Sinus Tarsi Approach for the Treatment of Calcaneus Fractures: an Increasingly Used Technique

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ABSTRACT

Objective: To describe functional and radiographic outcomes, and complications of osteosynthesis in calcaneus fractures with the sinus tarsi approach. **Materials and Methods:** 54 displaced articular calcaneus fractures in 50 patients were assessed through preoperative foot radiographs (anteroposterior and lateral) and computerized tomography. AP and lateral radiographs were obtained in the immediate postoperative period (without weightbearing), after 6 and 12 weeks (with weightbearing), and at the end of follow-up, measuring the Böhler angle and quantifying the degree of subtalar and calcaneocuboid osteoarthritis. The AOFAS score was determined, registering wound complications, neurological injuries and necessary additional surgeries—such as osteosynthesis and subtalar arthrodesis hardware removal. **Results:** Follow-up time was 30.8 months. The series consisted in 8 women and 42 men. The patients' average age was 39.40±14 years (18-65). There were 40 Sanders type II, 13 type III, and 1 type IV fractures. The AOFAS score was excellent (12 patients), good (25), regular (12), and poor (5). The Böhler angle was 10.8°±10.4° before surgery, and 30.77°±8.24° at the end of follow-up (p<0.00001). 3.7% of the patients presented minor wound complications, while 5.6% presented major wound complications. **Conclusion:** The sinus tarsi approach allows for acceptable reduction with good and excellent outcomes in most patients, coupled with few soft-tissue complications.

Keywords: calcaneus, mini-invasive approach, sinus tarsi, fractures, complications

Level of Evidence: IV

Abordaje del seno del tarso para el tratamiento de las fracturas de calcáneo: una técnica de creciente difusión

RESUMEN

Objetivo: Describir los resultados radiográficos y funcionales, y las complicaciones de la osteosíntesis de fracturas de calcáneo mediante el abordaje del seno del tarso. **Materiales y Métodos:** Se evaluaron 54 fracturas articulares de calcáneo desplazadas en 50 pacientes con radiografías de pie, de frente y de perfil, y tomografía computarizada preoperatorias. Se tomaron radiografías de pie, de frente y de perfil sin carga en el posoperatorio inmediato y con carga a las semanas 6 y 12, y al final del seguimiento. Se midió el ángulo de Böhler y se cuantificó el grado de artrosis subastragalina y calcaneocuboidea. Se determinó el puntaje de la AOFAS y se registraron las complicaciones de la herida, las lesiones neurológicas y la necesidad de cirugías adicionales, como retiro del material de osteosíntesis y artrodesis subastragalina. **Resultados:** El seguimiento fue de 30.8 meses. La serie estaba formada por 8 mujeres y 42 hombres, con una edad de 39.40 ± 14 años (rango 18-65). Cuarenta fracturas eran Sanders tipo II, 13 tipo III y 1 tipo IV. El puntaje de la AOFAS fue: excelente (12 casos), bueno (25 casos), regular (12 casos) y malo (5 casos). El ángulo de Böhler preoperatorio era de 10,8 ± 10,4º y 30,77 ± 8,24º al final del seguimiento (p <0,00001). El 3,7% tuvo complicaciones menores de la herida y el 5,6%, complicaciones mayores. **Conclusión:** El abordaje del seno del tarso permite una reducción aceptable con resultados buenos y excelentes en la mayoría de los pacientes y escasas complicaciones de partes blandas.

Palabras clave: Calcáneo; abordaje mininvasivo; seno del tarso; fractura; complicaciones.

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INTRODUCTION

Calcaneus fractures represent 60% of traumatic foot injuries in adults and 2% of total fractures.[1] The treatment of displaced calcaneal joint fractures is still controversial, although open reduction and osteosynthesis through the extended lateral approach (ELA) have been the reference pattern in the last three decades.[2, 3]

The high rate of published complications[4, 5] has led to the development of less invasive surgeries[6, 7] to reduce soft tissue trauma and the risk of complications, with acceptable success.

The minimally invasive sinus tarsi approach allows for adequate visualization and reduction of the fracture, reducing the rate of complications.[8]

The aim of our research was to describe the radiographic and functional outcomes, as well as the complications, of calcaneus fracture osteosynthesis through the sinus tarsi approach.

MATERIALS AND METHODS

Our retrospective analysis comprised 54 displaced calcaneal joint fractures in 50 patients, treated with osteosynthesis through the sinus tarsi approach between 2011 and 2018. The exclusion criteria were ipsilateral ankle and foot fractures, growing-age patients, >65 years, follow-up <12 months, previous surgeries on the same foot or ankle, and fractures with more than 30 days of evolution. The surgical criteria were Böhler angle<20°, joint incongruity >2 mm, varus >5°, valgus >10°, width ≥5 mm, and gap >3 mm.

The fractures were classified according to Sanders[4] and Essex-Lopresti. The exposed fractures were treated with a surgical mechanical toilet plus intravenous antibiotics, according to Gustilo's classification.[9]

Radiographic evaluation

The patients were evaluated before surgery with anteroposterior and lateral foot radiographs. The radiation in the lateral and anteroposterior projections was 4 mA, 60 kV, 3,2 mA, and 57 kV, respectively. In the lateral projection, the ray was centered on the medial malleolus;

in the anteroposterior projection, on the medial cuneiform. The ray was parallel to the ground in the lateral radiograph and inclined 15° in the caudocranial direction in the anteroposterior. The distance from the tube to the cassette was 120 cm in both projections. Before surgery, a CT scan with multiplanar reconstruction was performed.

Anteroposterior and lateral foot radiographs were taken without weight-bearing in the immediate postoperative period, and with weight-bearing at weeks 6 and 12, and at the end of follow-up.

On the lateral radiograph, the Böhler angle was measured, consisting of two lines, one from the highest point of the anterior tuberosity to the highest point of the posterior facet, and the other, tangential to the superior border of the posterior tuberosity. Their value ranges from 20º to 40°.[10] It was quantified if there were changes >5° that indicate a collapse of the calcaneal height.[7] The degree of osteoarthritis in the subtalar and calcaneocuboid joints was evaluated.[11] The CT scan was taken to detect any involvement of the calcaneocuboid joint.

Clinical evaluation

A functional evaluation was conducted using the AOFAS (American Orthopaedic Foot and Ankle Society) scale. The result was classified as: excellent >90, good >80, fair >70 and poor ≤70.[12]

Subtalar range of motion was evaluated comparatively. Wound complications were recorded and divided into minor (edge necrosis, superficial dehiscence) and major (deep infection or dehiscence, and osteomyelitis).[13] Neurological injury and the need for additional surgeries were also evaluated, such as the removal of osteosynthesis material and subtalar arthrodesis.

The statistical analysis was carried out through descriptive measures (mean and standard deviation, maximum and minimum). The data were loaded into the Epidat 4.2 system, considering a p-value <0.05 as statistically significant.

Surgical technique

The patient is placed in the lateral decubitus position and a 3-5 cm approach is performed on the sinus tarsi, 1 cm distal to the fibula up to the fourth metatarsal (Figure 1).

The peroneals are retracted posteriorly, proceeding to capsular opening to observe the subtalar joint, the anterior tuberosity, and the lateral wall (Figure 2).

Figure 1. Marking of the sinus tarsi approach.

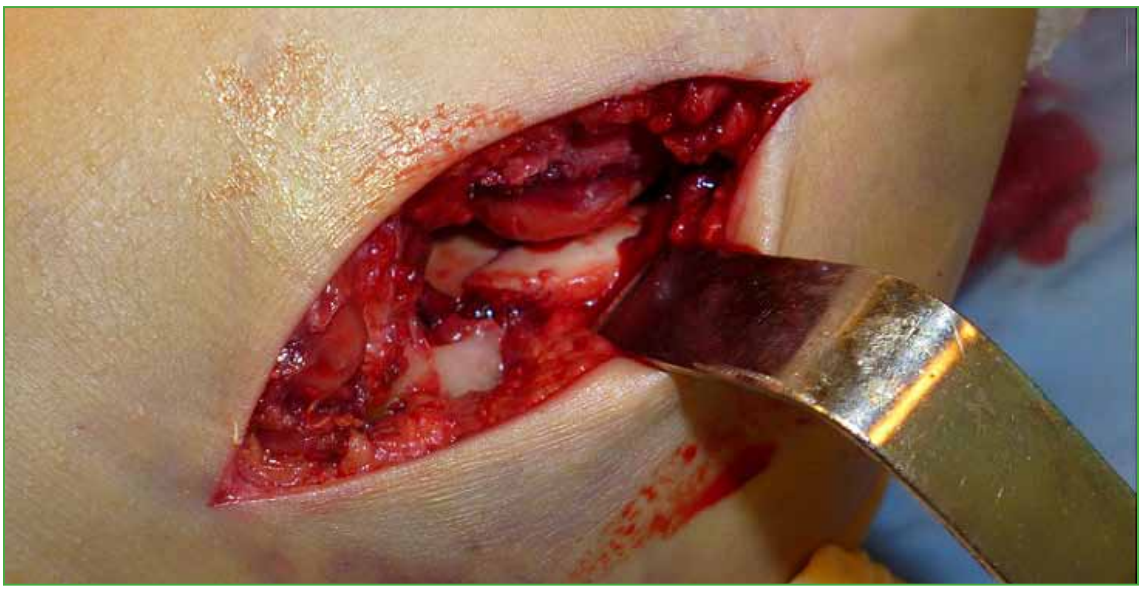

Figure 2. Facet joint and anterior process of the calcaneus.

One distractor with a 5 mm cancellous Schantz or a Kirschner pin of the same diameter is placed on the posterior tuberosity, and a second one is placed on the lateral part of the talus —to recover height— or on the cuboid —to restore length— (Figure 3).

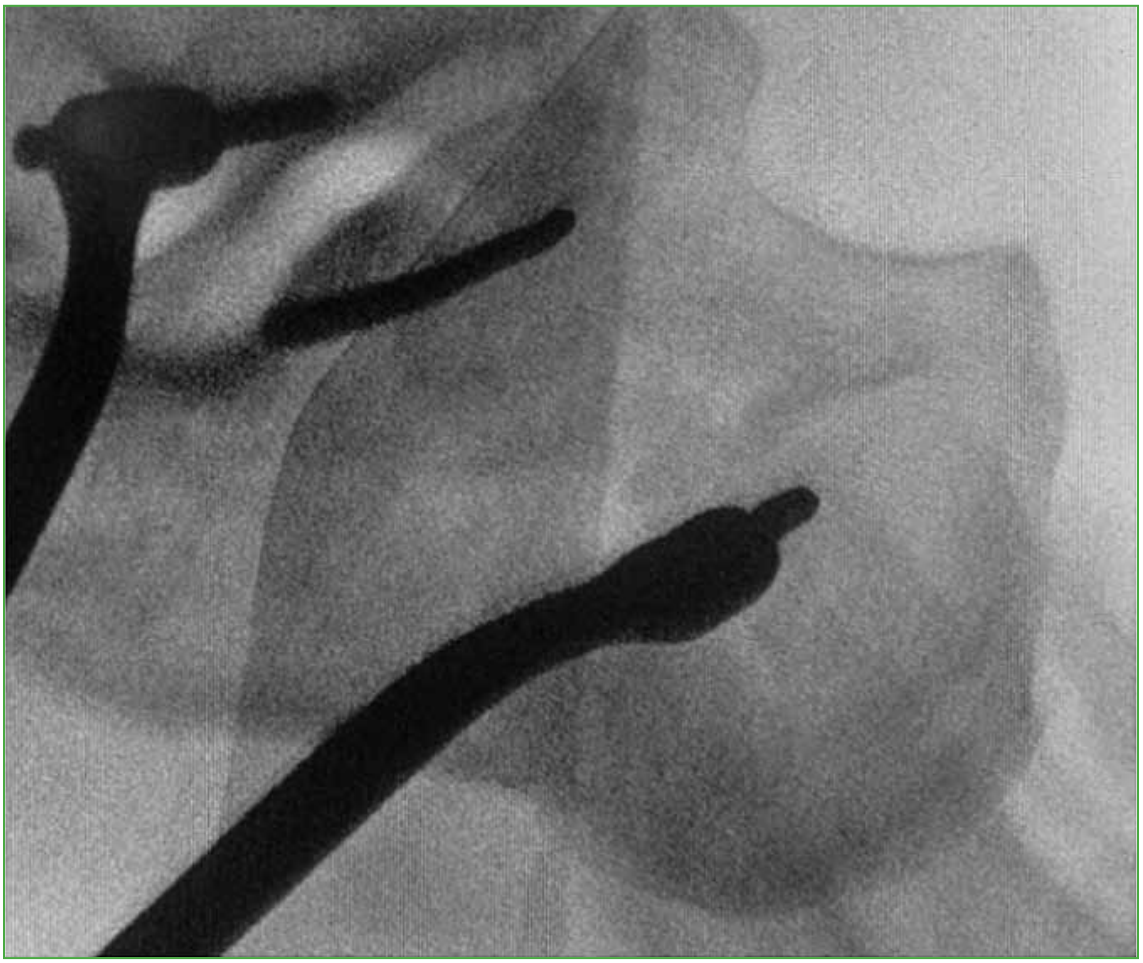

Figure 3. Placing of Kirschner pins on the posterior tuberosity and the lateral part of the talus, and mounting of the distractor on them.

If necessary, the medial fragment is reduced by direct incision. Afterward, the posterior tuberosity is aligned percutaneously with the distractor's Schantz of Kirschner and fixed with a needle to the medial segment. Then, the superolateral fragment is stabilized to the medial fragment before disimpacting and elevating it, in Sanders type II cases. In Sanders III or IV fractures, the intermediate fragments are reduced and then fixed with Kirschner pins (Figure 4).

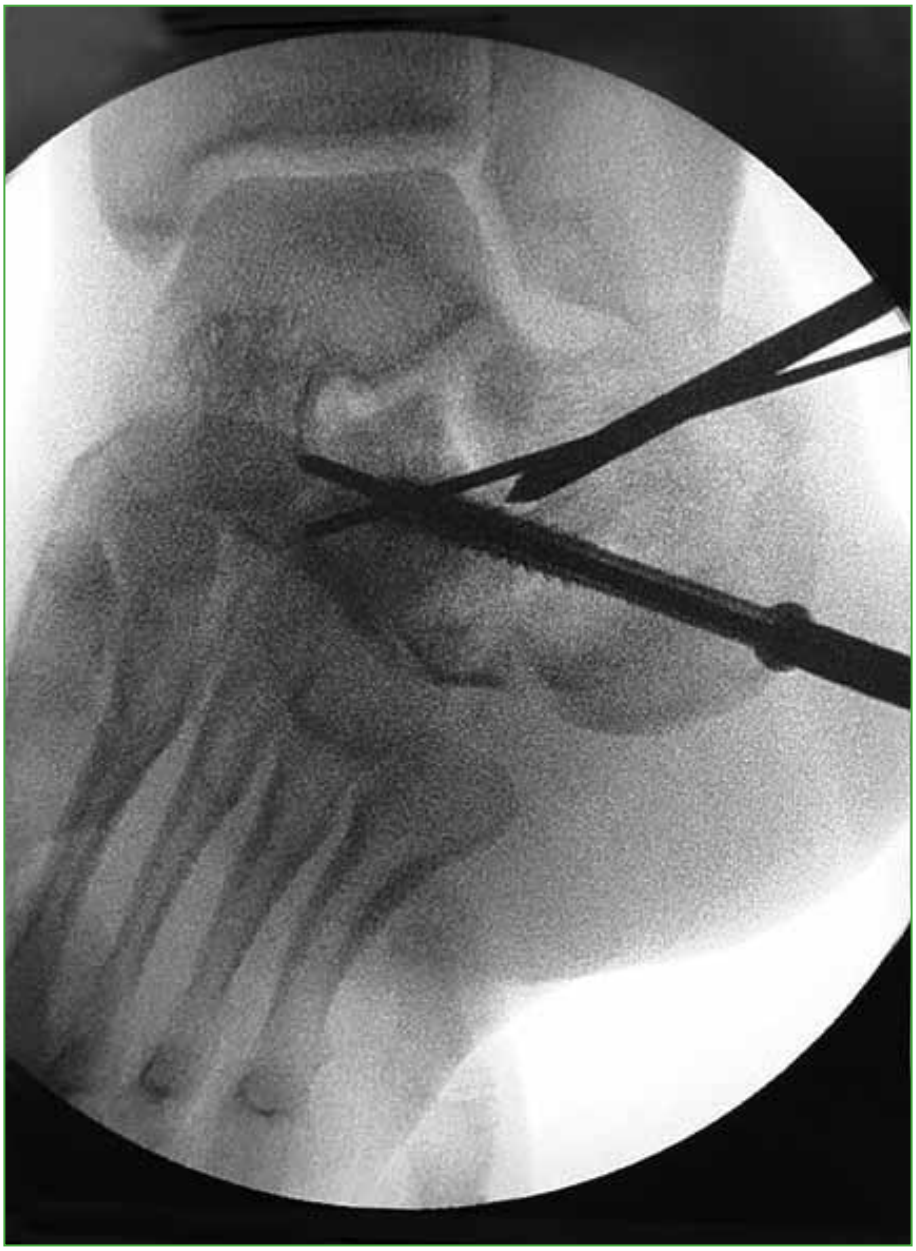

Figure 4. Broden view. The stabilization of the posterior tuberosity toward the sustentaculum tali, using a screw and pin, plus the reduction of the superolateral fragment towards the sustentaculum tali, can be observed.

The talus's lower surface is used as a mold. 6.5 mm full-thread or partially threaded screws and 3.5 mm cortical screws without compression are placed from the posterior tuberosity up to the medial fragment; 3.5 mm screws are used from the superolateral to the medial fragment (Figure 5).

Figure 5. A. Lateral foot radiograph. "Joint depression" fracture pattern. **B.** Anteroposterior foot radiograph. **C.** Computerized tomography of the foot, coronal plane. Sanders IIIAB. **D.** Computerized tomography, axial plane**. E.** Computerized tomography, sagittal plane. **F.** Intraoperative lateral image of the foot with intensification, osteosynthesis control. **G.** Intraoperative image with Broden view. Reduction of the facet joint. **H.** Lateral radiograph of the foot with weight-bearing, one year after surgery. Adequate reduction of subtalar and Böhler angle. **I.** Anteroposterior radiograph of the foot with weight-bearing, one year after surgery.

From the posterior tuberosity to the anterior process, 6.5 mm or 3.5 mm screws are used. One or two additional screws may be necessary from the upper edge of the superolateral to the plantar fragment for the "tongue-type" fracture pattern (Figure 6).

Figure 6. A. Lateral foot radiograph. "Tongue" fracture pattern. **B.** Computerized tomography of the foot, sagittal plane. **C.** Computerized tomography, coronal plane. Sanders IIA. **D.** Lateral foot radiograph, one year after surgery. Adequate Böhler angle. **E.** Anteroposterior foot radiograph, one year after surgery.

2.7 mm or 3.5 mm locking plates are placed from the joint surface to the anterior tuberosity (Figure 7).

An intraoperative Broden view of the calcaneus with image intensifier was used to verify the reduction of the posterior facet and to assess the existence of joint gap or step-off (Figure 8).[14]

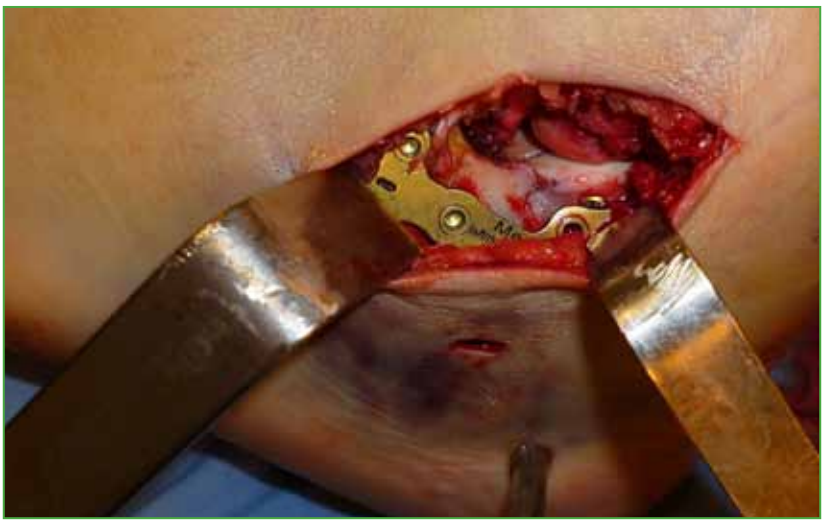

Figure 7. Image of the anatomical reduction of the calcaneus's facet joint and mounting with a 3.5 mm locking titanium plate, solidifying the joint surface and the anterior tuberosity.

Figure 8. Intraoperative Broden view with acceptable reduction of the subtalar joint.

In the postoperative period, a posterior splint is placed for 10 days, and ankle and subtalar range of motion is initiated. Partial weight-bearing with crutches and a splint starts at week 4 and progresses until weeks 10-12, when weight-bearing is total.

FINDINGS

The average follow-up was 30.8±23.2 months. Eight patients were women and 42 were men. The age was 39.40 ± 14 years (range 18-65). The trauma mechanism had been a fall from height (74%) and traffic accidents (26%). The 2% were exposed fractures and the 8% were bilateral. The fracture patterns were of the "joint depression" (63%) and "tongue" (37%) types. Based on the Sanders classification, 40 fractures were type II (50% subtype A; 42.5% subtype B; and 7.5% subtype C); 13, type III (84.6% subtype AC, 7.7% subtype AC; and 7.7% subtype BC); and one, type IV. There was involvement of the calcaneocuboid joint in 37% of cases.

The time between injury and surgery was 9.2± 6.3 days (range 1-31). No correlation between this parameter and the restoration of the Böhler angle was found.

The AOFAS scale score was excellent in 12 patients, good in 25, regular in 12, and poor in five.

The Böhler angle was 10.8° ± 10.4 before surgery; 32.5 ± 7.73 (range 22-54) in the immediate postoperative period; and 30.77 ± 8.24 (range 17-54) after six weeks and at the end of follow-up. These values were statistically significant ($p < 0.00001$) (Figure 9).

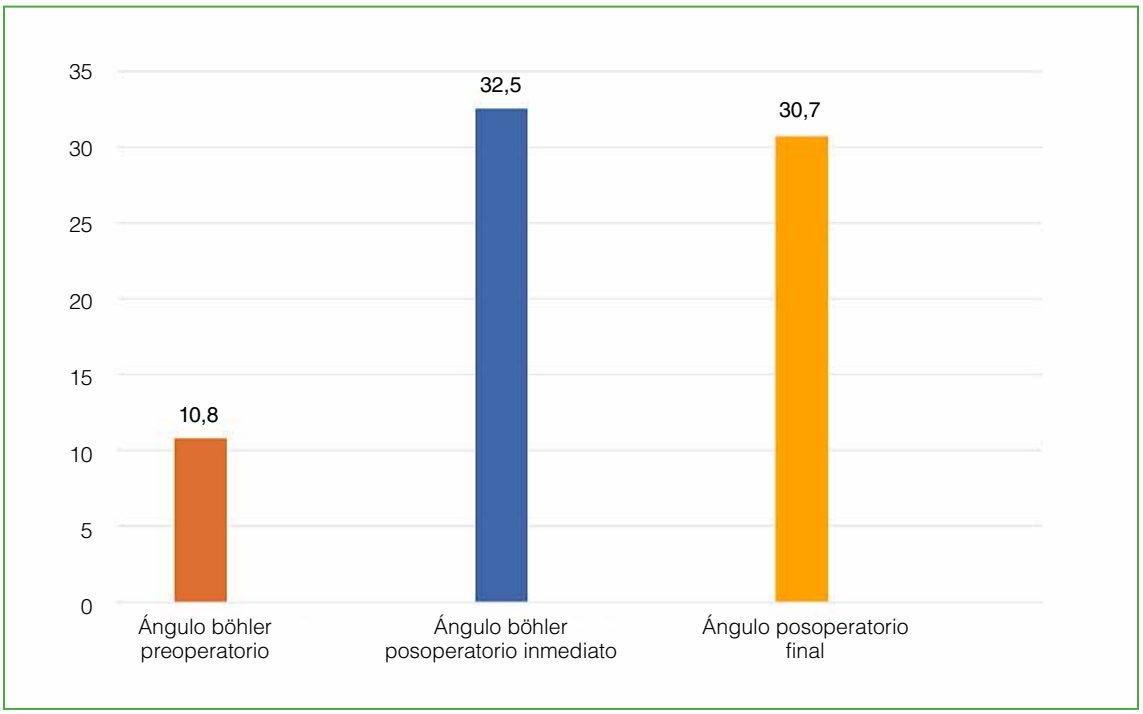

Figure 9. Preoperative and postoperative Böhler angle.

A loss of more than 5° was observed between the immediate postoperative period and the end of follow-up in four patients: one case of early withdrawal of the material due to infection and three cases of insufficient fixation in fractures with significant comminution. The patient whose osteosynthesis material was withdrawn due to infection was the only one who remained with a <20° Böhler angle.

44.4% of grade I developed subtalar osteoarthritis; grade II, 7.4%; and grade III, 3.8%. There was no relation between subtalar osteoarthritis and the AOFAS scale score. All patients lost subtalar range of motion to some degree: 72.2% had moderate restriction; 11.1%, severe restriction; and 16.7%, mild restriction.

In 9.3% of cases, it was necessary to remove the osteosynthesis material: two cases were due to infection, and three cases due to peroneal tendonitis. Subtalar arthrodesis was performed in 3.7% of the fractures owing to symptomatic subtalar osteoarthritis that did not improve with the conservative treatment (Figure 10).

3.7% suffered minor complications in the wound (edge necrosis). The infection rate was 5.6% in 54 fractures. Three patients had temporary sural nerve injuries which disappeared within six months after the surgery.

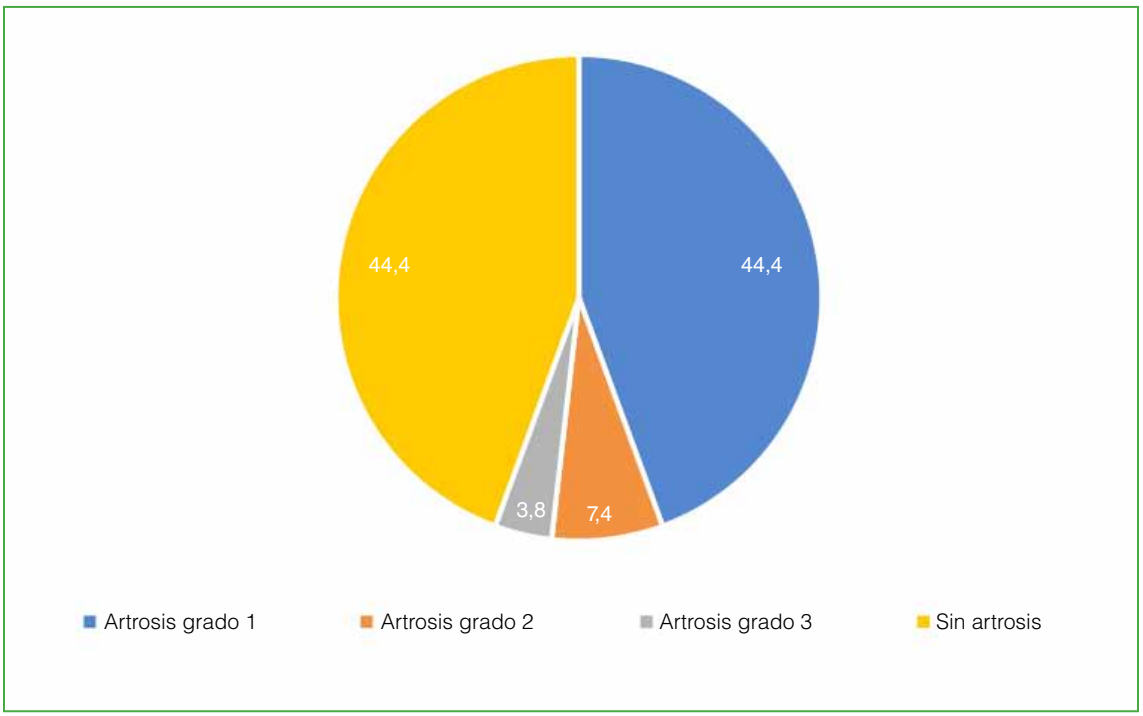

Figure 10. Degrees of subtalar osteoarthritis.

DISCUSSION

Calcaneus fractures account for 2% of all fractures and most occur in adult patients. The issue of treatment remains controversial, as evidence shows similar results for conservative and surgical management,[2, 15] but most orthopedic surgeons favor surgery due to its satisfactory results.[4]

Surgical approaches continue to generate controversy, although minimally invasive techniques have been proven to reduce soft tissue complications and infections, in comparison with the ELA.[7, 8]

The sinus tarsi approach could be considered the current reference pattern, as it yields low soft tissue complications with clinical outcomes similar to the ELA.[16]

The significant improvement of the postoperative Böhler angle in this study proves that the calcaneus's height can be restored through this incision. The final, postoperative Böhler angle averaged 30.77°. This is linked to improved clinical outcomes.[2, 7] Four patients suffered a >5° Böhler angle loss, which could be ascribed to insufficient osteosynthesis in three cases, and to the early removal of the material due to infection in one patient, who had a postoperative <15° Böhler angle.

There are different options to stabilize the calcaneus through the sinus tarsi approach. Schepers recommends placing only screws in patients with fractures without comminution and good bone quality. If the implant is not stable or the calcaneus's width cannot be restored, a plate should be added.[17] Kir *et al.* communicate that stabilization with plates, in comparison with screws, offers a lower rate of reoperation and implant withdrawal, along

with a better reconstruction of the calcaneus's width and improved functional outcomes in Sanders type II and III fractures.[18] Pitts *et al.*[19] found no difference between plates and screws regarding postoperative Böhler and Gissane angles or wound complications. In a biomechanical study, the stability achieved with intramedullary screws is shown to be higher than with traditional plates, possibly because they are anchored to areas of greater density in the calcaneus.[20] In our series, we combined 2.7 mm locking plates or 3.5 mm plates with 3.5 mm, 4.0 mm and 6.5 mm cannulated screws.

In our study, the rate of minor wound complications was 3.7%, while the rate of deep infection was 5.6%. Schepers published a 4.8% of wound complications (range 0-15.4) in patients treated with the sinus tarsi approach.[21] Nosewic presents a systematic review and a meta-analysis, informing a 4.9% of wound complications with the sinus tarsi approach, against 24.9% with the ELA[7]. There have also been cases of neurovascular injury in the 9.1-25%[22-23] with the ELA, and in 5% with the sinus tarsi approach.[24] In our series, three patients suffered temporary sural nerve injuries.

Our rate of good and excellent outcomes according to the AOFAS scale (68.5%) coincides with other published results for the sinus tarsi approach.[24]

All patients presented some degree of stiffness in the subtalar joint. 83.3% suffered a moderate to severe loss of range of motion. This could be related to the irreversible injury of the articular cartilage.[25]

The reduction of the subtalar joint is very important, since a >1 mm step-off alters weight distribution in said joint and produces post-traumatic osteoarthritis.[26] 55.6% of our patients developed osteoarthritis, with 44.4% being grade I.

Regarding the limitations of our own research, we had only one patient with a Sanders type IV fracture, which has precluded us from assessing the treatment in this group of fractures. Secondly, the follow-up time was relatively short. While osteoarthritis did occur and subtalar arthrodesis was needed, had the follow-up been longer, perhaps the results might have shown some decline. Thirdly, there was no randomized comparison group, although the results are similar to those obtained in groups of patients treated with the sinus tarsi approach, and were also compared with the ELA.

CONCLUSION

The sinus tarsi approach allows for an adequate exposition of the fracture and an acceptable reduction, with good and excellent outcomes in most patients and few soft tissue complications.

Conflict of interest: The authors declare no conflicts of interest.

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