Outcomes of Distraction Subtalar Arthrodesis for the Treatment of Calcaneal Fracture Malunion: A Case Series

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ABSTRACT

Objectives: The objective of this study is to evaluate and analyze the outcomes of a series of patients diagnosed with calcaneal fracture malunion treated with distraction subtalar arthrodesis. **Materials and Methods:** Nine patients (five women and four men; mean age, 56.3 years) were retrospectively evaluated, with a mean follow-up of 31.28 months. Weight-bearing lateral radiographs were used to assess talocalcaneal height, talar declination angle, calcaneal declination angle, and Meary's angle. Clinical outcomes were evaluated using the Visual Analog Scale (VAS) for pain and the American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot Score. Patient satisfaction was also assessed. **Results:** Talocalcaneal height increased by 0.7 cm, talar declination angle by 4.5°, CP by 1.3°, and Meary's Angle decreased by 4.8°. The VAS pain score decreased by 5.8 points, and the AOFAS score increased by 50 points. Eight patients reported being very satisfied and one patient was satisfied with the outcome. **Conclusions:** Distraction subtalar arthrodesis provides excellent clinical and radiographic outcomes in patients with calcaneal fracture malunion. It reduces pain and improves function while restoring hindfoot height and talar declination.

Keywords: Calcaneal fracture; malunion; subtalar arthrodesis.

Level of Evidence: IV

Resultados de la artrodesis subastragalina distractiva en el tratamiento de secuelas de una fractura de calcáneo: serie de casos

RESUMEN

Objetivos: Evaluar y analizar los resultados de una serie de pacientes con diagnóstico de secuela de una fractura de calcáneo tratados con artrodesis subastragalina distractiva. **Materiales y Métodos:** Se evaluó, en forma retrospectiva, a 9 pacientes (5 mujeres y 4 hombres; edad promedio 56.3 años), con un seguimiento de 31.28 meses. En las radiografías de perfil con carga, se evaluaron la altura astrágalo-calcánea, el ángulo de declinación del astrágalo, el ángulo de declinación del calcáneo y el ángulo de Meary. Se emplearon la escala analógica visual para dolor y la escala de la AOFAS de tobillo y retropié, y se determinó la satisfacción del paciente. **Resultados:** La altura astrágalo-calcánea aumentó 0,7 cm; el ángulo de declinación del astrágalo, 4,5°; el ángulo de declinación del calcáneo, 1,3° y el ángulo de Meary disminuyó 4,8°. La medición en la escala analógica visual disminuyó 5,8 puntos y la de la escala AOFAS aumentó 50 puntos. Ocho pacientes se manifestaron muy satisfechos y uno, satisfecho con el resultado. **Conclusiones:** La artrodesis subastragalina distractiva logra muy buenos resultados clínico-radiográficos en pacientes con diagnóstico de secuela de una fractura de calcáneo, disminuye el dolor y mejora la funcionalidad del paciente, al tiempo que restaura la altura del retropié y la declinación del astrágalo.

Palabras clave: Fractura de calcáneo; consolidación viciosa; artrodesis subastragalina.

Nivel de Evidencia: IV

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INTRODUCTION

The sequelae of calcaneal fractures may be associated with a variety of structural and functional abnormalities of the hindfoot that result in pain and significant functional impairment, including peroneal tendon pathology, subtalar arthritis and stiffness, varus or valgus malalignment, and widening of the calcaneus.[1-3] Subtalar arthrodesis is the most commonly used salvage procedure because, when combined with other techniques such as osteotomies and lateral wall exostectomy, it has proven effective in relieving pain and correcting malunion deformities.[4-6]

Severe collapse of the posterior facet represents a more challenging scenario because it leads to secondary loss of talar declination and decreased hindfoot height, potentially resulting in anterior ankle pain, reduced ankle dorsiflexion, and diminished triceps surae function if not adequately corrected.[7–9] In 1988, Carr et al.[4] reported their results using distraction subtalar arthrodesis in these situations, and since then, several studies have demonstrated favorable outcomes with this technique.[1–9] Despite these encouraging results, there is still no consensus regarding certain aspects of the procedure, such as the optimal graft material or fixation method.

The aim of this study was to evaluate and analyze the outcomes of a series of patients with calcaneal fracture malunion treated with distraction subtalar arthrodesis.

MATERIALS AND METHODS

A retrospective review was performed of a series of patients with calcaneal fracture malunion following an intra-articular calcaneal fracture who were treated with distraction subtalar arthrodesis and had a minimum follow-up of 6 months.

Patients treated with in situ subtalar arthrodesis, those with other ipsilateral leg, ankle, or foot injuries, and those with diabetes or neurological disease were excluded.

Eleven patients treated by the senior authors between May 2015 and December 2022 were identified. Four were excluded from the final analysis: one because follow-up was shorter than 6 months at the last evaluation, one because of an ipsilateral ankle fracture, and two because adequate preoperative clinical and radiographic assessments were unavailable. The final cohort consisted of 7 patients (5 women and 2 men) ranging in age from 36 to 74 years (mean age 61 years).

During the acute phase, four patients had been treated nonoperatively, one had undergone open reduction and internal fixation, and two had received no treatment because the initial injury had gone unrecognized.

Preoperative and postoperative clinical and functional evaluations were performed using the Visual Analog Scale (VAS) for pain[10] and the *American Orthopaedic Foot and Ankle Society* (AOFAS) Ankle-Hindfoot Scale (maximum possible postoperative score: 94/100, because the scale awards 6 points for normal or only mildly restricted subtalar motion).[11] Patient satisfaction was also assessed and categorized as dissatisfied, satisfied, or very satisfied.

For preoperative planning, weight-bearing anteroposterior and lateral radiographs of both feet and ankles, axial radiographs of both calcanei, and computed tomography scans were evaluated. The following parameters were measured on weight-bearing lateral foot radiographs: 1) Talocalcaneal height (TCH): distance from the talar dome to the plantar cortex of the calcaneal tuberosity measured along a line perpendicular to the ground, expressed in centimeters. 2) Talar declination angle (TDA): angle formed between a line perpendicular to the ground and a line perpendicular to the longitudinal axis of the talus. 3) Calcaneal declination angle (CDA): angle formed between a line tangent to the plantar cortex of the anterior process and calcaneal tuberosity and a line parallel to the ground. 4) Meary's angle (or Meary's line): angle formed by the longitudinal axes of the talus and the first metatarsal. If the talar inclination exceeds that of the first metatarsal, the resulting angle is considered negative (Figure 1). All measurements were performed by one of the authors using a goniometer.

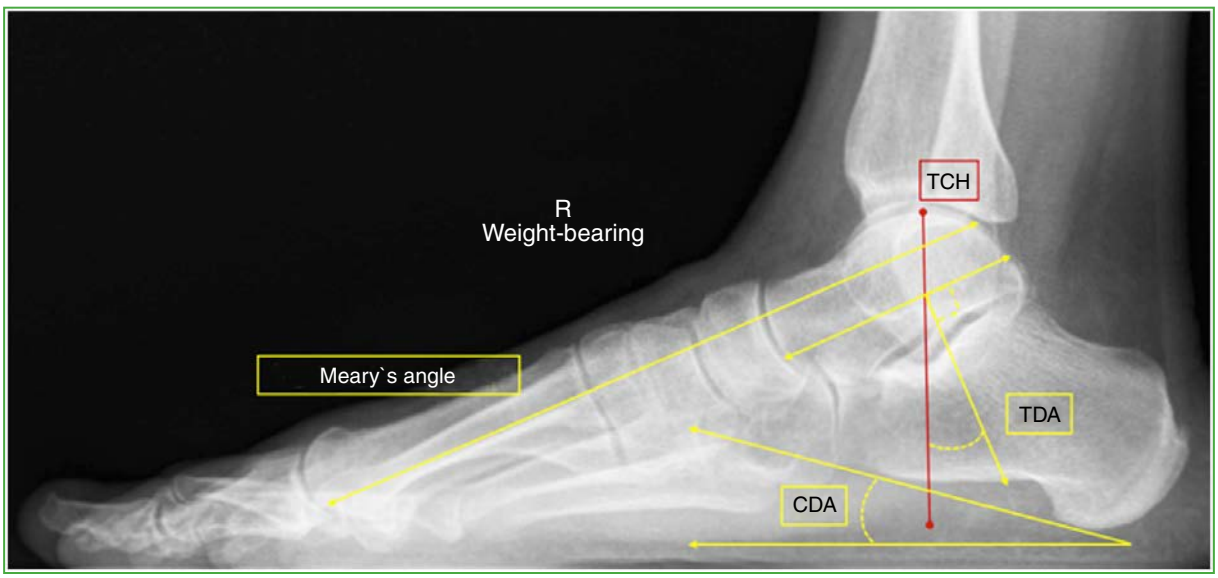

Figure 1. Measurements obtained on a weight-bearing lateral radiograph of an uninjured foot. TCH = talocalcaneal height; TDA = talar declination angle; CDA = calcaneal declination angle.

Surgical Technique

In six patients, the extensile lateral approach described by Benirschke and Sangeorzan was used. Patients were positioned in the lateral decubitus position with pelvic straps, elevation of the operative limb, and a thigh tourniquet. The vertical limb of the incision was made longitudinally between the lateral border of the Achilles tendon and the posterior border of the fibula, with identification and protection of the sural nerve. The horizontal limb was made along the junction between the plantar and lateral skin. During dissection, care was taken to avoid injury to the peroneal tendons. The first step consisted of resection of the lateral wall of the calcaneus using a saw or osteotome when calcaneal widening was present, followed by removal of the subtalar articular cartilage. In cases of varus malalignment, a Dwyer-type osteotomy was performed using a saw or osteotome, whereas a medial sliding osteotomy was performed when valgus malalignment was present. The joint was distracted with a laminar spreader, and a PEEK spacer was inserted together with bone graft harvested from the previous bone cuts. Fixation was then achieved with two fully threaded 6.5- or 7.0-mm cannulated screws under fluoroscopic guidance.

In one patient, a posterolateral approach was used because substantial calcaneal widening was not present. The patient was positioned supine, and the incision included only the vertical limb of the extensile lateral approach.

RESULTS

All patients reported hindfoot pain and stiffness and had failed conservative treatment, including oral analgesics, orthotics, and physical therapy. None reported anterior ankle pain.

Radiographs of all patients demonstrated subtalar osteoarthritis and collapse of the posterior calcaneal facet. Five patients had calcaneal widening associated with varus deformity >10°, whereas two had varus deformity without widening.

The mean postoperative follow-up was 32 months (range 6-98 months) (Table 1).

Table 1. Patient information

	Age	Gender	Initial treatment	Follow-up (months)	Additional procedure	Bone graft	6.5 mm cannulated screws	Complications
1	59	F	None	30	None	Autologous - Iliac crest	Partial thread	Graft collapse
2	36	M	ORIF	29	RO + lateral wall resection + Dwyer	Autologous -Calcaneus	Partial thread	No
3	57	M	None	18	Lateral wall resection + osteotomy	Autologous -Calcaneus	Full thread	No
4	21	M	ORIF	12	RO + lateral wall resection + osteotomy	Autologous -Calcaneus	Full thread	No
5	57	F	None	26	Lateral wall resection + Dwyer	Autologous -Calcaneus	Full thread + PEEK spacer	No
6	74	F	Conservative	6	Lateral wall resection + Dwyer	Autologous -Calcaneus	Partial thread	Graft collapse
7	70	F	Conservative	98	Lateral wall resection	Autologous -Calcaneus	Partial thread + PEEK spacer	No
8	73	M	Conservative	9	Lateral wall resection + osteotomy	Autologous -Calcaneus	Partial thread	No
9	60	F	Conservative	6	Lateral wall resection	Autologous -Calcaneus	Full thread	No

F = female; M = male; ORIF = open reduction and internal fixation; RO = removal of osteosynthesis.

Clinical and Functional Assessments

According to the visual analog scale, the mean pain score was 7.5 (min. 6, max. 9) before surgery and 1.7 (min. 0, max. 5) at the postoperative evaluation.

The mean AOFAS score was 35.2 (min. 19, max. 61) before surgery and 87 (min. 74, max. 94) afterward (Figure 2). Six patients reported being "very satisfied" and one reported being "satisfied" with the treatment outcome.

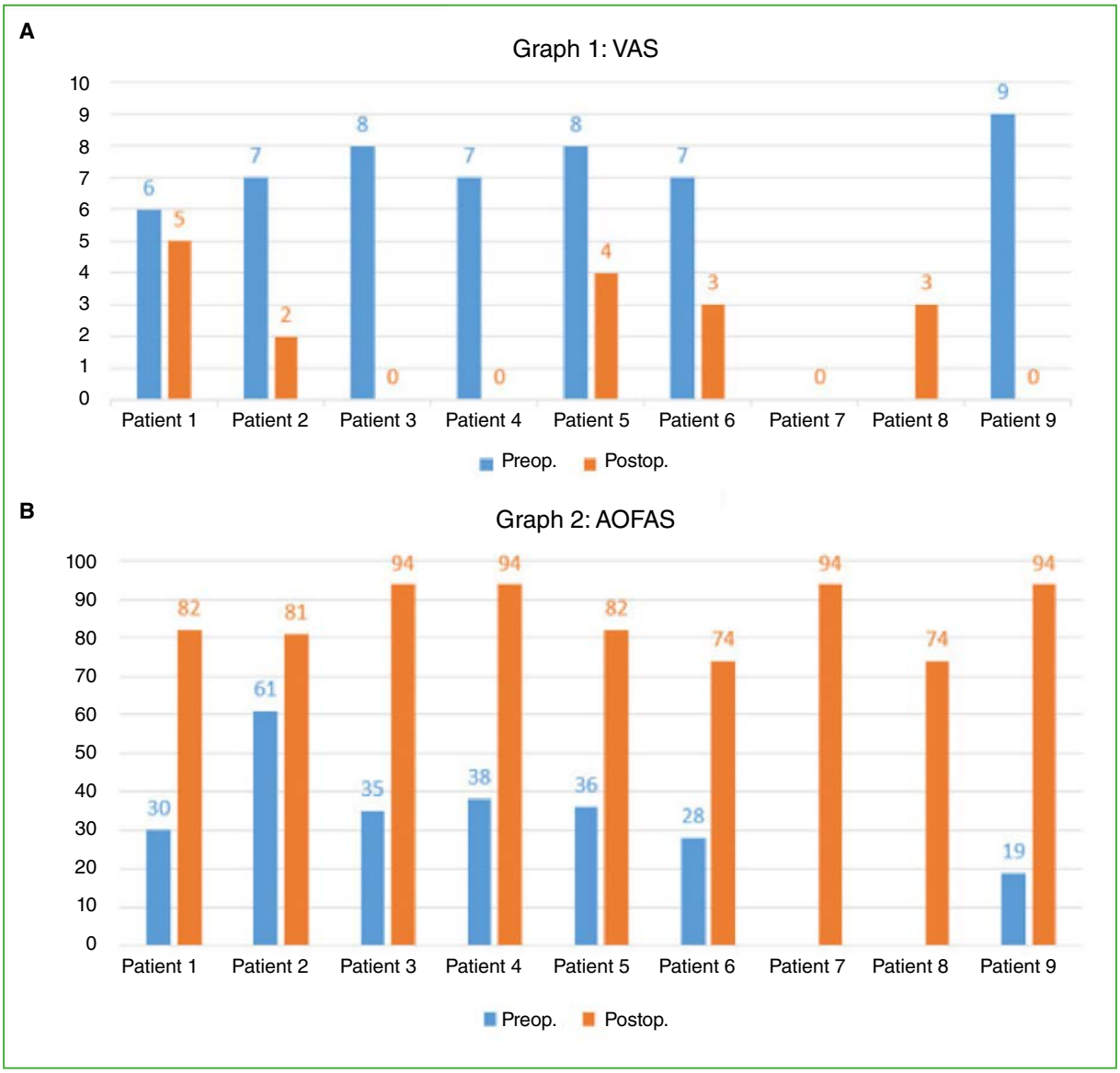

Figure 2. Comparison of preoperative and postoperative Visual Analog Scale (VAS) pain scores (**A**) and AOFAS Ankle-Hindfoot Scale scores (**B**).

Radiographic Evaluation

The mean talocalcaneal height (TCH) in the uninjured feet was 7.1 cm (range 5.8-10.1 cm). The mean TCH in the affected feet was 7.1 cm (range 6.0-9.2 cm) preoperatively and 7.8 cm (range 5.6-10.7 cm) postoperatively. The mean talar declination angle (TDA) in the uninjured feet was 20° (range 14°-29°). The mean preoperative TDA in the affected feet was 12.5° (range 5°-23°), improving to 17° (range 5°-24°) postoperatively. The mean calcaneal declination angle (CDA) in the uninjured feet was 18° (range 15°-23°). The mean preoperative CDA in the affected feet was 13.7° (range 9°-25°), increasing to 15° (range 7°-22°) after surgery. The mean Meary's angle in the uninjured feet was −1.7° (range −7° to 3°). In the affected feet, the mean Meary's angle was 11.1° (range 0°-16°) preoperatively and 6.3° (range 0°-18°) postoperatively (Table 2).

Table 2. Radiographic measurement values.

	TDA (°)			CDA (°)			Meary's angle (°)			TCH (cm)		
	Preop.	Postop.	CF	Preop.	Postop.	CF	Preop.	Postop.	CF	Preop.	Postop.	CF
1	5	5	14	9	9	15	16	18	0	6.5	5.6	7.2
2	15	16	20	9	8	15	14	0	0	8.1	10.7	9.3
3	--	15	27	--	13	16	--	0	-7	--	8.5	9
4	--	22	20	--	22	21	--	0	0	--	8.2	8.4
5	23	24	23	9	7	15	0	0	-2	6.7	8.2	6.1
6	5	12	29	14	15	20	16	13	-6	6	6.5	6.7
7	10	16	20	25	22	24	16	13	3	6.8	7.5	7.1
8	18	20	25	11	15	20	10	0	-5	6.6	6.8	7.6
9	12	16	20	19	15	19	6	3	0	9.2	9.5	10.1
Mean	12.5	16.2	22	13.7	14	18.3	11.1	5.2	-1.9	7.1	7.9	7.9

TDA = talar declination angle; CDA = calcaneus declination angle; TCH = talocalcaneal height; Preop. = preoperative; Postop. = postoperative; CF = contralateral foot.

DISCUSSION

Distraction subtalar arthrodesis is a well-established indication in patients with calcaneal fracture malunion associated with loss of hindfoot height and talar horizontalization, regardless of whether anterior ankle impingement is present.[12,13]

Our findings are consistent with those reported in the international literature highlighting the benefits of this procedure.[1,6,7,14-20] Since the initial descriptions by Gallie[14] and the popularization of the technique by Carr et al.,[4] restoration of hindfoot height has been one of the primary objectives. In this regard, Myerson and Quill[7] proposed a loss of talocalcaneal height (TCH) greater than 8 mm together with radiographic evidence of tibiotalar impingement as an indication for surgery. Similarly, Zwipp and Rammelt[13] incorporated this indication into their classification of type 3, 4, and 5 lesions, in which restoration of hindfoot height and talar declination are key treatment goals.[8,15,19,20]

In our series, the effectiveness of the procedure was reflected in substantial clinical improvement, with a mean reduction of 5.8 points on the Visual Analog Scale and a mean increase of 50 points on the AOFAS Ankle-Hindfoot Scale. Radiographically, mean TCH increased by 0.7 cm, TDA improved by 4.5°, and CDA improved by 1.3°, whereas Meary's angle decreased by 4.8°. These results translated into a high level of patient satisfaction, with 88.8% of patients reporting that they were "very satisfied," including one patient who experienced significant clinical improvement despite partial graft collapse.

Graft collapse is a recognized complication of this procedure.[21] In our series, it occurred in two cases (22.2%), highlighting the importance of fixation strategy and structural support (Figure 3). Although controversy remains regarding the use of fully threaded screws[1,3,4,22] versus partially threaded screws to achieve compression,[5–7] our experience suggests that maintaining correction with fully threaded screws may be advantageous in preventing loss of alignment.

With regard to grafting, although autologous iliac crest bone graft remains the gold standard because of its biological properties,[1-5,14,22,23] we have used alternative options to reduce donor-site morbidity. Structural grafts obtained from the Dwyer osteotomy or lateral wall resection, as well as the use of PEEK spacers,[24] appear to be effective alternatives (Figure 4). The latter provide excellent structural support and may reduce the risk of graft collapse.[25]

Regarding surgical exposure, the extensile lateral approach provided adequate visualization for removal of previous fixation hardware and performance of complex osteotomies. However, we agree with Pollard and Schuberth[21] that skin tension following distraction is a critical factor. Therefore, in severe deformities, we recommend making the vertical limb of the incision as vertical as possible to minimize the risk of wound-closure complications.

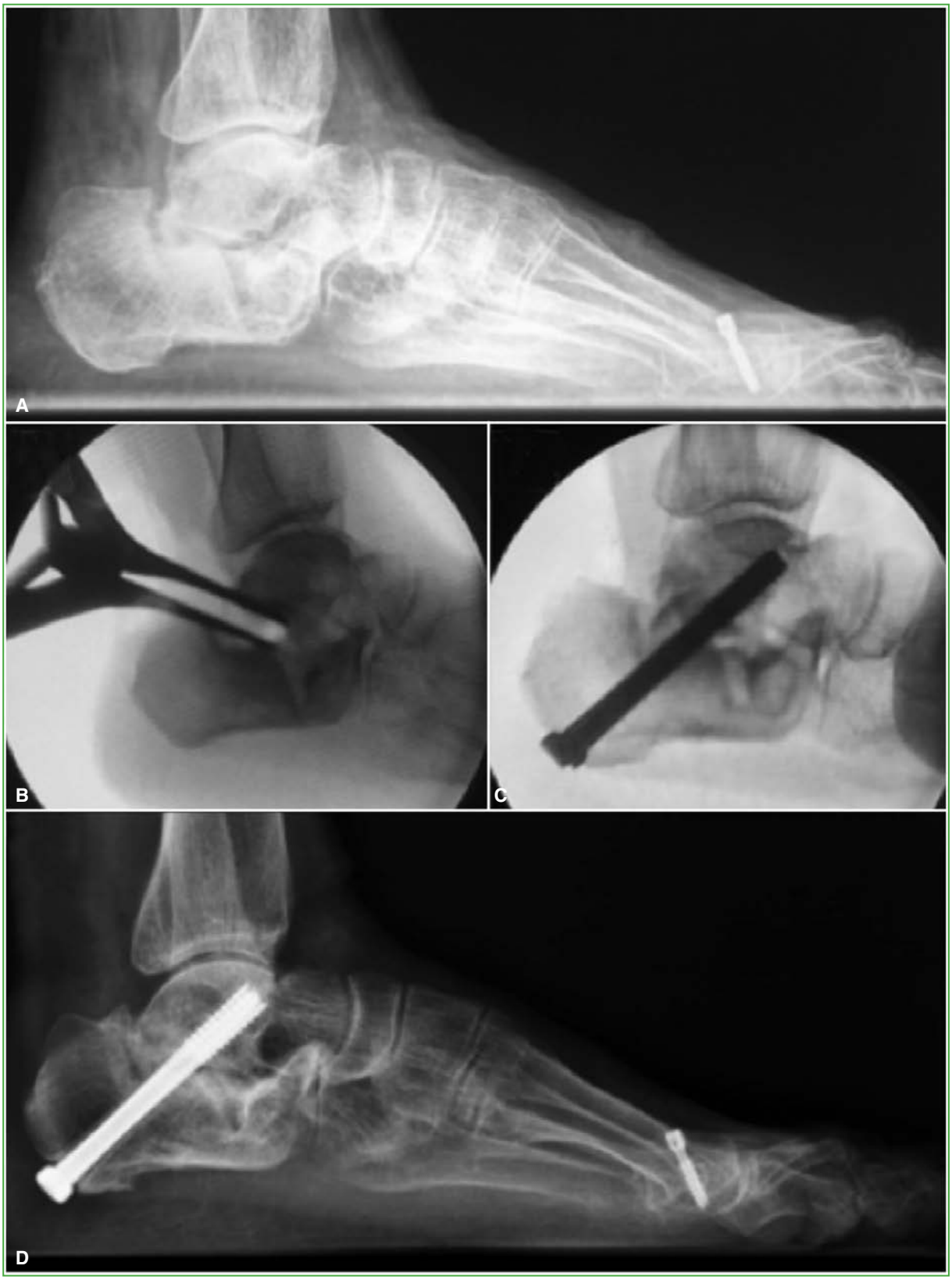

Figure 3. Representative case. Preoperative radiograph (**A**), intraoperative subtalar distraction (**B**), placement of the bone graft (**C**), and postoperative radiograph showing graft collapse (**D**).

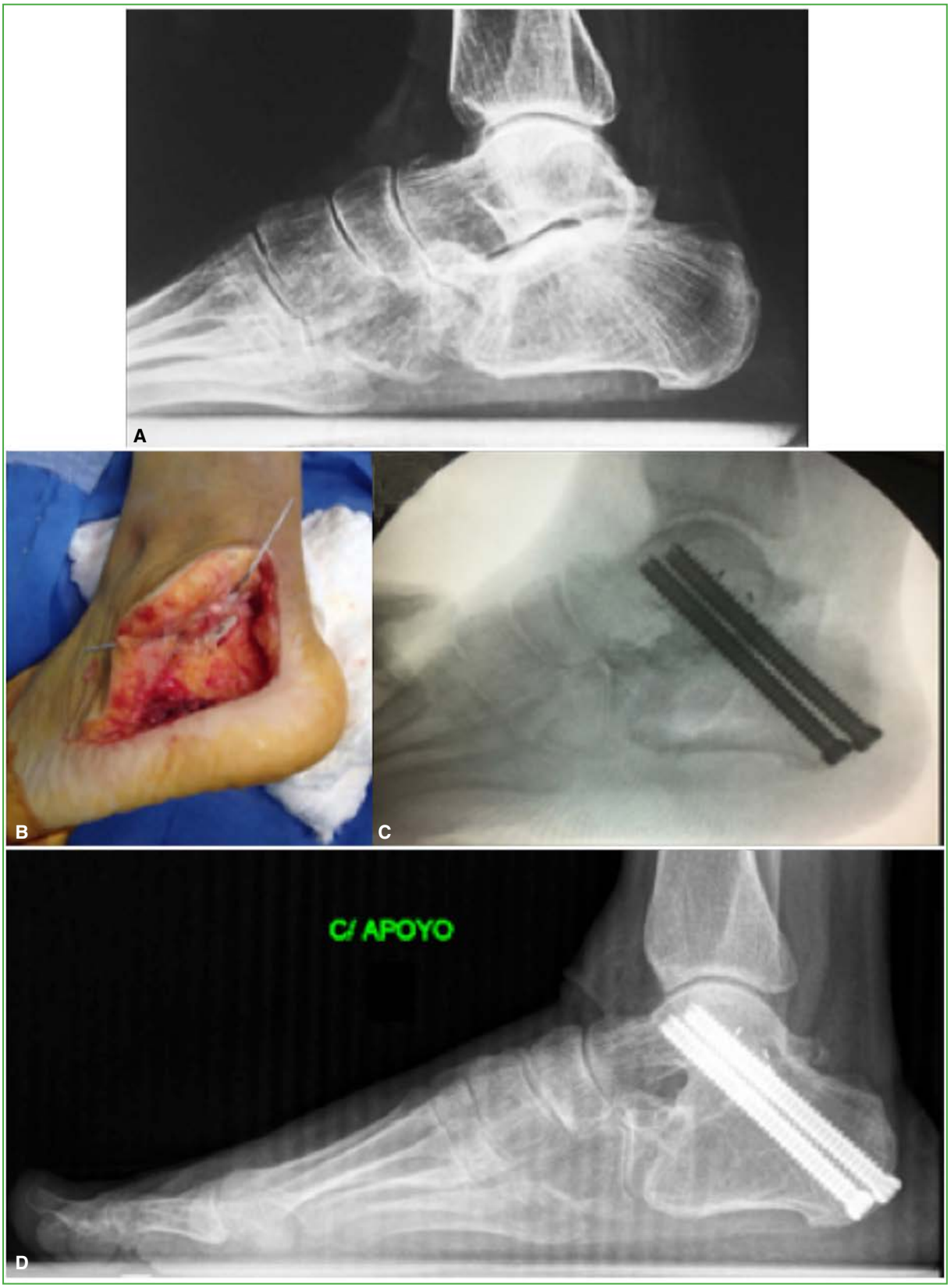

Figure 4. Representative case. Preoperative radiograph (**A**), intraoperative image of the PEEK spacer (**B**), placement of the bone graft (**C**), and postoperative radiograph (**D**).

No infections or wound complications occurred, and the fusion rate in this series was 100%, comparable to that reported in other published studies.[21,25]

The main limitations of this study are the small sample size (7 patients) and the relatively short follow-up period. A major strength is the thorough clinical and radiographic evaluation of the patients.

Future studies with larger cohorts and longer follow-up are needed to further compare fixation methods and the types of bone graft used.

CONCLUSIONS

Distraction subtalar arthrodesis is associated with excellent clinical and radiographic outcomes in patients with calcaneal fracture malunion. The procedure reduces pain, improves function, restores hindfoot height, and improves talar declination.

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

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