The subtalar distraction bone block arthrodesis following the late complications of calcaneal fractures: a systematic review

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Abstract

Introduction: The late complications following a displaced intra-articular calcaneal fractures includes painful arthrosis for which a subtalar fusion might be considered. In case of malalignment due to loss of height and varus deformity a reconstructive arthrodesis is necessary. The primary aim of the current review study was to assess the functional outcome of the subtalar distraction bone block arthrodesis in the management of late complications of displaced intra- articular calcaneal fractures.

Methods: The literature was searched for studies in which a subtalar distraction bone block arthrodesis was used in the management of persistent complaints following a displaced intra-articular calcaneal fractures, after its first description in 1988 up to November 1st 2011. The methodological quality of the included studies was assessed using the Coleman Methodology Score.

Results: Twenty-one studies reporting on 456 patients were identified. In 93 percent the procedure was a salvage procedures following the late complications of a calcaneal fracture (372 cases). Duration of follow-up ranged from 21 to 108 months (average 40 months). Union rates were reported with an overall average of 96% (range 83 to 100 percent). The average modified AOFAS score (maximum 94 points) was 73 points at final follow-up (range 64-83 points). Six studies reported pre- and post-reconstruction AOFAS outcome scores with an average increase of 44.2 points. Wound complications occurred in approximately six percent. With the exception of one study all were level 4 retrospective case series, with an average Coleman Methodology Score of 55 (range 41–79) points.

Conclusions: The subtalar distraction bone block arthrodesis is a technically demanding procedure which, in the right hands, provides an overall good result. This is reflected in a significant increase in outcome scores post-operatively. Although most complications are considered minor, there are several pitfalls which should be recognized and avoided.

Keywords

calcaneal fracture; complications; malunion; subtalar arthrodesis

Introduction

Outcome after displaced intra-articular calcaneal fractures directly correlates with residual deformities. The typical range of deformities is highly dependent on the severity of the fracture and the initial treatment. Treatment fails more commonly after non-operative compared with operative treatment, hence the six fold increase in the need for a secondary subtalar arthrodesis after conservative management (1). Residual complaints after a mildly displaced fractures with an intact height and width treated conservatively or a fracture adequately treated operatively will most like be due to incongruence or cartilage damage at the subtalar joint and will respond well to an in situ subtalar arthrodesis. On the other hand a severely displaced calcaneal fracture treated conservatively or a failed operative treatment where height and width are not restored will cause more than just bother from subtalar arthritis, but also from, amongst others, fibular abutment (peroneal impingement) and tibiotalar impingement. Various different techniques are available, each with modifications, to address some or all deformities and subsequent complaints after failed initial treatment of displaced intra-articular calcaneal fractures (2-11). An overview of the most common deformities and residual complaints after a displaced calcaneal fracture and the subsequent treatment strategies is shown in Table 1.

One technique which combines subtalar arthrodesis and realignment of the hindfoot is the subtalar distraction bone block arthrodesis, first described by Carr et al. in 1988 (12-15). To date, only relatively small studies have been published on this technique.

The aim of the current systematic review was therefore to assess the literature on the functional outcome of the subtalar distraction bone block arthrodesis in the treatment of failed initial management of displaced intra-articular calcaneal fractures and to determine overall union and complication rates.

Material and method

Literature search

A literature search was conducted to identify studies in which a subtalar distraction bone block arthrodesis was performed for the treatment of the late complications of displaced intra-articular calcaneal fractures. The electronic databases up to November 1st 2011 of 'the Cochrane Library', 'Pubmed Medline', 'EMbase', and 'Google Scholar' were explored using the combination of the following search-terms and Boolean operators: ‘subtalar’ OR ‘talocalcaneal’ AND 'arthrodesis' OR 'fusion' AND 'distraction' AND ‘calcaneus’ OR 'calcaneal' OR 'calcis'. No restriction in language and publication date were applied in the initial search. Publications were requested at the university medical (internet) library and reviewed. In addition, a comprehensive search of reference lists of all identified articles was conducted to find additional studies. An article was found eligible when it concerned 1) the salvage following residual complaints after the treatment of displaced intra-articular calcaneal fractures, 2) usage of subtalar distraction bone block arthrodesis as surgical technique. Series in which more than one operative treatment modality was used, were included only if sufficient data on follow-up, union rates, and outcome could be extracted on those patients treated by subtalar distraction bone block arthrodesis.

Besides a systematic review on outcome, union rates and complications; the studies were also reviewed for an overview of the indications of a subtalar distraction bone block arthrodesis and the technical aspects of this realignment arthrodesis.

Coleman Methodology Score

The studies concerning the subtalar distraction bone block arthrodesis were tested for their methodological quality according to the Coleman Methodology Score (CMS) [10]. This score

was introduced in 2000 by Coleman et al. and assesses a study for methodological quality on ten items with zero points as minimum (worst quality) and 100 points as maximum (best quality with low influence of bias, confounding factors and chance) [10].

Results

A total of 25 publications were identified from its first description in 1988 by Carr et all to November 1st 2011. Four studies were excluded being review studies or technical descriptions (12-14, 16), leaving 21 studies available for analysis on outcome, union rates, and complications (Table 2).

Literature review

The twenty-one studies reported on 456 patients (average 22 per study; range 4-40). In 19 studies the average percentage of salvage procedures post calcaneal fracture was reported and approached 93 percent (372 cases). Fifteen studies reported time between the initial injury and the salvage procedure; which was on average 30 months (range 16-66). Duration of follow-up was mentioned in seventeen studies and ranged from 21 to 108 months (average 40 months). Union rates were reported in all studies, with an overall average of 96% (range 83 to 100 percent). When studies with less than ten procedures were removed the fusion percentage remained 95 percent.

Considering outcome following a subtalar distraction bone block arthrodesis three studies reported outcome as the percentage good to excellent result, which ranged from 81 to 87 percent (15, 17-18). The most frequently used outcome score was the American Orthopaedic Foot Ankle Society (AOFAS) hindfoot score. The AOFAS hindfoot score (range, 0 to maximum 100 points) focuses on pain, the ability to perform daily activities, walking distance, footwear requirements, terrain difficulties, gait abnormalities, range of motion of the subtalar and ankle joint, and alignment. Because subtalar motion is excluded as goal of the procedure the maximum score following a subtalar distraction bone block arthrodesis is 94 point.

One study reported only an increase of 46 points on the modified AOFAS score (19). A total of 15 studies reported an average modified AOFAS score (maximum 94 points) of 73 points at final follow-up (range 64-83). Six studies reported pre- and post-reconstruction AOFAS outcome scores (17, 20-24). The average pre-surgery score was 29.4 points, which in all studies statistical significantly increased to an average of 73.6 post-surgery (average increase 44.2 points; range 32-50).

Complications

The occurrence of complications was reported in almost all studies. However, in two studies it was unclear whether these complications occurred in the distraction arthrodesis group (25-26). Superficial wound infection and dehiscence varied between zero and 31 percent in 421 patients. The overall rate of superficial wound complications was approximately five percent (N = 21). A total of four deep infections were reported in these same number of patients. Malunion or secondary dislocation was reported in thirteen cases, sural neuritis in twelve and complex regional pain syndrome in four new cases. The most common secondary procedure was implant removal, which was reported in 41 cases at follow-up.

Indication

The indication for a realignment subtalar distraction bone block arthrodesis of the hindfoot following a failed initial treatment of a displaced intra-articular calcaneal fracture (Figure 1a) are the same four indications as for any arthrodesis when unresponsive to conservative measures: 1) achieving correction of the deformity, 2) relieving pain, 3) stabilizing joints, and 4) improving functional outcome (8). Similar as in an in situ subtalar arthrodesis there is painful subtalar arthrosis, but in contrast there is also significant loss of height, 8mm or more compared with the uninjured contralateral side on a weight-bearing radiograph (27), with or

without pain in the anterior aspect of the ankle due to tibiotalar impingement. Anterior tibiotalar impingement can be demonstrated by a talar declination angle of 20 degrees or less on a lateral weight-bearing radiograph (27). A different physical sign of significant hindfoot height loss is less than 10 degrees dorsiflexion of the ankle (28).

Technique (Figure 1b-d)

There are several modifications described in the literature. The patient is usually positioned prone (25, 29), or in a lateral decubitus position (15, 21, 25, 27). Infrequently the patient is positioned in a supine position (30). To prevent problems with closing the wound after restoring height frequently a posterolateral Gallie incision is utilized (15, 17, 19, 21, 23-25, 29). In cases where a previous extended lateral approach is used or implant removal is required an extended lateral approach (Seattle modified Kocher or Atkins approach) can be used (19, 31-32). Other approaches used are a more direct approach following the peroneal tendons (according to Judet) (15, 27, 33-34), a sinus tarsi approach (modified Palmer) (20, 22, 30, 35), or a posterior trans-calcaneal tendon approach (36). Frequently more than one incision is used per study, making comparison of wound complications difficult. The direct approach however seems to suffer from more complications, especially delayed closure or dehiscence (15, 34, 37). Peroperatively the sural nerve can be transected and buried in muscle when there is too much traction on it after restoring height (15). Depending on the severity of the lateral calcaneal extrusion most studies advise a lateral wall resection to reduce width and decompress the peroneal tendons and sural nerve (31). Different tools can be used to create space between the talus and calcaneus: a medially placed femoral distractor, laminar (bone) spreader, or a specially designed (Hintermann distractor) spreading forceps with holes for Kirschner wires. The use of a anterior or posterior (depending on patient position) tricortical iliac crest graft is advocated by most (15, 17, 19, 21, 25, 27, 29, 32, 38), other grafts are structural interposition grafts frequently from (fresh frozen) donor femoral head allograft (23-24, 33), or with the use of the resected lateral wall

(31). The graft is placed more medially if there is an increased varus alignment of the hindfoot. Two individual grafts have been proposed to prevent height loss during follow-up (38). To fixate the bone block and to reduce motion between talus and calcaneus one or two screws are placed. These are usually large caliber screws (6.5 mm or more) to resist large forces, they are partially threaded to gain compression or fully treaded to prevent collapse, and placed from heel to talus or vice versa, which usually gives less complaints related to the implant but might bring harm to the neurovascular bundle. The most frequently used after-treatment is 12 weeks of plaster or brace of which the first six to eight weeks are nonweight-bearing.

Pre- and postoperative radiographical analysis

The following parameters (Figure 2) are considered useful in the pre-operative and post-reconstruction radiographical analysis and pre-operative planning: a. talocalcaneal (heel) height, b. navicular and c. cuboid to floor distance, d. calcaneal inclination (pitch) angle, e. talocalcaneal angle, f. talar declination angle, and the g. talus-first metatarsal (Meary) angle. As there is quite some variance in between persons, it is best to compare these measurements and angles to the uninjured side if possible.

Coleman Methodology Score

The average Coleman Methodology score was 55 points (range 41 to 79). The average score of studies published before 2000 the CMS was 52, for studies after 2000 this score was 57 points on average.

Discussion

This review reports on the results of twenty-one studies on the functional outcome of subtalar distraction bone block arthrodesis in the management of late complications of displaced intra- articular calcaneal fractures. A total of 456 patients were treated of which 93 percent was a salvage procedures following the late complications of a calcaneal fracture (372 cases). The average modified AOFAS score (maximum 94 points) was 73 points at final follow-up (range 64-83 points) and six studies reported pre- and post-reconstruction AOFAS outcome scores with an average increase of 44.2 points. Wound complications occurred in approximately six percent.

The union rates were reported with an overall average of 96% (range 83 to 100 percent) which is quite similar to the union rates of in situ subtalar arthrodesis (94 percent) after a calcaneal fracture(8) or primary arthrodesis union rates (97 percent) (39). Most studies use tricortical iliac crest graft and only a few use allograft (23-24, 33). And even though Trnka saw 80% nonunions in five cases with an allograft, others have shown adequate union rates (23-24, 33). Other complication rates were quite low, with the exception of the need for implant removal, even though this procedure is considered technically demanding by many. This might be explained by the fact that most studies came from large centers with a well-renowned expertise in complex foot and ankle surgery.

There is a known improved outcome of subtalar arthrodesis after an initial operative treatment of a displaced intra-articular calcaneal fracture compared with initial conservative management (40). This is also reflected in the study by Chen, where the best restoration of height provided an improved functional outcome (22). Huang et al. found similar improved outcome with an in situ subtalar arthrodesis plus sliding osteotomy (rather than a distraction arthrodesis) compared with an arthrodesis alone (2).

The choice for a treatment strategy for the different residual deformities can be guided by the Stephens and Sanders classification (41). This classification divides calcaneal malunions into three groups. In a Type-I malunion there is a large lateral wall exostosis without subtalar arthritis, which can be treated with a lateral wall resection. A Type-II deformity displays a large lateral wall exostosis concomitantly with significant subtalar arthritis, which in addition to the lateral wall resection needs a subtalar arthrodesis. Finally, a Type-III malunion exists of a lateral exostosis, significant subtalar arthritis, and calcaneal body malalignment of more than 10 degrees hindfoot varus, which in adjunct to the treatment of a type-II needs a correction osteotomy (e.g. Dwyer osteotomy). In this type there is frequently a significant amount of loss of height. Compared with other procedures, which usually correct only one aspect of the residual deformities after a calcaneal fracture, the subtalar distraction bone block arthrodesis addresses all deformities. However, other described reconstructive procedures for malunited calcaneal fractures can be useful additives. Lateral impingement from bulging lateral wall should be adequately resected (5-6, 10-11). This should be done in combination with any type of fusion as resection alone might provide less favorable result (27). Plantar exostosis should be resected (7). And a sliding, open- or closed-wedge osteotomy might be necessary for residual hindfoot malalignment (2-4, 42-43).

With the exception of one study all were level 4 retrospective case series, with an average Coleman Methodology Score of 55 (range 41–79) points. This is also the main limitation of the current review. Comparing in situ subtalar arthrodesis with the distraction bone block arthrodesis in cases with severe loss of heel height might be undesirable or even unethical. But more prospective studies with a clear treatment protocol(31), guided by an established malunion classification(41, 44), are needed to refine the technique of the distraction bone block arthrodesis. This might also provided more clarity as to which is the best approach,

fixation technique and after-treatment. On the other hand, this complete systematic review, containing data of twenty-one studies, provides good baseline data to use as comparison in future research, and as patient education to set realistic expectations.

In conclusion, the subtalar distraction bone block arthrodesis is a technically demanding procedure which, in the right hands, provides an overall good result. This is reflected in a significant increase in outcome scores post-operatively. Although most complications are considered minor, there are several pitfalls which should be recognized and avoided.

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Tables and figures

Table 1. Post-traumatic deformities, complaints and reconstructive measures following a displaced intra-articular calcaneal fracture

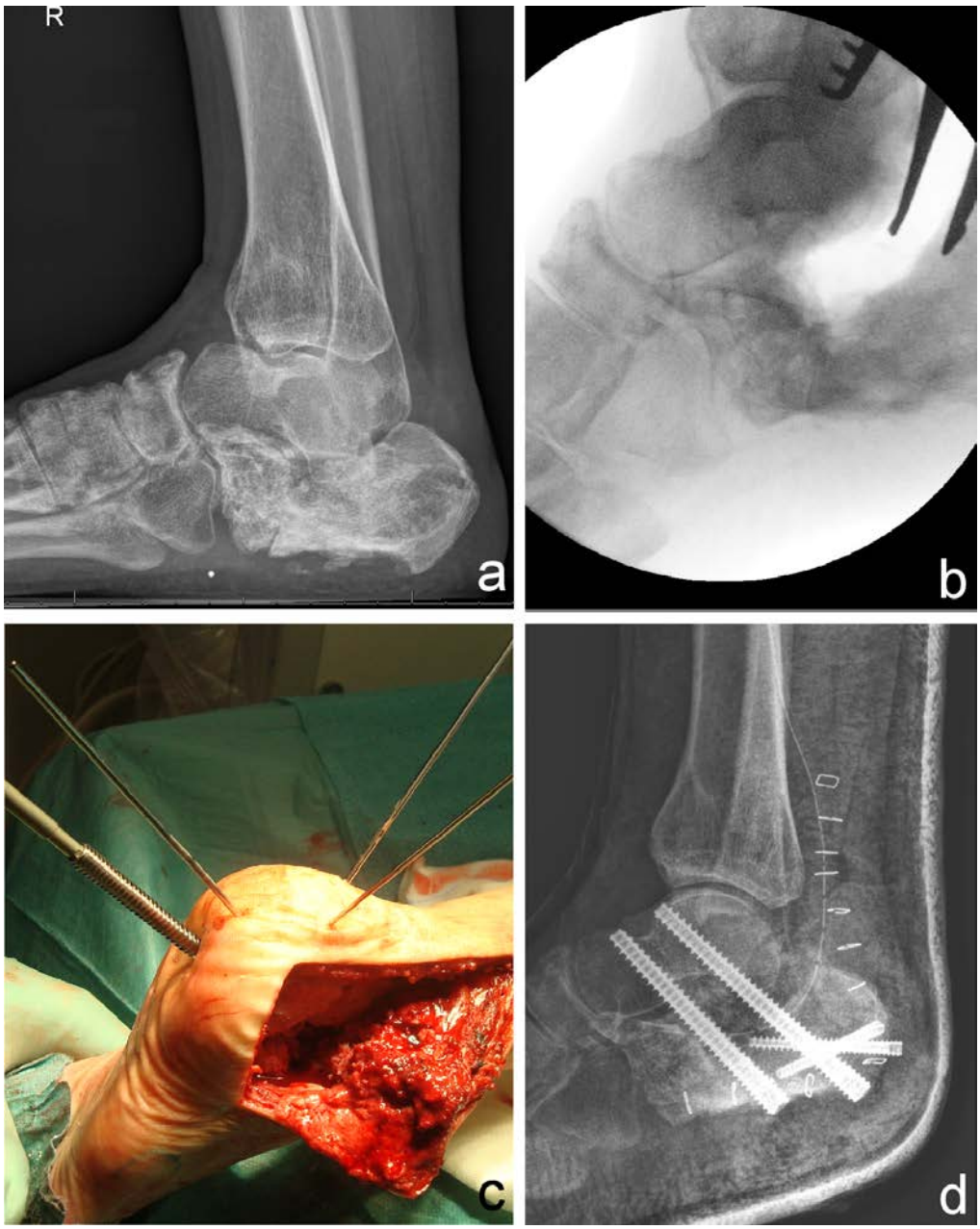
Deformity of initial injury	**Resultant**	**Solution**
Loss of height caused by collapse of the posterior talocalcaneal facet	1. Shortened gastroc-soleus complex 2. Decrease talar declination; horizontal talus a. Tibiotalar impingement with impaired dorsiflexion of ankle joint b. Subluxation at the talonavicular (chopart) joint c. Incongruence at the ankle joint 3. Shoe ware problems (malleoli on shoe edge) 4. Limb leg discrepancy	Restore height and subsequently increase talocalcaneal angle by inserting bone block in subtalar joint
Loss of longitudinal arch and flattening in severe fractures causing rockerbottom heel or 'Banana-shape'	Painful ambulation, fatigue, tendinitis caused by pes planus	Restoring talocalcaneal angle, addional downward calcaneal tuberosity displacement osteotomy
Widening of calcaneus	1. Fibular abutment 2. Lateral impingement, tendinitis, dislocation of the peroneal tendons and impingement of nerve	Reduce width by lateral wall resection (exostectomy) to decompress tendons and nerve
Hindfoot varus or valgus deformity	Painful ambulation	Place bone-block medially in varus deformity Additional Dwyer closing wedge osteotomy or lateral/medial calcaneal tuberosity displacement osteotomy
Intra-articular displacement with subtalar and/or calcaneocuboid joint incongruence	1. Painful arthritis during ambulation 2. Stiffness caused by arthrofibrosis	Subtalar, double or triple arthrodesis
Plantar exostosis	Painful ambulation	Resection
Crushed heel fat pad	Painful ambulation	Orthotic (silicone or rubber) insoles

Table 2. Bone block distraction arthrodesis outcome measures

Author (year)	LOE	Patients (n) / calcaneal # [n]	Time from injury (months)	Follow-up (months)	Union rate (%)	AOFAS/other scoring system	Return to work (%)	Coleman score
Carr (1988)(15)	4	13 [16]	20 (6-34)	22 (3-63)	94	86% G+S[1]	-	44
Myerson (1993)(27)	4	14 [14]	22 (5-90)	34 (24-43)	100	p35.6/a67.9 (26-94)[1]	71	44
Amendola (1996)(20)	4	15 [15]	48	-	100	p38.3/a70.3	-	53
Bednarz (1997)(21)	4	28 [19]	34 (9-132)	33 (11-54)	86	p25/a75 (43-94)	64	69
Chan (1997)(38)	4	9 [9]	74 (64-103)	-	100	76.5 (53-93)	-	41
Burton (1998)(29)	4	12 [13]	22 (12-60)	45 (25-76)	100	76	100	53
Chen (1998)(22)	4	32 [36]	16 (4-26)	64 (52-86)	97	p47.4/a83.1[2]	94	58
Tiemann (1998)(35)	4	27 [16]	66.4 (3-456)	14	100	75.8	85	56
Marti (1999)(30)	4	22 [23]	-	108 (60-240)	96	72[3]	-	54
Easley (2000)(25)	4	34 [N.A.]	17 (4-126)	51 (24-130)	83	64	-	74
Flemister (2000)(32)	4	26 [26]	24	50	95	74.1 (47-94)	71	62
Kolodziej (2001)(26)	4	4 [4]	18 (11-24)	54 (20-77)	100	70 (59-83)	50	47
Trnka (2001)(23)	4	37 [35]	17 (4-78)	70 (26-140)	87	p21.1/a68.9	84	62
Baravarian (2004)(19)	4	12 [12]	-	>18	100	+46	-	60
Rammelt (2004)(17)	3	31 [31]	36 (7-345)	33 (24-68)	100	p23.5/a73.2 (87%GE)		79
Clare (2005)(31)	4	40 [40]	16 (2-117)	64 (24-151)	93	74.7	-	59
Refae (2006)(18)	4	36 [36]	(2-14)	22 (12-30)	97	81%GE[3]	94	48
DeOrio (2008)(36)	4	6 [1]	-	-	100	-	-	40
Garras (2008)(24)	4	21 [N.A.]	-	36 (13-73)	91	p21/a71	-	59
Pollard (2008)(34)	4	22 [13]	26	27 (12-64)	96	-	-	49
Lee (2010)(33)	4	15 [13]	-	21 (13-31)	93	-	-	42

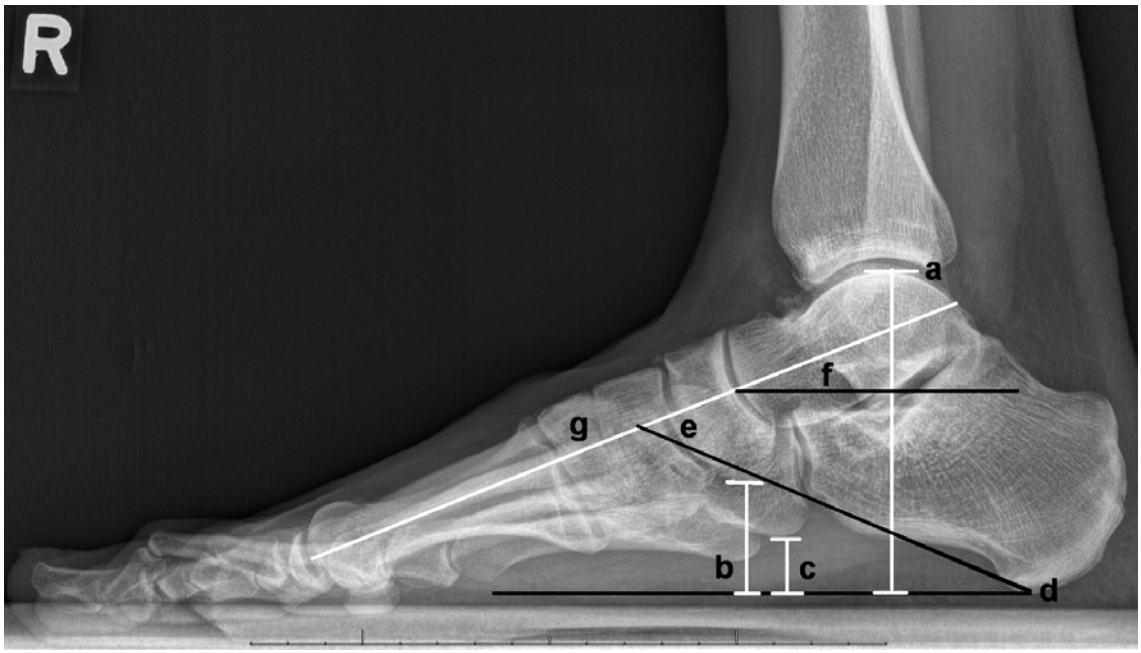
LOE, level of evidence; 1, Own scoring system; 2, Modified AOFAS; 3, (Modified) Paley and Hall score; p, pre-reconstruction; a, after reconstruction

Figure 1. Case example of failed initial treatment of a displaced intra-articular calcaneal fracture treated with a subtalar distraction bone block arthrodesis



a. pre-operative image with collapse of talus into the calcaneus, b per-operative image with laminar spreader in place, c. peroperative view after lateral wall resection, Dwyer osteotomy and placement of bone block (lateral wall fragment), d. post-operative image with headless compression screws

Figure 2. Radiographical measurements for pre- and post-operative evaluation in weight-bearing image



a. talocalcaneal (heel) height, b. navicular-to-floor distance c. cuboid-to-floor distance, d. calcaneal inclination (pitch) angle, e. talocalcaneal angle, f. talar declination angle, and g. talus-first metatarsal (Meary) angle