Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2024.318548.3564 Volume 31, Issue ٢, FEB. 2025, Supplement Issue
Manuscript ID ZUMJ-2409-3564
DOI 10.21608/zumj.2024.318548.3564

ORIGINAL ARTICLE

Distraction Subtalar Arthrodesis after Malunited Calcaneal Fractures

Mohsen Mohamad Mar'ei [1], Mohamad Elsadek Attia [1], Ahmed Mahmoud Salama Shaaban[1]*, Shamel Ali Elgawhary [1]

[1]Department of Orthopedic, Surgery, Faculty of Medicine, Zagazig University, Egypt

Corresponding author
Ahmed Mahmoud Salama Shaaban

Email:
ahmedsaalamaa@gmail.com

Submit Date 05-09-2024
Revise Date 24-12-2024
Accept Date 25-12-2024

ABSTRACT

Background: Displaced intra-articular calcaneal fractures can cause angular deformity, chronic foot discomfort, and reduced hind foot motion. This study aimed to assess the functional outcome of the distraction subtalar arthrodesis in the management of late complications of displaced intra-articular calcaneal fractures. **Methods:** This prospective interventional cohort study was conducted on 24 patients diagnosed with subtalar arthritis after malunited calcaneal fracture, 20 patients (83.7%) were treated conservatively and 4 patients (16.7%) were treated surgically. The scoring system was based on the hind foot score of the American Orthopedic Foot and Ankle Society (AOFAS). Preoperative Radiological examination (X-ray and CT) was done for both affected and normal foot and ankle. **Results:** Associated injuries were encountered in 6 patients (12.5%). Two had burst fractures of the first lumbar vertebrae that were managed by internal fixation. Another patient had a wedge fracture of the eleventh dorsal vertebrae which was treated conservatively and the other last was treated for internal hemorrhage due to a rupture of the spleen. After a mean period of follow-up of 2 years. The outcome of treatment was excellent in 8 patients (16.7%), good and accepted in 36 patients (75%), and it was poor in 4 patients (8.3%). The mean and range of the AOFAS score before and after correction was found that the mean AOFAS score highly significantly improved after operation, where it increased from 24.8(10-49) before to 73.9(58-90) after operation. **Conclusion:** Distraction subtalar arthrodesis is associated with a high incidence of full improvement in cases with malunited calcaneal fractures.

Keywords: Calcaneal malunion; Distraction subtalar arthrodesis; Calcaneal Fractures.

INTRODUCTION

A calcaneal fracture can significantly impair a patient's quality of life and cause lifelong disability. Angular deformity decreased hindfoot motion, and persistent foot pain are frequent consequences of displaced intra-articular calcaneal fractures **[1]**.

Isolated subtalar arthrodesis is currently regarded to be effective in treating hindfoot pathologies such as inflammatory arthritis, talocalcaneal coalition, posterior tibial tendon insufficiency, isolated subtalar joint instability, and post-traumatic arthritis **[2]**.

When treating either conservatively or surgically for late complications from calcaneal fractures, as well as when the talus had developed avascular necrosis,

subtalar bone block distraction arthrodesis was employed**[3]**.

Distraction reconstruction via subtalar joint arthrodesis with structural bone graft will not only normalize the biomechanics of the gastrocnemius-soleus complex but also restore the height of the calcaneus and the talus's normal inclination concerning the plantar aspect of the foot, relieving anterior impingement at the ankle joint and achieving subtalar fusion **[4]**.

Subtalar arthrodesis is the gold standard for managing subtalar joint osteoarthritis that is not improving with medication. A subtalar arthrodesis aims to restore a painless, plantigrade foot that allows normal weight bearing with the least amount of mobility constraints **[5]**.

According to comparative research, the results of triple arthrodesis or solo subtalar fusion appear to have a similar biomechanical impact on the calcaneocuboid and talonavicular joints**[6].**

The prognosis following displaced intra-articular calcaneal fractures is directly related to the abnormalities that remain. The degree of the fracture and the early course of treatment have a significant impact on the typical spectrum of deformities. The requirement for a secondary subtalar arthrodesis increases six times following conservative management because treatment fails more frequently following non-surgical than operative treatment**[7]**.

Aim of the study: The aim of this study assess the functional outcome of the distraction subtalar arthrodesis in the management of late complications of displaced intra-articular calcaneal fractures.

METHODS

This prospective interventional cohort studied 24 patients diagnosed with subtalar arthritis after a malunited calcaneal fracture. The cases were recruited from the Orthopedic Surgery Department of Zagazig University Hospitals during the period from January 2018 to January 2019. They were 20 male (83.3%) and 4 females (16.7%), the oldest was 58 with a mean of 40.9 years (SD=± 10.3), 20 patients (83.3%) were manual workers, 3 patients (12.5%) were housewives, and one patient (4.2%) was a student. In the current study, 20 patients (83.7%) were treated conservatively and 4 patients (16.7%) were treated surgically.

Sample size*:* Assuming that the attendance rate of malunited calcaneal fracture cases is 8 cases per month in ZUH the total number of cases in the study period (6 months) is 48 cases will be included as a comprehensive study.

Inclusion criteria were; both genders, age > 18 years, subtalar arthrosis secondary to calcaneal fracture, patients with considerable discomfort and impairment following unsuccessful conservative measures in an incongruent subtalar joint with lateral impingement or operative treatment. **Exclusion criteria were;** bilateral cases, young age < 18 years, Charcot deformity, and Refusal to participate in the study.

In the current study Preoperatively 40 patients (83.7%) were treated conservatively and 8 patients (16.7%) were treated surgically. Methods of fixation 14 (29.2%)fixed with One C-screw, 18 (37.5%) fixed with Two C-screws, 4 (8.3%) fixed with Triple C-screws using stables, and 12 (25%) fixed with Minimal invasive (no hardware).

All the included cases were subjected to the following:

History taking: Demographic data (Age, sex, occupation, Smoking). Previous condition analysis (Causes of the previous fracture, duration since the fracture, mode of treatment, and duration since treatment). Medical and surgical history.

Clinical examination: All notes were obtained and a scoring system, based on the hind foot score of the American orthopedic foot and ankle Society (AOFAS) was completed**[8].**

Radiological examination: Preoperative radiological examination was done for both affected and normal foot and ankle to demonstrate the degree of damage and subtalar arthritis caused by a malunited calcaneal fracture.

Pre-operative:

Clinical assessment was based on the history taking, and clinical examination the right side was fractured in 24 patients (50 %), one of them had also fractured talus, and the left side was fractured in 24 patients (50%), after gathering all of the notes, a scoring system based on the American Orthopedic Foot and Ankle Society's (AOFAS) hindfoot score was developed **[8].**

Only 8 patients (16.7%) patients had heel pain at rest, but it started and aggravated in all patients by standing and weight bearing or side stress on the heel either on the varus or valgus. 22 patients (45.8%) had moderate pain and they used to take the maximum dose of analgesics to walk. The other 26 patients (54.2%) had severe pain that caused limitation of standing and walking. Primary treatment; 40 patients (83.7%) were treated conservatively and 8 patients (16.7%) were treated surgically.

Surgery was performed within one year following injury in 18 patients (37.5%) and was done after a

period of more than one year in 30 patients (62.5%). The mean time to surgery was 14.3 months (8-26 months), (SD= ± 4.1).

Associated injuries were encountered in 6 patients (12.5%). One had a burst fracture of the first lumbar vertebrae that was managed by internal fixation. Another patient had a wedge fracture of the eleventh dorsal vertebrae which was treated conservatively and the other last was treated for internal hemorrhage due to a rupture of the spleen.

The preoperative radiological examination was done for both the affected and normal foot and ankle to demonstrate the degree of damage and subtalar arthritis caused by the malunited calcaneal fracture.

An axial view of the calcaneus was used to measure the degree of varus malalignment. Varus deformity was mild (>5 ° degrees) in 8 patients (33.3%), moderate (5-10 ° degrees) in 10 patients (41.7%), and severe (<10 ° degrees) in 6 patients (25%). Coronal and transverse CT examination was done to demonstrate the amount of joint incongruity, the degree of subtalar arthritis, and the amount of calcaneal broadening.

Operative technique:

All patients had either spinal or general anesthesia. They received a prophylactic antibiotic. A tourniquet was applied to the thigh. On a beanbag, the patient was positioned in the lateral decubitus posture. In front of the wounded extremity, the normal leg was down (Figure 1A). A full-thickness subperiosteal flap was elevated following a lateral extensile incision across the calcaneus (Figure 1B), with the vertical limb of the incision placed just posterior to the sural nerve and anterior to the Achilles tendon. All surrounding soft tissues were released from the calcaneus lateral wall as far distally as the calcaneocuboid articulation (Figure 1C). Any hardware from the cases of the previous fixation of recent fractures was removed. Resection of the lateral wall exostosis was done to decompress the area of impingement in the sub-fibular region by using a thin-bladed osteotomy saw and a thin osteotome. In order to prevent an osseous block to joint motion caused by the remnant lateral wall overhang, the exostectomy was carried out up to the level of the calcaneocuboid joint (Figure 1D). Particularly in cases with conservatively treated calcaneal fractures, the removed segment of the lateral wall was preserved and utilized to supplement autografting. It was ideal to use an osteotome to thoroughly remove any remaining cartilage and sclerotic subchondral bone from the talar and calcaneal joint surfaces. To promote vascular ingrowth, many perforations were made into the subchondral bone. To make these perforations, a 2.5 mm drill bit was used. A lamina spreader that was fully inflated within the posterior subtalar joint was used to assess the height of the heel that had been reached fluoroscopically in a lateral view. The restoration of the medial column and the talocalcaneal angle is indicated by the talar head's anatomical alignment with the navicular **[9]**, to confirm the position of the hindfoot, we additionally utilized the axial radiograph of the calcaneus. A cortical autograft from the ipsilateral iliac crest was cut (Figure 1E) to fit the defect's size after the defect's dimensions were measured. The graft was then placed and reinforced by the previously removed lateral wall fragment **(Figure 1F).** In 4 cases of severe varus malalignment of more than 10° degrees, to address this varus malalignment, a Dwyer lateral closure wedge osteotomy was carried out posterior to the posterior facet. In seven cases (29.2%), Fixation was achieved by using one 6.5mm cancellous screw **(Figure 1G)** and it was achieved by using two 6.5mm cancellous screws in 18 cases (37.5%) **(Figure 1H).** These cancellous screws were inserted perpendicular to the plane of the posterior facet, from the plantar posterior edge of the calcaneus into the talus, and transfixing the block graft. Fully or partially threaded cancellous screws or a combination of both were used according to the best stability obtained together with the addition of the washer to prevent the sinking of the screw head in the osteoporotic bone and to add some compression. In 4 cases (8.3%), arthrodesis was done using stables for fixation **(Figure 1J).** In 12 cases (25%), arthrodesis was stable during surgery and we did not need any hardware for fixation, and the fixation was done only by the “no hardware” minimally invasive technique using only an external cast **(Figure 1K).**

To ensure proper screw placement without compromising the ankle or talonavicular joints and to ensure adequate hindfoot alignment, fluoroscopic mortise pictures of the ankle and an axial radiograph of the calcaneus were taken. On the lateral view, the heel height that had been attained was verified. The wound healed in strata. In 36 cases (75%) a suction drain was kept in place for two days. The leg was raised and a cast was placed below the knee. On the first day, patients were mobilized using crutches and started on isometric exercises.

Follow up:

After 3 to 4 weeks, the sutures were removed. At the time of suture removal, the cast was changed and for seven to ten weeks, the patients were permitted to

walk while partially bearing weight. After this period, the K-wire in cases of triple arthrodesis was removed without anesthesia and later on, patients were examined every two weeks until union was achieved. The clinical follow-up included scar, swelling, the ability to walk, the capacity to carry out routine tasks, the hindfoot's posture, and sural nerve complaints. The functional outcomes were assessed using the AOFAS ankle hindfoot score. Weight-bearing anteroposterior and lateral radiographs of the ankle and foot, as well as an axial radiograph of the calcaneus were used to evaluate the patients radiologically. Measurements for the talocalcaneal height (TCH), calcaneal pitch angle (CPA), talocalcaneal angle (TCA), and talar declination angle (TDA) were included in the radiographic assessment. The rate of union and any arthritic changes were also included in the radiographic assessment. The unaffected side on the other side was compared to the radiographic follow-up.

Ethical approval:

All participants provided written informed permission, and the research ethics committee of Zagazig University's Faculty of Medicine authorized the study (ZU-IRB #4794-4-9-2018). The work has been completed in compliance with the Declaration of Helsinki, the World Medical Association's code of ethics for human subjects research.

Statistical Analysis

Version 27 of IBM SPSS (Statistical Package for Social Science) was used to code, process, and analyze the data (Chicago, USA). The test statistics' P-values represented the level of significance at which the null hypothesis, or the hypothesis that there is no difference, was rejected. This threshold was set at 0.05, meaning that P-values greater than 0.05 are deemed statistically non-significant, P-values less than 0.05 are considered significant, and P-values less than 0.01 are highly significant.

RESULTS

Table 1 shows the results of treatment for 48 heels with malunited calcaneal fractures and subtalar arthritis treated with subtalar distraction arthrodesis based on the American Orthopaedic Foot and Ankle Society scaling system and after an average follow-up time of 2 years (6–24 months). The results were excellent in 8 patients (16.7%), good and accepted in 36 patients (75%), and poor in 4 patients (8.3%) (the AOFAS score was below 60).

Table (2) shows the mean and range of the AOFAS score before and after correction and it was found that the mean AOFAS score highly significantly improved after operation, where it increased from 24.8 (10-49) before to 73.9 (58-90) after operation.

Clinically

Table 3; shows that 36 patients (75%) were free of pain, 8 patients (16.7%) had mild to moderate pain that needed an analgesic to walk and 4 patients (8.3%) had severe pain that caused limitations in walking. The mean and range of pain before and after correction was found that the mean pain significantly improved after the operation, where it increased from 7.3 (3-20) before to 28.87 (20-38) after the operation. 30 patients (62.5%) returned to their previous work within a mean period of 6 months, 8 (16.7%) patients returned to the same work with restriction after a mean period of nine months, 6 patients (12.5%) had changed their job to less active one and 4 patients (8.3%) remained unable to work. When compared to the unaffected side, ankle dorsiflexion improved, going from a mean of 5° (0–25) to a mean of 12° (4–30) which was about 21° (18-28), while plantar flexion decreased from a mean of 35° (7-45) to a mean of 31 (10-38) compared with the unaffected side which was about 48° (45-56).

Table (3) shows the mean and range of function before and after correction and it was found that the mean function highly significantly improved after operation, where it increased from 15.4 (10-29) before to 36.8 (23-44) after operation.

Shoe size; 4 patients (8.3%) continued to wear abnormally wide shoes as they did preoperatively due to under-correction of varus deformity and heel width, while the remaining 44 patients were able to wear normal shoes.

Table (3) shows the mean and range of aspects before and after correction and it was found that the mean aspect highly significantly improved after operation, where it increased from 2.2 (0-5) before to 7.5 (5-10) after operation.

Radiological results:

The union was achieved in all patients with an average of 14 weeks with an average delay of about 3 weeks in 10 smokers compared with nonsmokers.

Table (4) shows the mean and range of TCA before and after correction and it was found that restoration of more than 90% of the talocalcaneal angle was highly significantly achieved, where it increased from 25.5° (20-29.8) before to 28.5° (24.5-32.1) after operation.

Table (4) shows the mean and range of TDA before and after correction and it was found that restoration of more than 90% of the talus declination angle was highly significantly achieved, where it increased

from 12.7° (10-15.6) before to 16.1° (13.5-20.2) after operation.

Table (4) shows the mean and range of CPA before and after correction and it was found that restoration of more than 90% of the calcaneal pitch angle was highly significantly achieved, where it increased from 16.4° (13.5-20.9) before to 17.8° (14.5-21.3) after the operation.

Table (4) shows the mean and range of TCH before and after correction and it was found that restoration of more than 90% of the talocalcaneal height was highly significantly achieved, where it increased from 71mm (60-78.2) before to 79.8mm (75-89) after operation.

Table 5; Shows that Prominent hardware required removal in 2 cases. Delayed wound healing was noted in 6 cases, superficial infection occurred in 2 cases and was treated by oral antibiotics and repeated wound dressings and deep infection was noted in one case that was treated by antibiotics administered intravenously together with irrigation and debridement. Varus malalignment of more than 5º relative to the anatomical alignment was observed in 4 cases, two of them improved with orthotic treatment and shoe modifications and the other was still symptomatic. Sural nerve injury was noted in 4 cases, 2 of them were detected preoperatively and the other complicated the procedure of distraction arthrodesis, and the two cases were treated conservatively. Prolonged edema of the heel and distal leg was observed in 3 cases postoperatively, these included two cases of infection and one case with varicose veins in the leg. They were treated by medical treatment and elevation of the leg with interrupted periods of active walking. Mild arthritic changes in the ankle were noted in 4 patients and moderate arthritic changes were seen in the calcaneocuboid joint in one case and the talonavicular joint in one case.

Table (1): Overall results

Final results	**Frequency**
Excellent	8 (16.7%)
Good and accepted	36 (75%)
Unsatisfactory	4 (8.3)
Total	48 (100%)

Table (2): Changes in AOFAS score before and after correction

AOFAS score	**Mean ± SD (range)**	**p**
Pre	24.8 ± 9 (10-49)	< 0.001 (HS)
Post	73.9 ± 8.9 (58-90)	

Table (3): Changes in pain, function, and aspect before and after correction.

Postoperative pain	**No**	**%**
Free of pain	36	75
Mild to moderate pain	8	16.7
severe pain	4	8.3
	Mean ± SD (range)	**P**
Pain		
Pre	7.3 ± 4.1 (3-20)	< 0.001 (HS)
Post	28.87 ± 5.8 (20-38)	
Function		
Pre	15.4 ± 4.3 (10-29)	< 0.001 (HS)
Post	36.8 ± 5.1 (23-44)	

Aspect		
Pre	2.2 ± 0.96 (0-5)	< 0.001 (HS)
Post	7.5 ± 1.2 (5-10)	

Table (4): Changes in the talocalcaneal, talar declination, and calcaneal pitch angle (TCA) measurements before and after correction.

	Mean ± SD (range)	P
Talocalcaneal angle (TCA)		
Pre	25.5° ± 3.1 (20-29.8)	
Post	28.5° ± 3 (24.5-32.1)	< 0.001 (HS)
Unaffected side	29.4° ± 2.9 (24.5-3.59)	< 0.001 (HS)
Talar declination angle (TDA)		
Pre	12.7° ± 1.6 (10-15.6)	
Post	16.1° ± 1.6 (13.5-20.2)	< 0.001 (HS)
Unaffected side	19.7° ± 1.7 (16.8-23.5)	< 0.001 (HS)
Calcaneal pitch angle (CPA)		
Pre	16.4° ± 2.2 (13.5-20.9)	
Post	17.8° ± 2.1 (14.5-21.3)	< 0.001 (HS)
Unaffected side	21.9° ± 2.7 (17.5-26.5)	< 0.001 (HS)
Talocalcaneal height (TCH)		
Pre	71mm ± 4.5 (60-78.2)	
Post	79.8mm ± 3.9 (75-89)	< 0.001 (HS)
Unaffected side	83mm ± 3 (80-89)	< 0.001 (HS)

Table (5): Complications in the studied cases

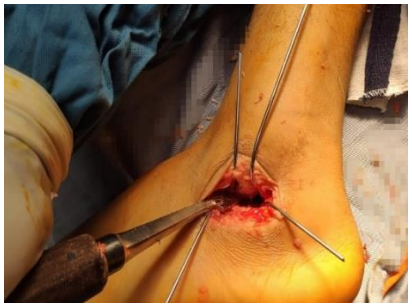
	No	%
Prominent hardware that needs removal	2	4.2
Delayed wound healing	3	12.5
Superficial infection	2	4.2
Deep infection	2	4.2
Varus malalignment	4	8.3
Sural nerve injury	4	8.3
Pre	2	50

	No	%
Post	2	50
Prolonged edema	6	12.5
Infection	4	66.7
Varicose vein	2	33.3

1A

1B

1C



1D

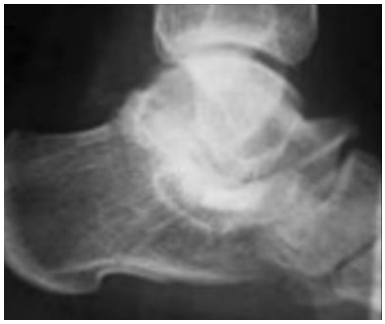
1E

1F

1G

1H

1J



1K

Figure 1: 1A; lateral positioning of the patient. **1B);** lateral extensile incision over the calcaneus.

1C: Raising of subperiosteal flap. **1D:** Resection of the lateral wall exostosis. **1E:** Iliac crest graft. **1F:** Insertion of the grft. **1G:**:Fixation by one cancellous screw.**1H:** Fixation by two cancellous screws. **1J** : Fixation by stables. **1K:** Minimally invasive technique of arthrodesis.

DISCUSSION

It can be difficult to treat displaced intra-articular calcaneal fractures and achieve an adequate reduction and internal fixation for the best possible outcome. Subtalar arthritis, heel broadening, loss of hindfoot height, and hindfoot malalignment (varus/valgus deformity) are the results of inadequate reduction, mismanagement, or conservatively handled displaced calcaneal fracture**[10].**

Arthrodesis across the joint has proven to be a viable treatment for painful subtalar arthritis arising from the incongruous joint caused by malunited intra-articular calcaneal fractures**[11]. Joveniaux et al. [12]** believed that isolated subtalar arthrodesis was a successful treatment for hindfoot pathology.

Displaced intra-articular fractures of the calcaneum when treated conservatively or reduced inadequately may cause serious malalignment of the hindfoot. The most common problems include painful subtalar arthritis, loss of calcaneal height with subsequent tibiotalar impingement and flattening of the longitudinal arch, increased calcaneal width causing fibula-calcaneal abutment and impingement of the peroneal tendons, as well as axial malalignment of the hindfoot.1-5 Subtalar arthrodesis eliminates the pain that occurs as a result of residual movement with severe joint incongruity **[13]**.

This prospective interventional cohort studied 24 patients diagnosed with subtalar arthritis after a malunited calcaneal fracture. The cases were recruited from the Orthopedic Surgery Department of Zagazig University Hospitals during the period from January 2018 to January 2019 to assess the functional outcome of the distraction subtalar arthrodesis in the management of late complications of displaced intra-articular calcaneal fractures.

In the current study preoperatively patients were treated conservative preoperatively 40 patients (83.7%) were treated conservatively and 8 patients (16.7%) were treated surgically.

Two short-term studies suggest that following conservative treatment for calcaneal fractures, the frequency of subtalar arthritis varies from 27% to 54% **[14, 15]** and 91% in a 15-year study**[16]**.

While it can also occur following internal fixation and open reduction, malunion typically happens following conservative treatment for calcaneal fractures**[17, 18]**. Under the general phrase "calcaneal malunion," conditions such as subtalar joint incongruity, included are subfibular impingement, arch collapse, and hindfoot malalignment**[19, 20]**.

The extensile posterolateral approach to the calcaneus was used in each case. This technique allowed for the complete removal of the lateral wall expansion over its whole length and revealed the peroneal tendons. It also allowed the removal of implants in four cases of surgically treated calcaneal fracture, easy exposure, and arthrodesis of the subtalar joint in all cases and also the midtarsal joint in the two cases of triple fusion, it also allowed for the performance of a Dwyer lateral wedge osteotomy in 4 cases of severe varus malalignment. This approach also allowed safe and stable fixation of the subtalar joint from the plantar aspect of the heel.

In 12 cases (25%), the minimally invasive "no hardware" approach was applied in this investigation. The use of a minimally invasive "no hardware" surgical method allowed for rapid weight bearing, assisted in correcting the hindfoot deformity, and helped prevent hardware problems (lowered the chance of infection and hardware prominence). The AOFAS scores significantly improved as a result. Eid et al. reported a union rate of 94% and a considerable improvement in the AOFAS scores using the same fixing procedure in all of their patients **[21]**.

The American Orthopedic Foot and Ankle Society scaling system was used as the assessment criteria in the current study to determine the treatment result for 48 heels with malunited calcaneal fractures and subtalar arthritis after an average follow-up period of **2 years (6–24 months)** by subtalar distraction arthrodesis was excellent in 8 patients (16.7%) (the AOFAS score was above 80), good and accepted in 36 patients (75%) (the AOFAS score was from 60 to 80), and it was poor in 4 patients (8.3%) (the AOFAS score was below 60).

This agreed with Sundararajan et al. It had 36 patients, divided into two groups, who presented with excruciating subtalar joint arthritis. There were 22 patients in situ group I and 14 in distraction group II. They showed that the distraction group showed 100% union **[10]**.

Schepers' comprehensive evaluation revealed a 4% nonunion incidence with 456 patients from 21 trials considered**[22]**.

Easley et al. reported 109 cases of subtalar joint arthrodesis resulting from calcaneal malunions, including both bone block distraction and in situ arthrodesis, with an overall union rate of 88% **[23].**

In research by Catanzariti and colleagues, 10% of primary subtalar joint arthrodesis cases had nonunion**[24].**

Clare et al. reported good results after 40 patients (45 feet) underwent subtalar arthrodesis with autologous bone graft injected from the calcaneus lateral wall, with a 93.5% union rate**[9].**

Ziegler et al. discovered that 23.8% of primary subtalar joint arthrodesis patients did not heal. This procedure is used to treat posttraumatic arthritis. This nonunion rate was not different from the revision subtalar joint arthrodesis nonunion rate, which was 23.6%. They discovered that even with no bone block added, the nonunion rate remained at 12% when all risk factors were eliminated**[25]**.

Distraction arthrodesis has been associated with a higher rate of non-union and malunion, according to early studies**[26]**.

In the current study, the mean and range of the AOFAS score before and after correction was found that the mean AOFAS score highly significantly improved after operation, where it increased from 24.8 (10-49) before to 73.9 (58-90) after operation.

This agreed with **Henning et al. [27],** where they assessed 12 cases of subtalar arthrodesis, six of which had autografts and six of which had freeze-dried bovine xenografts. Following an average follow-up of 58 weeks, the patients had a clinical assessment using the visual analog scale (VAS) and the AOFAS scale for pain as well as the final radiographic parameter measurement. They showed that the average AOFAS score improved from an average of 37 points preoperatively to 64 points postoperatively ($p = 0.02$), and the mean VAS score increased from 4.7 to 1.9 ($p = 0.028$). The xenograft group's AOFAS score increased from 38 to 74 points ($p = 0.02$); their VAS improved from 5.5 to 2.7 ($p = 0.046$).

From March 2006 to December 2017, **Woo et al.** looked at 51 people in 57 consecutive incidences of calcaneal malunion. For an average of 22.8 months, all patients were monitored. Every case was handled by SDA. The average AOFAS scores at 3, 6, and 12 months after surgery showed a statistically significant improvement over the preoperative value, according to the data**[28]**.

From a preoperative average of 20 to 40 points to an average of 69 to 75 points after surgery, the improvement in AOFAS scores varies from 32 to 50 points. These values are in line with what has been published in the literature **[29]**.

All radiological parameters, including the talocalcaneal angle (TCA), talar declination angle (TDA), calcaneal pitch angle (CPA), and talocalcaneal height, increased significantly and statistically in the current study (TCH) postoperative as compared to the preoperative measurements.

This came in accordance with Sundararajan et al. They demonstrated that in the patients who received distraction subtalar arthrodesis when comparing the postoperative measurements of the calcaneal height, talar declination angle, lateral talocalcaneal angle, and calcaneal pitch to the preoperative data, there was a statistically significant increase **[10]**.

A statistically significant improvement in talocalcaneal height was observed from pre to postoperative values with a persisting statistically significant difference ($p = 0.04$) when subtalar arthrodesis was done on the cases in **Henning et al. [27]**.

The average time until union, according to a **Wang et al.** analysis, was 12.2 ± 1.11 weeks. The ankle and hindfoot score of 86.3 ± 4.45 ($t = 27.64$, $P < 0.0001$, paired t-test) on the American Orthopedic Foot and Ankle (AOFAS) evaluation was significantly higher than the preoperative assessment. Significant improvements in the talocalcaneal height (65.15–72.68 mm) and Calcaneus-talus angle (from 34.46° to 39.7°) were observed in the postoperative radiographic assessment results, and Böhler's angle (25.4° to 86.3°)**[30]**.

In the same setting, **Bai et al.** showed that the patients' radiographic parameters the Böhler angle, pitch angle, calcaneal width, talocalcaneal height, and hindfoot alignment angle were significantly better at the last follow-up than they were at the pre-op. Additionally, the patients showed no signs of contracture of the triceps surae muscle, peroneal tendinitis, anterior ankle impingement, or other problems **[31]**.

In the current study, complications included prominent hardware required removal in one case. Delayed wound healing was noted in 6 cases, superficial infection occurred in one case, deep infection was noted in one case, Varus malalignment of more than 5º relative to the anatomical alignment was observed in 4 cases, one of them improved with orthotic treatment, and shoe modifications and the other still symptomatic. Sural nerve injury was noted

in 4 cases. Prolonged edema of the heel and distal leg was observed in 6 cases postoperatively. Mild arthritic changes in the ankle were noted in 4 patients and moderate arthritic changes were seen in the calcaneocuboid joint in 2 cases.

The total incidence of problems was 38% (106/278), according to **Thompson and Roukis** meta-analysis, even though complications are recorded for all treatments rather than per patient because many patients may have had many difficulties. Because of this, for every 2.6 bone block distraction subtalar arthrodesis treatments performed for calcaneal malunion, there is one complication. Minor and significant soft tissue or bone issues were the types of complications. Mild soft tissue issues accounted for 45 cases (16.2%) and mild bone difficulties for 37 cases (13.3%). It was determined that transient paresthesia and superficial soft tissue infections that did not require surgery were examples of minor soft tissue problems. One of the minor bone problems was lateral calcaneal wall exostosis, which required hardware removal and modification or excision of the shoe gear. Six (2.2%) significant soft tissue issues and eighteen (6.5%) major bone complications were reported as serious complications for all 278 surgeries**[32]**.

Schepers' systematic study found that out of the 278 procedures covered, 106 total problems occurred, representing a 38% incidence rate. Of those, 24 were classified as serious complications and the remaining 82 as minor**[22]**.

Limitations

The sample size was small, and the study was carried out at a single center, so the results' generalizability was addressed

.

CONCLUSIONS

Concluded that; Distraction subtalar arthrodesis is associated with a high incidence of full improvement in the cases with malunited calcaneal fractures.

Conflicts of Interest

The authors report no conflicts of interest.

Funding Information

None declared

REFERENCES

1- Radnay CS, Clare MP, Sanders RW. Subtalar Fusion After Displaced Intra-Articular Calcaneal Fractures: Does Initial Operative Treatment Matter?: Surg Technique. JBJS. 2010 Mar 1;92(Supplement-1-Part-1):32-43.

2- Davies MB, Rosenfeld PF, Stavrou P, Saxby TS. A comprehensive review of subtalar arthrodesis. Foot Ankle Int. 2007 Mar;28(3):295-7.

3- DeOrio JK, Leaseburg JT, Shapiro SA. Subtalar distraction arthrodesis through a posterior approach. Foot Ankle Int. 2008 Dec;29(12):1189-94.

4- Thordarson DB. Fusion in posttraumatic foot and ankle reconstruction. JAAOS- J Am Acad Orthop Surg. 2004 Sep 1;12(5):322-33.

5- Nihal A, Gellman RE, Embil JM, Trepman E. Ankle arthrodesis. Foot Ankle Surg. 2008 Jan 1;14(1):1-0.

6- Schepers T, Kieboom BC, Bessems GH, Vogels LM, van Lieshout EM, Patka P. Subtalar versus triple arthrodesis after intra-articular calcaneal fractures. Strategies Trauma Limb Reconstr. 2010 Aug;5:97-103.

7- Csizy M, Buckley R, Tough S, Leighton R, Smith J, McCormack R, et al. Displaced intra-articular calcaneal fractures: variables predicting late subtalar fusion. J Orthop Trauma. 2003 Feb 1;17(2):106-12.

8- Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot ankle int. 1994 Jul;15(7):349-53.

9- Clare MP, Lee III WE, Sanders RW. Intermediate to long-term results of a treatment protocol for calcaneal fracture malunions. JBJS. 2005 May 1;87(5): 963-73.

10- Sundararajan SR, Ramakanth R, Shreeram V, Joseph JB, Rajasekaran S. Is distraction bone block Arthrodesis better than subtalar arthrodesis for malunited calcaneal fractures with subtalar arthritis? A retrospective case series. J Foot Ankle Surg. (Asia Pacific). 2021 Mar 8;8(1):3-7.

11- Chaudhari, N., Godoy-Santos, A. L., Netto, C. d. C., Rodriguez, R., Dun, S., He, J. K., et al. (2020). Biomechanical comparison of plantar-to-dorsal and dorsal-to-plantar screw fixation strength for subtalar arthrodesis. *Einstein (São Paulo)*, *18*.

12- Joveniaux, P., Harisboure, A., Ohl, X. and Dehoux, E. (2010). Long-term results of in situ subtalar arthrodesis. *International Orthopaedics*, *34*, 1199-1205.

13- Rammelt S, Grass R, Zawadski T, Biewener A, Zwipp H. Foot function after subtalar distraction bone-block arthrodesis. A prospective study. J Bone Joint Surg Br. 2004;86(5):659-68.

14- Nouraei MH, Moosa FM. Operative compared to non-operative treatment of displaced intra-articular calcaneal fractures. Journal of Research in Medical Sciences: J Offic Isfahan Med Sci. 2011 Aug;16(8):1014.

15- Ågren PH, Wretenberg P, Sayed-Noor AS. Operative versus nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial. JBJS. 2013 Aug 7;95(15):1351-7.

16- Ibrahim T, Rowsell M, Rennie W, Brown AR, Taylor GJ, Gregg PJ. Displaced intra-articular calcaneal fractures: 15-year follow-up of a randomized controlled trial of conservative versus operative treatment. Injury. 2007 Jul 1;38(7):848-55.

17- Flemister AS, Infante AF, Sanders RW, Walling AK. Subtalar arthrodesis for complications of intra-articular calcaneal fractures. Foot ankle int. 2000 May; 21(5): 392-9.

18- **Rammelt S, Grass R, Zawadski T, Biewener A, Zwipp H.** Foot function after subtalar distraction bone-block arthrodesis: a prospective study. J Bone Joint Surg British Vol . 2004 Jul 1;86(5):659-68.

19- Guerado E, Bertrand ML, Cano JR. Management of calcaneal fractures: what have we learned over the years? Injury. 2012 Oct 1;43(10):1640-50.

20- De Boer AS, Van Lieshout EM, Den Hartog D, Weerts B, Verhofstad MH, Schepers T. Functional outcome and patient satisfaction after displaced intra-articular calcaneal fractures: a comparison among open, percutaneous, and nonoperative treatment. J Foot Ankle Surg. 2015 May 1;54(3):298-305.

21- Eid MA, El-Soud MA, Mahran MA, El-Hussieni TF. Minimally invasive, no hardware subtalar arthrodesis with autogenous posterior iliac bone graft. Strategies Trauma Limb Reconstr. 2010 Apr;5:39-45.

22- Schepers T. The subtalar distraction bone block arthrodesis following the late complications of calcaneal fractures: a systematic review. *Foot*. 2013; *23*(1), 39-44.

23- Easley ME, Trnka HJ, Schon LC, Myerson MS. Isolated subtalar arthrodesis. JBJS. 2000 May 1;82(5):613.

24- Catanzariti AR, Mendicino RW, Saltrick KR, Orsini RC, Dombek MF, Lamm BM. Subtalar joint arthrodesis. J Am Podiatr Med Assoc. 2005 Jan 1; 95(1):34-41..

25- Ziegler P, Friederichs J, Hungerer S. Fusion of the subtalar joint for post-traumatic arthrosis: a study of functional outcomes and non-unions. Int Orthop. 2017 Jul;41:1387-93.

26- Trnka HJ, Easley ME, Lam PC, Anderson CD, Schon LC, Myerson MS. Subtalar distraction bone block arthrodesis. J Bone Joint Surg British Vol. 2001 Aug 1;83(6):849-54.

27- Henning C, Poglia G, Leie MA, Galia CR. Comparative study of subtalar arthrodesis after calcaneal fracture malunion with autologous bone graft or freeze-dried xenograft. J Exp Orthop. 2015 Dec;2:1-9.

28- Woo SH, Goh TS, Ahn TY, You JS, Bae SY, Chung HJ. Subtalar distraction arthrodesis for calcaneal malunion-comparison of structural freeze-dried versus autologous iliac bone graft. Injury. 2021 Apr 1;52(4):1048-53.

29- Garras DN, Santangelo JR, Wang DW, Easley ME. Subtalar distraction arthrodesis using interposition frozen structural allograft. Foot ankle int. 2008 Jun;29(6):561-7.

30- Wang B, Guan X, Hu Y, Jiang G, Lin Q, Ye J, Xiang D, Yu B. Multiple Reconstructive Osteotomy Treating Malunited Calcaneal Fractures Without Subtalar Joint Fusion. Orthop Surg. 2023 Mar;15(3):810-8.

31- Bai W, Zhu Y, Xu J, Liang J, Lu J. Y-shape osteotomy combined with subtalar arthrodesis for calcaneus malunion: a retrospective study. J Orthop Surg Res. 2022 Dec 7;17(1):526.

32- Thompson MJ, Roukis TS. Management of Calcaneal Fracture Malunion with Bone Block Distraction Arthrodesis: A Systematic Review and Meta-Analysis. Clin Podiatr Med Surg. 2018 Dec 14;36(2):307-21.

Citation

Mar'ei, M., Attia, M., Salama Shaaban, A., Elgawhary, S. Distraction Subtalar Arthrodesis after Malunited Calcaneal Fractures. *Zagazig University Medical Journal*, 2025; (575-585): -. doi: 10.21608/zumj.2024.318548.3564