

Subtalar distraction bone block arthrodesis

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This retrospective study analyses the results of subtalar bone block distraction arthrodesis used in the treatment of late complications of calcaneal fractures, acute severely comminuted fractures, nonunion (and malunion) of attempted subtalar arthrodeses, avascular necrosis of the talus, and club-foot deformity. Of 39 patients (41 feet) who had this procedure, 35 (37 feet) returned for follow-up after a mean of 70 months (26 to 140). There were 24 men (25 feet) and 11 women (12 feet) with a mean age of 41 years (16 to 63). Each completed a standardised questionnaire, based on the hindfoot-scoring system of the American Orthopaedic Foot and Ankle Society and were reviewed both clinically and radiologically. Of the 37 operations, 32 (87%) achieved union. The mean hindfoot score (maximum of 94 points) increased from 21.1 points (8 to 46) preoperatively to 68.9 (14 to 82) at the final follow-up. The mean talocalcaneal and calcaneal pitch angles were 20.5° and 4.9° before operation, 25.9° and 8.3° immediately after, and 24.6° and 7.7° at the final follow-up, respectively. The mean talar declination angle improved from 6.5° (-10 to 22) before operation to 24.8° (14 to 32) at the final follow-up. The mean talocalcaneal height increased from 68.7 mm before operation to 74.5 mm immediately after and 73.5 mm at the final follow-up. Of the 37 arthrodeses available for review, 32 were successful; 29 patients (30 arthrodeses) were satisfied with the procedure. Minimal loss of hindfoot alignment occurred when comparing radiographs taken immediately after operation and at final follow-up.

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Mobility may be limited in the presence of decreased calcaneal body height, calcaneofibular abutment, flattening of the longitudinal arch, impingement of the tibiotalar neck and loss of ankle dorsiflexion. These conditions may arise as late complications of intra-articular calcaneal fractures. If the calcaneal height is maintained, symptoms may include pain due to post-traumatic arthritis of the subtalar joint. In such cases, isolated subtalar arthrodesis will usually bring relief.¹⁻³

Similar symptoms may occur after failed subtalar arthrodesis, with collapse and avascular necrosis (AVN) of either the talus or calcaneus, or as late sequelae of club foot. Primary and late subtalar bone block distraction arthrodesis has been described for treatment,⁴⁻⁶ and our aim was to analyse the outcome after this procedure with regard to patient satisfaction, complications and correction of deformity, in what is, to the best of our knowledge, the largest series to date.

Patients and Methods

Between 1988 and 1995 the senior authors (LCS, MSM) performed 41 subtalar bone block arthrodeses on 39 patients. The indications included the sequelae of calcaneal fractures (29), acute severely comminuted calcaneal fractures (7), nonunion (and malunion) after attempted subtalar arthrodeses for calcaneal fractures (3), AVN of the talus (1), and club-foot deformity (1).

All patients had severe subtalar pain, loss of the longitudinal arch, anterior tibiotalar impingement, loss of dorsiflexion, and loss of calcaneal height. Of the 29 feet with late sequelae of calcaneal fractures 16 had been treated conservatively and 13 operatively (11 by open reduction and internal fixation, 1 subtalar arthrotomy, and 1 Dwyer osteotomy). The mean time to surgery was 17 months (4 to 78). Three patients (3 feet, 1 at our institution) had had primary subtalar arthrodesis, and all had nonunion and residual deformity of the hindfoot. The mean time from attempted primary arthrodesis to final surgery for these three patients was ten months (7 to 11). The patient (1 foot) with AVN of the talus had not had a previous operation. The other (1 foot) with club-foot deformity had had a soft-tissue operation at the age of four months and a corrective calcaneal osteotomy at the age of 11 years.

Table I. The questionnaire based on the hindfoot score⁷ of the AOFAS

	Points
Pain	
None	40
Mild, occasional	30
Moderate, daily	20
Severe, always present	0
Maximum walking distances (blocks)	
>6	5
4 to 6	4
1 to 3	2
<1	0
Gait abnormality	
None, slight	8
Obvious	4
Marked	0
Hindfoot movement (inversion + eversion (%))	
75 to 100	6
25 to 74	3
<25	0
Alignment	
Good, plantigrade foot, ankle hindfoot well aligned	10
Fair, plantigrade foot, some degree of malalignment, no symptoms	5
Poor, non-plantigrade foot, severe malalignment	0
Activity limitations, support requirements	
No limitations	10
Limitation of recreational activity	7
Limited daily, cane	4
Severe limitation, crutches	0
Walking surfaces	
No difficulty any surface	5
Difficulty uneven terrain	3
Severe difficulties	0
Sagittal movement (flexion + extension)	
Normal or mild restricted (> 29°)	8
Moderate restricted (15 to 29°)	4
Severe restriction	0
Ankle hindfoot stability	
Stable	8
Definitely unstable	0

Autologous bone grafts were taken from the iliac crest for 36 of the 41 feet with allografts from the head of the femur for the other five.

Four patients (4 feet) were excluded, three of whom were lost to follow-up and one who had died. In each of these, however, there was radiological evidence of union at one year. The remaining 35 patients (24 men, 11 women) formed our study group.

All notes were reviewed and a questionnaire, based on the hindfoot score⁷ of the American Orthopaedic Foot and Ankle Society (AOFAS) was completed, retrospectively, to create a preoperative database (Table I). Patients were asked to describe the site, and to score the severity of pain on a scale of 0 to 10, both before and after surgery. Other questions included smoking habits, medication at the time of surgery, height, weight, occupation before and after the procedure, numbness, paraesthesiae, and other complications of the operation. A follow-up questionnaire was completed which combined the results of the physical examination and interview. Of the possible 100 points on the hindfoot score⁷

the maximum possible for a patient with subtalar arthrodesis is 94 because of loss of subtalar movement.

Dorsiflexion and plantar flexion of the ankle were measured with a goniometer, and the feet were examined for altered sensation.⁸ Alignment of the ankle and hindfoot was assessed from a posterior view of the standing patient. Gait was observed to assess limp.

Radiological analysis was based on lateral views taken before operation, immediately after and at follow-up, and on Broden views.⁵

Measurement of the talocalcaneal angle was made using a line representing the long axis of the talus and its intersection with the longitudinal axis of the calcaneus.⁹ The calcaneal pitch angle, represented by a line at the plantar cortex of the calcaneus and its intersection with the floor, and the talar declination angle which is formed by the axis of the talus to the plane of support, were measured. The talocalcaneal height was also assessed before and after operation by measurement from the dome of the talus to the base of the calcaneus (Fig. 1).

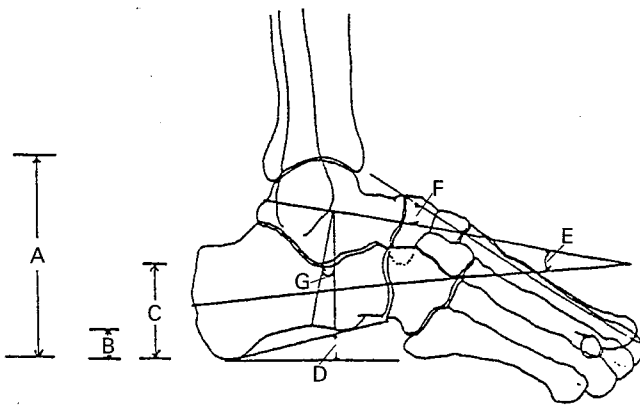


Fig. 1

Diagram showing the radiological measurements: A, talocalcaneal height; B, cuboid to floor distance (the distance from the most inferior aspect of the cuboid to the floor on a weight-bearing lateral radiograph); C, navicular to floor distance (the distance from the most inferior aspect of the navicular to the floor on a weight-bearing lateral radiograph); D, calcaneal pitch angle; E, talocalcaneal angle; F, talus-first metatarsal angle; and G, talus declination angle (reproduced with permission from Buch BD, Myerson MS, Miller SD: Primary subtalar arthrodesis for the treatment of comminuted calcaneal fractures. *Foot Ankle Int* 1996;17:61-70).

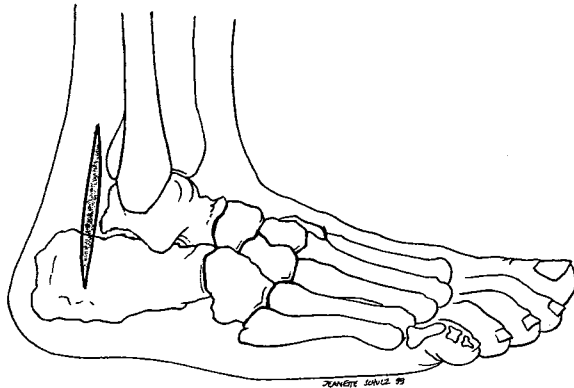


Fig. 2

Diagram showing vertical incision which allows closure without tension after distraction.

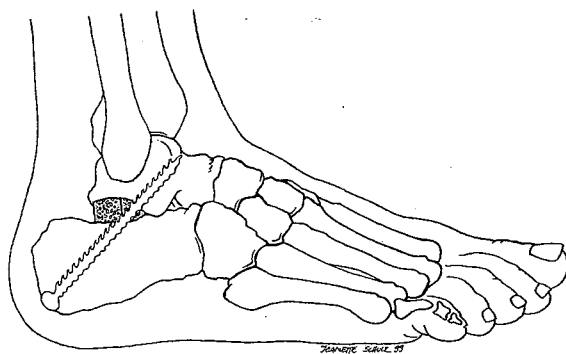


Fig. 3

Diagram showing a bone block placed in the subtalar joint space to restore calcaneal height and talar inclination. Fixation is performed by one or two fully-threaded screws.

Operative technique. The patient is positioned prone or lateral with the affected side up and a tourniquet is applied. A longitudinal posterolateral incision is made anterior to tendo Achillis (Fig. 2).^{2,4} In those with fracture of the calcaneus, the lateral calcaneal wall is exposed and excised to a more normal width. This procedure also serves to decompress the peroneal tendons and the tip of the fibula.

After the introduction of a laminar spreader to distract the subtalar joint, the residual cartilage is debrided and the subchondral surfaces prepared. If distraction causes a varus tilt of the hindfoot, a unilateral half-pin distractor is applied medially to the tibia and calcaneus. The subtalar joint space is measured, and either a tricortical iliac bone block or a femoral head is contoured to fit the space. The bone block is positioned while holding the hindfoot in distraction and slight valgus, and one or two screws are placed through an incision in the posterior heel across the calcaneus into the talus (Fig. 3). After routine closure a compression splint is applied.

A non-weight-bearing cast is retained postoperatively for six weeks, followed by a weight-bearing cast for a further six weeks, except for patients with acute fractures (7 in the current series) who are not allowed to bear weight for 12 weeks.

Results

Clinical. At a mean follow-up of 70 months (26 to 140) 32 of the 37 arthrodeses (31 patients) had a sound fusion with a mean time to fusion of 18 weeks (10 to 26). The mean AOFAS hindfoot score for these feet was 21.1 points (8 to 46) before operation and 68.9 points (14 to 82) at the final follow-up (Table II). Of the 31 patients, 29 were satisfied with the outcome. Of the two dissatisfied patients, one (2 feet) had complex regional pain syndrome (CRPS) before surgery and reported increased pain, and the other who had diabetes continued to suffer from tarsal tunnel syndrome and sural neuralgia unrelated to the procedures.

Before surgery, six patients (6 feet) were not working. Of these, two had retired (not because of the injury), one was disabled as a result of the injury, one was addicted to analgesics and was unemployed, and two were unable to find work. At the final follow-up, a further three patients (3 feet) were not working. The remaining 26 patients (28 feet), including those with nonunion, returned to the same type of occupation.

Of the 31 patients (32 feet) with successful fusion, 26 had less pain, four had similar pain, and one had increased pain (bilateral CRPS) at follow-up. On a pain scale from 0

Table II. Mean (range) AOFAS and pain scores for the 31 patients who underwent subtalar distraction bone block arthrodesis

	AOFAS score ⁷	Pain score
Before operation	22.1 (8 to 46)	8.1 (7 to 10)
Follow-up	68.9 (14 to 82)	2.0 (0 to 10)

to 10 points, the mean score was 8.1 points (7 to 10) before operation and 2.0 points (0 to 10) at the final follow-up (Table II). Seven patients were free from pain at the final follow-up. The patient with CRPS reported a pain level of 8.0 points before operation and 10.0 points at the final follow-up. Evaluation of function and walking distance showed that in 29 patients (29 feet), the walking distance and the activity improved after surgery.

At the final follow-up, the mean plantar flexion of the ankle was 32° (5 to 50) and dorsiflexion was 0° (0 to 20). All patients had less movement at the ankle compared with that of the contralateral side.

A total of 33 patients (35 feet), including those with nonunion (4 patients, 5 feet), stated that they would undergo the surgery again. Only the patient who developed CRPS and the one with diabetes stated that they would not.

Radiological. The mean preoperative talocalcaneal angle of 20.5° (5.0 to 35.0) and calcaneal pitch angle of 4.9° (-15.0 to 15.0) were corrected to immediate postoperative values of 25.9° (10.0 to 39.0) and 8.3° (0.0 to 23.0) and to final values at follow-up of 24.6° (8.0 to 39.0) and 7.7° (-4.0 to 23.0), respectively. The mean talocalcaneal height increased from 68.7 mm (54.0 to 79.0) before operation to 74.5 mm (63.0 to 89.0) immediately after surgery and to 73.5 mm (62.0 to 79.0) at the final follow-up. The mean talar declination angle increased from 6.5° before operation (-10 to 22) to 24.8° (14 to 32) at the final follow-up (Fig. 4).



Fig. 4a



Fig. 4b

A 35-year-old woman with a closed fracture of the calcaneus. Lateral weight-bearing radiographs show a) loss of heel height, a horizontal talus, and subtalar arthritis and b) the foot two years after subtalar distraction arthrodesis.

Statistical analysis showed significant differences between the preoperative and follow-up findings in the talocalcaneal ($p = 0.002$), calcaneal pitch ($p = 0.03$) and talar declination angles ($p < 0.001$).

AVN of either the talus or the calcaneus was noted radiologically in 20 feet and confirmed at operation. Five of these patients (5 feet) developed nonunion. The mean time to union for the remaining 15 (15 feet) was 14.5 weeks (10 to 18).

Complications. All five patients (5 feet) with nonunion had AVN of the talus or the calcaneus. One has had a successful revision operation, one was treated further during the study period, and three are awaiting revision. In three other patients (3 feet), progression of osteoarthritis was observed in the transverse tarsal joints. Seven patients (7 feet) had sural neuralgia at their last follow-up. Two of these had been primarily treated by casting and sural neuralgia had been present in one at the initial presentation. Five had had open reduction and internal fixation of calcaneal fractures before subtalar distraction arthrodesis. One of these had a sural neuroma at presentation. Prominent metalwork was removed in four of the 37 feet. One patient developed an infection at the iliac donor site and another osteomyelitis at the site of the arthrodesis. Both were successfully treated by debridement and antibiotics.

Discussion

Symptomatic subtalar arthritis after intra-articular calcaneal fractures can be treated by subtalar arthrodesis *in situ*.¹⁰⁻¹⁵

Often this is combined with decompression of the lateral wall to relieve symptoms from calcaneofibular abutment and subfibular impingement. *In situ* subtalar arthrodesis cannot, however, restore physiological heel height, the talocalcaneal angle, or the talar declination angle in injuries or deformities which involve collapse at the subtalar joint. Carr et al⁴ introduced subtalar bone block distraction arthrodesis to restore satisfactory orientation of the hind-foot in an attempt to improve function. The concept was that substantial loss of heel height may lead to symptomatic anterior tibiotalar impingement, and they recommended that this deformity be corrected. In a retrospective review of 42 patients, Myerson and Quill¹ provided guidelines for the surgical management of the various late complications of calcaneal fractures. The indication for bone block distraction was loss of heel height of more than 8 mm and radiological evidence of anterior tibiotalar impingement demonstrated by an abnormal talar declination angle. Pain felt in the anterior aspect of the ankle was not a prerequisite for subtalar bone block distraction.

The results of this procedure have been favourable. Carr et al⁴ reported satisfactory preliminary functional results in six of eight patients followed for more than one year. Several other authors have reported results using the same technique with longer follow-up.^{1,6,16,17} Myerson and Quill¹ noted good results in seven of 14 after this operation.

Amendola and Lammens¹⁶ reported that, based on a visual analogue scale, 11 of 15 patients were satisfied with the procedure. Chan and Alexander¹⁷ noted an improvement in the mean AOFAS hindfoot score from a preoperative value of less than 50 to 76.5 points at follow-up. Bednarz et al⁶ found that the mean AOFAS hindfoot score improved from 25 points preoperatively to 75 points at a mean follow-up of 33 months. Burton et al⁸ noted a mean AOFAS hindfoot score of 76.1 points for the 15 feet (14 patients) in their study at a mean follow-up of 47 months. The results of our study are similar to those of previous reports; the mean AOFAS hindfoot score improved from 21 points preoperatively to 68 points at a mean follow-up of 70 months.

There is concern as to the rate of union after bone block distraction arthrodesis. With an interpositional bone graft, two interfaces must unite and most studies have shown a rate of union of 100%.^{1,8,16,17} The original study by Carr et al⁴ included only one nonunion. Bednarz et al⁶ reported a rate of union of 86%, with four nonunions occurring in patients who smoked. Our study had an identical rate of union, but of the five patients with nonunion, only one smoked. Although we believe that smoking contributes to a higher rate of nonunion, as demonstrated in an earlier study,¹⁰ our results do not show a negative influence of smoking. Since four of the five cases of nonunion occurred in patients treated with allograft, its routine use for subtalar bone block distraction arthrodesis is not recommended. To optimise the healing potential, it is important to remove any avascular bone from the sites of arthrodesis.¹⁰ In our study, and those of Chan and Alexander¹⁷ and Burton et al,⁸ no cases of varus malunion were observed.

Objective radiological evaluation of the talocalcaneal angle, talar declination angle, and talocalcaneal height suggests that bone block distraction improves alignment of the hindfoot in the sagittal plane. The talocalcaneal angle improved from 20.5° before operation to 24.6° at follow-up. Other authors have reported similar or better correction of this angle.^{4,6,8} The substantial change in the talar declination angle from 6.5° to 24.8° exceeded that of other reports,^{4,6,8,16} although the final mean value for this angle was essentially identical to that reported by Carr et al.⁴ It is unlikely that our patients had a greater preoperative deformity than that of other study groups; the difference is most likely to be a reflection of variability in radiological interpretation. Talocalcaneal (or heel) height increased from 68.7 to 73.5 mm in our study, which is similar to the improvement noted by Amendola and Lammens,¹⁶ Burton et al⁸ and Carr et al.⁴

A comparison of the initial postoperative radiographs with those at final follow-up showed a loss in most radiological variables. Although some of the loss may be attributable to weight-bearing, these findings suggest settling within the hindfoot during incorporation of the graft. Similar observations were made by Chan and Alexander¹⁷ who found a mean loss of 4.7 mm in heel height from the time of surgery to final follow-up. This loss was seen when a

single tricortical graft of the iliac crest was used; with a double graft the mean loss of heel height was 1.4 mm. In our investigation, the mean loss with a single-graft technique was 1.0 mm. Carr et al⁴ noted loss of heel height in two patients, both of whom lacked internal fixation with which to secure the bone block. One also had a Dwyer lateral closing wedge calcaneal osteotomy.

Although a satisfactory outcome may be obtained using subtalar bone block distraction arthrodesis, the complexity of the procedure introduces a number of potential complications such as wound healing,^{4,16} neuralgia,^{1,8,16} prominent metalwork^{1,4} and varus malunion.^{1,6,16} We recommend the vertical posterolateral incision introduced by Gallie¹⁸ and popularised by Carr et al.⁴ In our study and those of others, no wound problems occurred using this approach.^{6,8,17} Myerson and Quill¹ reported two superficial wound infections in 14 patients with this approach, and Amendola and Lammens¹⁶ noted one wound dehiscence in 15 patients managed by a curvilinear incision. Carr et al⁴ reported five superficial wound infections in 16 patients using a J-shaped incision, but fewer difficulties when the Gallie approach was used.

In order to restore heel height, the bone block is used to distract the hindfoot. Although some compression is applied for stability of the graft, distraction may be associated with less compression than is usually used with arthrodesis in situ. Removal of the screw may be needed if it causes symptoms. In our series, and in those of Myerson and Quill¹ and Carr et al,⁴ 4/37 (11%), 7/14 (50%), and 7/16 (44%), respectively, required removal of metalwork, but other series have suggested that this is rarely, if ever, required.^{6,8,16} In contrast to other series in which the screws were applied from the calcaneus into the talus, Chan and Alexander¹⁷ inserted the screw from the talus into the calcaneus. Although this may involve a greater risk to the neurovascular bundle, it probably reduces the prominence of the screw.

Neuralgia has been reported as a complication of subtalar bone block distraction arthrodesis with the sural nerve at the greatest risk of injury. Six of our patients had this problem. Carr et al⁴ had one sural neuroma despite using routine sural nerve transection and burial, and Burton et al⁸ found one case of sural neuralgia in a series of 15 distraction arthrodeses. Although Myerson and Quill¹ observed no cases of sural neuralgia, they cautioned about the risk of entrapment of the tibial nerve.

Finally, CRPS may occur or be worsened after bone block distraction arthrodesis. Carr et al⁴ warn of a 'central pain syndrome'. In our series and in that of Amendola and Lammens,¹⁶ this was diagnosed in one and two patients, respectively, who had a poor result. Although the nerves in the hindfoot, particularly the sural nerve, are at risk for direct injury, subtalar arthrodesis with an interpositional bone graft for distraction may create a traction neuralgia, resulting in compromise of the sural and/or tibial nerves which may develop into CRPS.

Although the procedure may be successful it may also be fraught with complications and it is debatable if the outcome is better than that of in situ arthrodesis combined with decompression of the lateral wall. Myerson and Quill¹ reviewed the late complications of calcaneal fractures and compared the results of various treatments after empirically devising a treatment algorithm. They concluded that bone block distraction is preferable to in situ arthrodesis for patients with loss of heel height, thus supporting the conclusions of Carr et al.⁴

In a retrospective study, Chandler et al¹⁵ suggested that the indications for subtalar bone block distraction arthrodesis should be more closely scrutinised. In their investigation of 19 fusions in situ they observed that even with loss of heel height and some continuing minor pain in the ankle, subtalar arthrodesis without interpositional bone grafting gave satisfactory results. After reviewing radiological parameters, they suggested that distraction is indicated only for patients with disabling pain in the ankle and less than 10° of dorsiflexion. A larger series comparing subtalar arthrodesis with and without distraction is necessary to validate their hypothesis.

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