or MSTA. (A) Anatomic scheme showing the landmarks for ELA. (B) ELA during surgery, exposing the lateral wall of calcaneus. (C) ELA exposing the view of fracture segment. (D) ELA after skin sutured. (E) Anatomic scheme showing the landmarks for MSTA. (F) MSTA exposing the calcaneal anterior tuberosity and the calcaneocuboid joint via the anterior window. (G) MSTA exposing the posterior facet, the lateral wall and the calcaneal posterior tuberosity via the posterior window. (H) MSTA after skin sutured. Abbreviations: ELA, Extended Lateral Approach; MSTA, Modified Sinus Tarsi Approach.

Figure 2

Preoperative, postoperative, and 3-year follow-up radiographs of the right foot, which underwent ELA, are shown. (A)–(B) The preoperative X-rays show calcaneal fracture. (C)–(D) Post-operative X-rays (lateral and axial) after surgery through ELA. (E)–(F) The 3-year follow-up X-rays (lateral and axial) through ELA. Abbreviations: ELA, Extended Lateral Approach.

Figure 3

Preoperative, postoperative, and 3-year follow-up radiographs of the left foot, which underwent MSTA, are shown. (A)–(B) The preoperative X-rays shows calcaneal fracture. (C)–(D) Post-operative X-rays (lateral and axial) after surgery through MSTA. (E)–(F) The 3-year follow-up X-rays (lateral and axial) through MSTA. Abbreviations: MSTA, Modified Sinus Tarsi Approach