

# Calcaneal Fractures: Descriptive Study of Therapeutic Variability with a Case Series

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## Introduction

Calcaneal fractures represent 1-2% of all fractures and 60% of all tarsal bone fractures. Most of them are intraarticular (75%), and a significant percentage of cases are associated with other types of lesions, particularly lumbar spinal lesions or lesions in the ipsilateral lower limb [1,2].

They generally affect young people, between 20 and 45 years old, and they are more common in men. Many of them are occupational, with a significant socioeconomic impact [3].

Many authors have established classifications for these lesions, and the most widely used proposals nowadays are the Essex-Lopresti classification, which is based on conventional radiography, and the Sanders classification, based on CT images [4].

Within the proposed treatments based on the type of underlying lesion, there are endless variations that range from closed reduction such as the famous Omoto technique [5] to percutaneous reductions such as the Essex-Lopresti procedure [2], to open reduction, with the extended L-shaped lateral approach incision as the gold standard. Currently, there is an increase in the popularity of minimally invasive approaches [6,7] and newer techniques, such as calcaneoplasty with balloon kyphoplasty.

There are many complications that may be derived from this type of fractures, with a severe impact on the biomechanics of the foot, which can affect both the support and walking of patients and generate chronic residual pain. There is a possibility of developing compartmental syndrome, sympathetic dystrophy, or dermal lesions as non-surgical complications, as well as infections, scarring disorders, and nerve-vascular lesions, from a surgical perspective.

In the long term, the literature describes pseudoarthrosis, subtalar and calcaneocuboid arthritis, heel pain, peroneal tendinopathy, complaints associated with osteosynthesis material, and malunion or abnormal consolidation, among others [8-11].

Since ancient times, calcaneal fractures have been considered complex and disabling lesions that are associated with permanent secondary effects. This has led to the intense study of different therapeutic techniques in the search for the best solution, but a clear consensus on the optimal treatment has not yet been established. What is now clear is the therapeutic goal, which is reestablishing the bone architecture, restoring the Böhler angle and the subtalar joint, and therefore repairing the biomechanics of the rearfoot and the gastroc-soleus complex [5].

## Objectives

The main goal of this study is to reveal the complexities behind calcaneal fractures. We present a literature review and a descriptive analysis of a case series treated in our center. We want to summarize the reported evidence on the treatment of calcaneal fractures, to put forward some recommendations based on our experience, and to modify our working protocols.

## Material and Methods

### Cases 1 and 2: Conservative treatment

\*A 69-year-old patient presents torsion of the left foot while walking, and a 77-year-old patient presents direct trauma to the left foot after falling down the stairs.

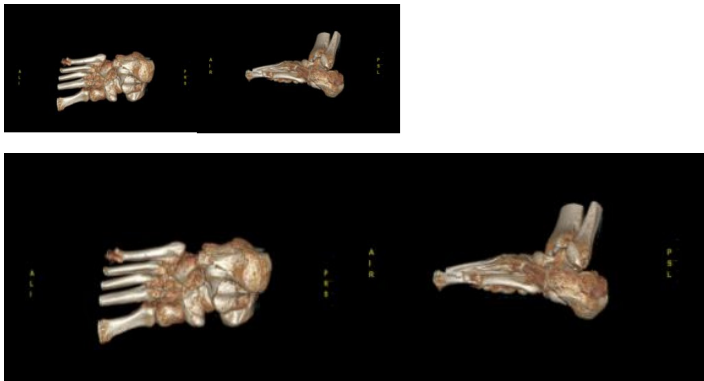
The first patient presents a calcaneal fracture with multiple patterns and associated horizontal collapse that causes incongruity of the posterior subtalar joint, vertical fracture that reaches the

anterior region of the middle subtalar joint, subluxation of the calcaneocuboid joint and fracture of the inferolateral edge of the talus. The patient was admitted for the management of pain and soft-tissue problems, and she was discharged after 24 hours with good pain control and a short leg cast.

**Figure 1:** PA and lateral X-ray of patient no. 1 at diagnosis.



**Figure 2:** Coronal and sagittal sections, and CT reconstruction of patient no. 1.



Patient number 2 presented a tongue-type calcaneal fracture associated with collapse of the Böhler angle by approximately 5 degrees, and lateral malleolus fracture without displacement. In view of the significant involvement of soft tissue, the patient was admitted, and orthopedic treatment was applied. The patient was discharged 4 days later with a short leg cast.

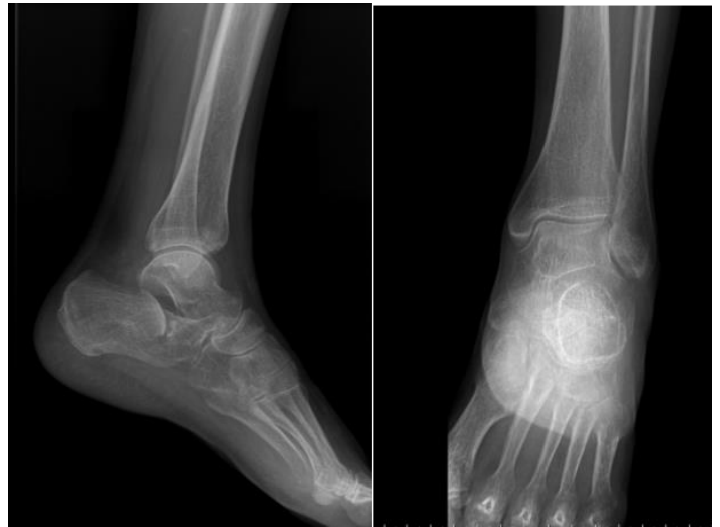
**Figure 3:** Lateral X-ray at diagnosis, and lateral and PA X-ray during the first follow-up session of patient no. 2.



### Cases 3 and 4: Treatment with open reduction and internal fixation with plate osteosynthesis

A 59-year-old patient fell from approximately 1 meter, with direct trauma to the left foot and calcaneal Sanders IIC fracture in two fragments. A surgical approach was decided with open reduction with lateral approach and plate osteosynthesis of the calcaneal fracture, associated with bone allograft substitute. The patient was discharged 3 days after surgery with good control of pain and of soft-tissue problems.

**Figure 4:** PA and lateral X-ray of patient no. 3 at diagnosis.



**Figure 5:** Images of CT sections of patient no. 3 at diagnosis.



**Figure 6:** Two X-ray views of post-surgery control in patient no. 3.



**Figure 7:** Follow-up lateral X-ray after plate osteosynthesis removal in patient no. 3.



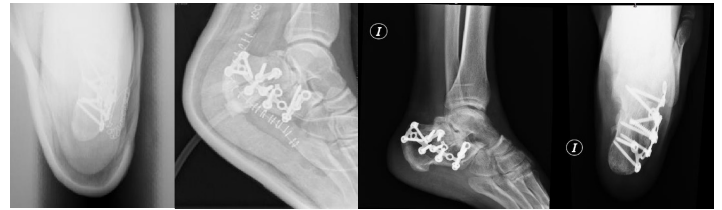
Patient no. 4 is a 44-year-old man who fell from his own height and suffered a left-foot Sanders type IV comminuted intra-articular calcaneal fracture.

**Figure 8:** Two X-ray views next to an axial, coronal, and sagittal section of the calcaneal fracture of patient no. 4 at diagnosis.



The patient underwent surgery with open reduction and internal fixation with plate osteosynthesis of the calcaneal fracture with the same approach as in the previous patient. He showed a good evolution and was discharged 48 hours after the operation without complications.

**Figure 9:** PA and lateral X-rays in the follow-up after surgery and 4 months after the intervention in patient no. 4.



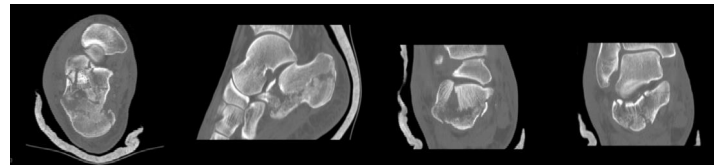
**Case 5: Orthopedic and surgical approach in the same patient**

The patient is a 42-year-old man who fell from a ladder, from approximately 3 meters, with trauma to both feet, a Sanders type II calcaneal fracture in the right foot, and a fracture without displacement and with preserved Böhler angle in the left foot. An orthopedic approach was decided for the left foot and surgery for the right foot, with open reduction and internal fixation with plate osteosynthesis with a lateral approach.

**Figure 10:** X-rays of both calcaneal fractures on admission of patient no. 5.



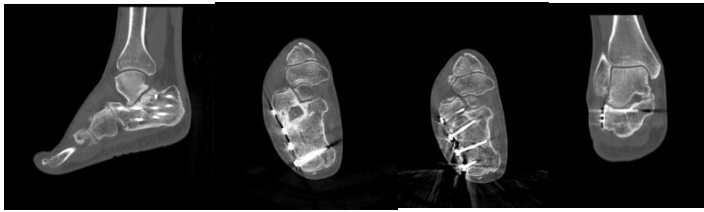
**Figure 11:** Different CT sections of the right calcaneal bone of patient no. 5.



**Figure 12:** Two X-ray views in the follow-up after surgery of the left foot and after 3 weeks of bilateral evolution of patient no. 5.



**Figure 13:** CT sections of the operated lower limb 6 months after the lesion of patient no. 5.



**Figure 14:** Two bilateral follow-up X-ray views 7 months after the lesion of patient no. 5.



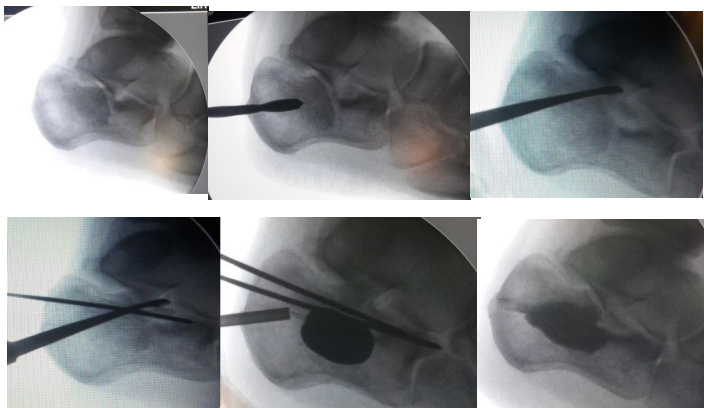
**Cases 6 and 7: Treatment with innovative techniques/ calcaneoplasty with balloon kyphoplasty**

The patients are 61 years old and 50 years old, respectively. They had both fell from ladders at work and suffered trauma to the right calcaneus with a mechanism of axial compression. They were diagnosed with calcaneal fracture Sander’s type IV and IIIIB, respectively.

In their personal history, both patients had insulin-dependent diabetes mellitus, which was difficult to manage in the first case.

The treatment in both cases was closed reduction with the Essex-Lopresti procedure under spinal anesthesia associated with cement calcaneoplasty with balloon kyphoplasty, using the same approach.

**Figure 15:** Surgical technique, “calcaneoplasty with balloon”.



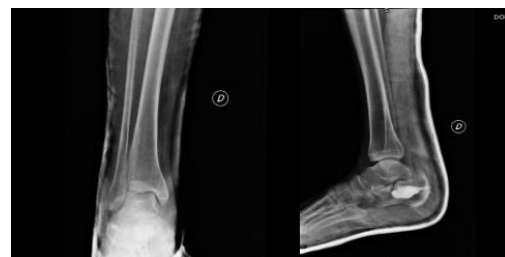
**Figure 16:** Images of the evolution of patient no. 6.



**Figure 17:** X-ray and CT on admission of patient no. 7.



**Figure 18:** Follow-up after surgery of patient no. 7.



**Figure 19:** Follow-up 15 days after calcaneoplasty of patient no. 7.





**Figure 20:** Follow-up 6 months after surgery of patient no. 7.

## Results

We assessed the patients at the beginning and at the end of the rehabilitation treatment, as well as periodically during their evolution, with an average follow-up period of 2 years, through goniometry (normal range of motion for plantar flexion was 0-50°, and 0-20° for dorsiflexion), Medical Research Council (MRC) scale, subjective assessment with visual analog scale (VAS) for pain and clinical global impression (CGI) scale, with the following results:

	VAS	MRC	Plantar Flexion	Dorsiflexion	CGI	Complications
CASE 1	7-3-2	5	30-50	5-20	3	No
CASE 2	6-3-1	5	30-50	10-20	2	No
CASE 3	8-3-2	4+	5-30	5-20	3	Dehiscence of surgical wound
CASE 4	7-4-9	3+	10-30	5-15	4	Disabling pain
CASE 5	6-3-2	5	20-40	10-20	2	No No
Left Right	8-4-4	4+	10-40	5-20	4	
CASE 6	9-3-2	5	30 -40	10-20	3	Ulcerative lesion
CASE 7	9-6-3	4+	10-40	10-20	2	No

*VAS: Visual Analog Scale. It measures the intensity of pain described by the patient with the maximum interobserver reliability (Scores 1-10). We obtain three measurements, corresponding to INITIAL VAS: Prior to the rehabilitation procedure; MIDDLE VAS: At the end of the rehabilitation procedure; and FINAL VAS: in the last follow-up.*

*MRC: Medical Research Council scale or modified scale for muscle strength (Scores 0-5).*

**Plantar flexion:** Normal range of motion 0-50° and Dorsiflexion 0-20°. In both cases, two measures were obtained, one for the range of motion before the procedure and one for the range of motion after the procedure.

**CGI:** Clinical global impression of the patient in the last follow-up meeting (8-point score ranging from 0 [not assessed] to 7 [very much worse]).

**Complications in the short to medium term.**

With regard to the range of motion of plantar flexion, the average value at the beginning of the procedure was 18°C, and the patients who had followed an orthopedic treatment achieved, in general terms, better results, with a final average value of 40°C, which remained stable in the follow-up period. Regarding dorsiflexion, the initial average value was 7.5°C, and patients with an orthopedic

treatment and patient no. 6 also obtained better results, with a final average of 19.5°C, with similar values for the angles between different cases.

The results of the VAS were favorable. In cases 3 and 4, with the longest average time of evolution in the study (4 years), the patients were able to walk more than 3 km without the assistance of external devices, and they reported a pain of 2-3 in the VAS scale at the beginning of the day, which subsided afterwards without the need for analgesics. In the remaining cases, with an average time of evolution of between 6 and 18 months, the patients report controlled pain that allows them to have an almost normal life. In almost all cases, the CGI score went from moderate to normal, with the exception of patient no. 4.

In the MRC scale, the results were globally satisfactory.

If we focus on the short-term complications, we can observe that case no. 6 presented an ulcerative lesion on the operated foot, probably associated with decompensated diabetes, which was assessed by the Department of Endocrinology during his admission. The lesion was approximately 2 cm in diameter and located in the inframalleolar region of the foot, which improved with local care, debridement with a scalpel in two occasions, and coverage with intravenous broad-spectrum antibiotics. The patient was discharged 7 days after the operation.

In case no. 3, the patient presented a dehiscence of the surgical wound in the angle of the L-shaped incision, with exposure of the plate osteosynthesis without signs of infection. Daily wound care was required, and surgery was performed, combined with plastic surgery, in order to remove the osteosynthesis material and to do an advancement flap repair, which healed without complications.

In case no. 4, after the patient could start assisted walking with crutches, he consulted for external anterior pain on the foot that radiated to the 5<sup>th</sup> toe. He presented antalgic gait that improved with the use of insoles and did not incapacitate him in his daily activities.

No long-term complications were observed in any of the patients, although a process of subtalar arthritis was observed in all cases, with flattening of the Böhler angle with different degrees of severity, depending on the case, which was well tolerated by the patients and did not require additional measures.

## Discussion

The main challenges in the treatment of calcaneal fractures are determined by factors such as the spongy nature of the bone, its specific anatomy, and the polymorphism of the lesion [12]. The literature on this topic establishes that the prognosis of the lesion is more intimately related to the articular alterations experienced by the bone as part of its normal anatomy than to the morphological alterations to the bone caused by the lesion itself, and that there is sometimes no correlation between the severity of the initial injury and its functional secondary effects [13]. Therefore, it is clearly

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necessary to achieve the most anatomical closure of the lesion, since this is the basic factor that determines the final functional result. However, we must not forget that the procedure for the reduction of these lesions is a difficult technique which involves a steep learning curve, and that poor results are a possibility, even in expert hands [14].

The goal of all the treatments described here is clear, and it involves patients being able to walk without pain, restoring the shape of the calcaneus and correcting any varus-valgus tilt in the heel [16]. Current advances in imaging techniques have provided an insight into the nature of each lesion, and they lead to correct diagnoses and a better choice of the treatment techniques in each particular case.

To date, there is a consensus on the gold standard treatment based on the Sanders classification, which involves orthopedic treatment in type I and some type II lesions; open reduction and internal fixation with plate osteosynthesis in the remaining type II and in type III lesions; and the use of subtalar arthrodesis as an initial treatment in some type III and in type IV lesions. In addition, in the field of open reduction and fixation, the development of low-profile locked plates has represented an advance that is used in cases of severe instability, comminuted fractures, and poor bone quality, and when bicortical fixation is impossible. On the other hand, there is a constant interest on the study of the best possible approach, due to the fact that complications related to soft tissue and, more specifically, skin necrosis, is one of the main challenges in the surgical treatment of these fractures. Therefore, there is an increasing use of percutaneous techniques [13], aimed at reducing the fracture and minimizing or avoiding any aggression to soft tissue [14,15].

As part of this research into gradually less invasive techniques, Bano et al. presented in 2009 a new technique for the reduction of calcaneal fractures with the use of balloon kyphoplasty followed by the use of calcium phosphate to repair the bone defect [16]. Since then, different authors have used this technique and carried out modifications to achieve the best possible results.

In our case series, we show the results obtained in 7 cases in which different treatments have been applied based on the characteristics of the patients and their lesions. Our decisions have been based on the criteria derived from the Sanders classification, and conservative techniques were used in patients that met any of the following criteria: nondisplaced intraarticular fractures; anterior calcaneal process fractures affecting less than 25% of the calcaneocuboid joint; and patients who are not good candidates for surgery (severe peripheral vascular disease, poorly controlled type I diabetes, high concomitant comorbidity, and institutionalized elderly patients, among others).

As we have already pointed out, although some authors recommend treatment with subtalar arthrodesis as an initial treatment for severely comminuted fractures (Sanders IV-IIIB), we decided to

apply a more conservative treatment in our center initially, based on the particular characteristics of our patients (young patients who are working, with a personal history of insulin-dependent diabetes mellitus), with the use of percutaneous reduction with the Essex-Lopresti procedure, followed by balloon-assisted percutaneous calcaneoplasty. We are aware that this technique may later turn into subtalar arthrodesis, which means that a correct initial reduction is very valuable. In both cases, after a 3-year follow-up, the patients report that they have resumed their daily routine with good pain control in the VAS scale, and they now reject the possibility of undergoing definitive surgical treatment with arthrodesis.

## Conclusions

The calcaneus is the bone of the tarsus that is most often fractured, and it is the one most likely to be affected by bilateral lesions. Calcaneal fractures are complex, and their treatment generally leaves traumatologists dissatisfied, even when they have long experience in the field, because the lesions are associated with functional, social, economic, and legal secondary effects.

The difficulty to find a treatment with satisfactory results has led to the proposal of a wide range of therapeutic techniques, and the comparative assessment of results is complex.

The objective of the treatment is to restore good subtalar articular congruity and return the calcaneus to its former shape as much as possible. To do so, the current gold standard procedure for displaced fractures is surgery. However, when a minimally invasive method is applied correctly in fractures without displacement, comminuted fractures or patients in which surgery is not indicated, its results may be better than those obtained from an insufficient operation.

The treatment of intraarticular calcaneal fractures by manipulation with the Omoto technique, or with the Essex-Lopresti procedure associated with balloon kyphoplasty is a simple and reproducible technique that does not require ischemic preconditioning and can be conducted on patients with associated comorbidities or on high-risk surgical patients. It also causes minimal postoperative pain and reduces hospital stays and the rate of skin complications [13].

We are aware that we have described the use of this technique in a minimal series of cases, and that even though the final results three years after the procedure are very satisfactory, it must be analyzed with a larger sample and over a longer follow-up period. Also, with regard to potential biases in our results, it is necessary to point out that not all the patients present a similar time of evolution, which may alter factors such as the final VAS score or the long-term complications, as well as the fact that not all the patients were operated by the same surgeon.

As a final conclusion, we believe that it is necessary to look for the best treatment in each case, based on the characteristics of each patient and fracture.

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