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Management of calcaneal fractures: systematic review of randomized trials

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Introduction: The optimal management of calcaneal fractures is controversial, as correlation between anatomical restoration and outcome has not been proven, and complications after surgery are frequent.

Sources of data: MEDLINE, EMBASE, CINAHL, Google scholar, the Cochrane Controlled Trials Register, and the Cochrane Musculoskeletal Injuries Group Trials Register were searched using the keywords 'calcaneal' and 'fractures', without time limits or restriction to language. Randomized and quasi-randomized trials were included. Two separate comparisons were identified in the trials: operative versus non-operative management (five studies), and impulse compression versus no impulse compression (one study). Two reviewers independently assessed trial quality, with a 12-item scale used by the Cochrane Collaboration.

Areas of agreement: Results showed no difference in residual pain, but favoured surgical management on ability to return to the same work and to wear the same shoes as before the fracture. Surgery reduced the need for subsequent subtalar fusion. workers' compensation affected outcome.

Areas of controversy: It is unclear whether general health outcome measures, injury specific scores and radiographic parameters improve after operative management, and whether the benefits of surgery outweigh the risks.

Growing points: The existing trials are of relatively poor quality.

Areas timely for developing research: There is still a need for a carefully designed large-scale trial comparing surgery and non-operative management. Other forms of fixation (external fixation or minimally invasive internal fixation) should be compared with 'conventional' surgery. Trials investigating joint reconstruction versus primary subtalar fusion for highly comminuted fractures, and impulse compression versus placebo could be of value.

Keywords: calcaneal/fractures/fixation

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Introduction

The optimal management of intra-articular calcaneal fractures is controversial.[1–3] The goal of operative management is to achieve anatomic joint reduction, and restore height, length, width and axis of the calcaneus. Stable internal fixation should allow early motion to restore function.[4–7] Open reduction and stable internal fixation is usually advocated for intra-articular fractures with relevant joint displacement (>1 mm), and in extra-articular fractures compromising the soft tissues and/or with unacceptable positioning, shortening and malalignment of the calcaneus (>10° valgus/>5° varus). Relative contraindications include old age, significant co-morbidities, smoking, diabetes mellitus, use of steroid medications and vascular insufficiency.[4,5] Several large series of intra-articular fractures that were classified by CT scanning and managed with open reduction and internal fixation (ORIF) showed good to excellent results in 60–85% of cases.[6–9] However, correlation between anatomical restoration and outcome (function, quality of life) has not been proven unambiguously, while calcaneal fractures are notorious for post-operative complications.[2–5] Injury to the soft-tissue envelope of the hindfoot affects both the timing of surgery and wound healing. Wound healing problems occur in 16–25% of patients after ORIF of calcaneal fractures, and have been reported to be as high as 43%.[4,5,10] Other forms of operative management are external fixation,[11–13] minimally invasive percutaneous fixation[14,15] and arthroscopically assisted fixation.[16] Non-operative management consists of elevation, ice, analgesia and early ankle and subtalar joint mobilization. Some clinicians advocate the use of a splint for 2 weeks to prevent equinus of the ankle and allow soft tissue healing. Weight bearing is initially restricted to prevent further collapse of the fracture. Impulse compression application has been proposed as a possible intervention to reduce swelling[17] and improve range of motion and function.[18] Although the advantages of operative versus non-operative management have been questioned, many orthopaedic surgeons approach displaced calcaneal fractures operatively. In a previous Cochrane Review,[2] which included studies published before 1998, only a few, small scale, randomized trials on calcaneal fracture management were included. All had methodological flaws, and the authors concluded that large-scale high-quality randomized controlled trials were needed to provide scientific evidence on interventions in the management of calcaneal fractures. This review identifies and evaluates randomized controlled clinical trials comparing different methods of treating calcaneal fractures. Based on the identified randomized trials, the following null hypotheses were tested for patients with intra-articular calcaneal fractures.

1. There is no difference in outcome between operative management involving Kirschner wire (K-wire) or plate fixation and non-operative management.[9–13]
2. There is no difference in outcome between management with impulse compression and management without (control).[18]
3. There is no change in volume of the affected foot, after the use of a pedal intemittent pneumatic compression device (foot pump) compared with a control group, in patients with a calcaneal fracture awaiting operative management.[17]

Methods

MEDLINE, EMBASE, CINAHL, the Cochrane Controlled Trials Register and the Cochrane Musculoskeletal Injuries Group Trials Register were searched using the keywords 'calcaneal' and 'fractures'. Randomized and quasi-randomized trials comparing interventions for treating patients with calcaneal fractures, published in peer reviewed journals were included. No time limits or restriction to language were applied. The date of the most recent search was 5 December 2008. Two reviewers assessed abstracts of all studies identified by the initial search and excluded non-relevant studies (investigations not about calcaneal fractures, reviews, descriptions of surgery). Abstracts of all other papers were categorized by two reviewers into observational studies (case series, case–control studies, cohort studies; retrospective or prospective with concurrent or historical controls) and intervention studies (controlled trials with no randomization, controlled trials with quasi-randomization and fully randomized controlled trials). Full text articles were obtained for any studies with unclear methodology and for all randomized or quasi-randomized studies. Disagreements on inclusion were resolved by discussion. Peto odds ratios and 95% confidence intervals (CI) were calculated for dichotomous outcomes for individual studies and pooled results. Weighted mean differences and, where standard deviations were available, 95% CI were calculated for continuous outcomes. Where it was possible to pool data, a meta-analysis was carried out. Two reviewers independently assessed trial quality, with a 12-item scale (Table 1) used by the Cochrane Collaboration.[19] This scale considers aspects of internal and external validity. The highest possible total score for a study is 24.

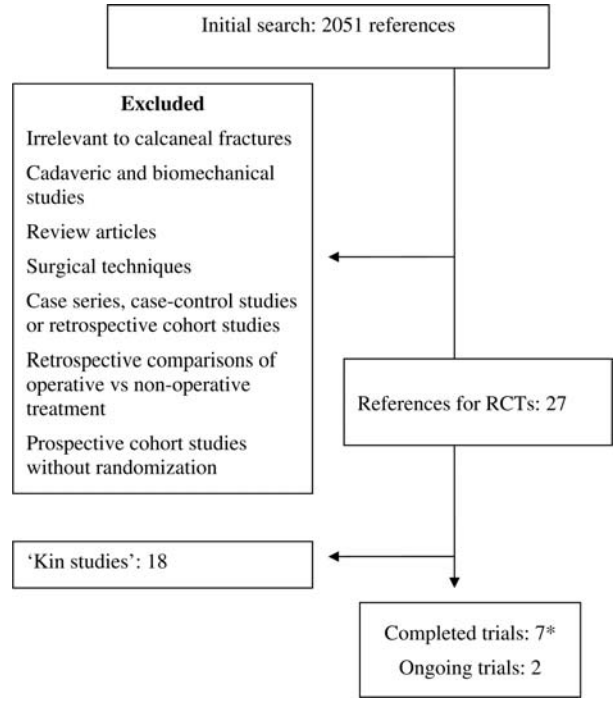
Results

Of 2051 references obtained using the search strategy above, only 27 involved randomized-controlled trials (Table 2). Eighteen studies were

Table 1 Assessment of studies' quality.

Question		Score		
		2	1	0
1	Was the assigned treatment adequately concealed prior to allocation?	Method did not allow disclosure of assignment	There was a small but possible chance of disclosure of assignment or unclear	Quasi-randomized or open list/ tables
2	Were the outcomes of patients who withdrew described and included in the analysis (intention to treat)?	Withdrawals well described and accounted for in analysis	Withdrawals described and analysis not possible	No mention, inadequate mention, or obvious differences and no adjustment
3	Were the outcome assessors blinded to treatment status?	Effective action taken to blind assessors	Small or moderate chance of unblinding of assessors	Not mentioned or not possible
4	Were the treatment and control groups comparable at entry?	Good comparability of groups or confounding adjusted for in analysis	Confounding small; mentioned but not adjusted for	Large potential for confounding, or not discussed
5	Were the participants blind to assignment status after allocation?	Effective action taken to blind participants	Small or moderate chance of unblinding of participants	Not possible, or not mentioned (unless double blind), or possible but not done
6	Were the treatment providers blind to assignment status?	Effective action taken to blind treatment providers	Small or moderate chance of unblinding of treatment providers	Not possible, or not mentioned (unless double blind), or possible but not done
7	Were care programmes, other than the trial options, identical?	Care programmes clearly identical	Clear but trivial differences	Not mentioned or clear and important differences in care programmes
8	Were the inclusion and exclusion criteria clearly defined?	Clearly defined	Inadequately defined	Not defined
9	Were the interventions clearly defined?	Clearly defined interventions are applied with a standardized protocol	Clearly defined interventions applied but application protocol isn't standardized	Intervention and/ or application protocol are poorly or not defined
10	Were the outcome measures used clearly defined?	Clearly defined	Inadequately defined	Not defined
11	Were diagnostic tests used in outcome assessment clinically useful?	Optimal	Adequate	Not defined or not adequate
12	Was the duration of surveillance clinically appropriate?	Optimal	Adequate	Not defined or not adequate

Table 2 Search strategy and criteria.



RCTs: randomized-controlled trials.
*Two studies 27,28 reported on the same trial, at different time intervals, with different outcome measures.

excluded, seven of which,[20–26] reported analyses from the same multicentre randomized trial.[10] These[20–26] were excluded, as analyses on different aspects were performed retrospectively, and were not included in the design of the original trial.[10] Seven studies[9,10,17,18,27–29] were included (Table 2). Three separate comparisons were identified in the trials: (i) clinical outcome of operative versus non-operative management; (ii) clinical outcome of impulse compression versus no impulse compression (control) for fractures treated non-operatively and (iii) foot pump versus no foot pump (control) for preoperative oedema reduction. Two trials are ongoing.[30,31]

All studies had methodological flaws, and no study reported confirmation of allocation concealment (Table 3). Incomplete details of the method of randomization were provided by Erdmann *et al.*[18] who used stratified randomization with a block size of two and Thordarson *et al.* [9,17] used sealed unmarked envelopes. Two studies were quasi-randomized, either according to the consultant on duty at the time of patient admission[27] or by year of birth.[29] Particular issues for most

Table 3 Quality assessment of individual studies.

Study	AC	1	2	3	4	5	6	7	8	9	10	11	12	Total
Thordarson and Krieger[9]	B	1	0	0	1	0	0	1	2	1	2	2	1	11
Buckley *et al.*[10]	B	1	0	0	0	0	0	2	2	2	2	2	2	13
Thordarson *et al.*[17]	B	1	1	0	1	0	0	1	2	2	2	1	1	12
Erdmann *et al.*[18]	B	1	0	0	2	0	0	2	2	2	2	2	1	14
Parmar *et al.*[27]	C	0	0	0	1	0	02	1		1	2	2	1	10
Ibrahim *et al.*[28]	C	0	0	0	1	0	0	2	1	1	2	2	2	11
O'Farrell *et al.*[29]	C	0	0	0	0	0	0	0	1	2	1	2	0	6

AC: allocation concealment.

studies were the lack of intention-to-treat analyses, and of blind assessors for all studies.[9,17,27–29] Patient and treatment provider blinding were not possible in any of the trials. The methodology scores, assessed by the scoring system described earlier (Table 1), ranged from 6 to 14 (Table 3) of a total of 24 points.

Analysis of data (Table 4) showed that there was no difference in residual pain, but operative management was favourable in terms of ability to return to the same work and to wear the same shoes as before the fracture.

In one large trial,[10] after stratification of the data, by removal of the patients who were receiving workers' compensation, the outcomes were significantly better in some groups of surgically managed patients. Significantly higher satisfaction scores ($P = 0.001$) were obtained among patients not receiving workers' compensation, and were managed operatively. Patients who were not receiving workers' compensation and were younger (less than 29 year old) had a moderately lower Böhler angle (0–14°), a comminuted fracture, a light workload or an anatomic reduction or a step-off of ≤ 2 mm after surgical reduction ($P = 0.04$) scored significantly higher on the scoring scales after surgery compared with those who were managed non-operatively. Women had significantly higher SF-36 score after operative management, compared with those managed non-operatively ($P = 0.015$). The need for subsequent subtalar fusion was significantly reduced after operative management[10] (3.4% versus 17%, $P < 0.001$).

One trial[17] reported a significant ($P = 0.02$) progressive decrease in foot volume in the first 48 h after the application of a pedal intermittent compressive device (foot pump) in patients with excessive oedema (positive wrinkle test), precluding operative fixation of their unilateral closed calcaneal fracture upon presentation. Patients in the foot pump-treated group underwent surgical fixation at an average of 9.7 days, whereas patients in the control group at 13 days. None of the patients in either group had a wound complication. Clinical outcome of the patients after follow-up was not reported.

Table 4 Analysis of data.

Outcome	Studies	Patients	Statistical method	Effect size
Comparison 1. Operative versus non-operative management				
01 Pain (no. of patients)	2	82	Peto odds ratio (95% CI)	0.90 [0.34, 2.40]
02 Use of analgesia (no. of patients)	1	56	Peto odds ratio (95% CI)	0.19 [0.05, 0.70]
03 Limited walking distance (no.of patients)	1	56	Peto odds ratio (95% CI)	1.32 [0.46, 3.78]
04 Can walk less than 6 blocks (no. of patients)	1	26	Peto odds ratio (95% CI)	0.21 [0.04, 1.11]
05 Limp (no. of patients)	1	56	Peto odds ratio (95% CI)	1.12 [0.34, 3.66]
06 Unable to wear same shoes (no. of patients)	3	106	Peto odds ratio (95% CI)	0.39 [0.16, 0.92]
07 Unable to return to same work (no. of patients)	3	90	Peto odds ratio (95% CI)	0.28 [0.11, 0.72]
08 Limitations on daily activity (no. of patients)	1	26	Peto odds ratio (95% CI)	0.13 [0.02, 0.86]
09 Not at previous recreational level (no. of patients)	1	56	Peto odds ratio (95% CI)	1.62 [0.51, 5.09]
10 Reduced subtalar movement (no. of patients)	1	56	Peto odds ratio (95% CI)	0.59 [0.14, 2.49]
11 Reduced ankle movement (no.of patients)	1	56	Peto odds ratio (95% CI)	0.66 [0.20, 2.17]
12 No improvement in Bohler's angle (no. of patients)	1	24	Peto odds ratio (95% CI)	0.02 [0.00, 0.45]
13 Complications (no.)	1	26	Peto odds ratio (95% CI)	2.38 [0.09, 64.05]
14 Patients treated with subtalar arthrodesis	1	424	Peto odds ratio (95% CI)	0.17 [0.07, 0.40]
15 Calcaneal functional score	1	26	Mean difference (IV, fixed, 95% CI)	31.70 [17.68, 45.72]
16 AOFAS hindfoot score	1	26	Mean Difference (IV, Fixed, 95% CI)	−8.50 [−20.28, 3.28]
17 Foot Function Index	1	26	Mean difference (IV, fixed, 95% CI)	0.09 [−0.69, 0.87]
18 Calcaneal fracture score	1	26	Mean difference (IV, fixed, 95% CI)	−6.60 [−27.97, 14.77]
19 Height of calcaneum	1	26	Mean difference (IV, fixed, 95% CI)	1.00 [−2.47, 4.47]
20 Bohler's angle	2	52	Mean difference (IV, Fixed, 95% CI)	12.13 [7.24, 17.02]
22 SF-36 scale	1	424	Mean difference (IV, fixed, 95% CI)	4.00 [−1.14, 9.14]
23 VAS	1	424	Mean difference (IV, fixed, 95% CI)	4.30 [−1.16, 9.76]
Comparison 2. Impulse compression versus control (non-operative management)				
01 Pain (VAS units) at 6 months	1	23	Mean difference (IV, fixed, 95% CI)	−1.90 [−3.18, −0.62]
02 Pain (VAS units) at 1 year	1	23	Mean difference (IV, fixed, 95% CI)	−1.40 [−2.82, 0.02]

Continued

Table 4 *Continued*

Outcome		Studies	Patients	Statistical method		Effect size
03	Subtalar range of motion	1	23	Mean difference (IV, fixed, 95% CI)		13.90 [3.17, 24.63]
	Outcome	Studies	Patients	Foot pump	Control	*P*-value
Comparison 3. Foot pump versus control for oedema reduction						
01	Foot volume difference (mm) —Days 1–2	1	28	−40 ($n = 13$)	+76 ($n = 15$)	0.02
02	Foot volume difference (mm) —Days 1–3	1	25*	−96 ($n = 11$)	+37 ($n = 14$)	0.02
03	Foot volume difference (mm) —Days 1–4	1	18*	−80 (nn = 7)	+40 (nn = 11)	0.09

*Some patients either left against medical advice, or underwent surgery prior to the 72 h measurement.

Another trial,[18] which evaluated impulse compression versus no therapy, showed that treated patients had better subtalar movement at 3 months, returned to work 3 months earlier and had less pain at 1 year.

Several disease specific and general health outcome measures were used (Table 5). It is unclear whether: (i) general health outcome measures (SF-36),[32] (ii) disease specific scores (calcaneal functional assessment,[9] pain visual analogue scale (VAS),[10] American Orthopaedic Foot Ankle Score (AOFAS),[33] Foot Function Index,[28] Calcaneal Fracture Score[28]) or (iii) radiographic parameters (Bohlers' angle,[9,28] calcaneal height[28]) improve after operative management (Table 4). Complication rates were only reported in two completed trials.[9,10] The lengths of mean follow-up were less than 2 years in three trials,[9,18,28] whereas one trial[17] only evaluated the preoperative swelling reduction and did not provide details regarding the patients' outcome after surgery. The two ongoing trials[30,31] aim to report complication rates and assess patients using disease specific and general health outcome measures (Table 6).

Discussion

Besides being few in number, randomized trials reporting on the management of calcaneal fractures were generally of relatively poor quality, and most of them contained small numbers of patients. Given the protracted time often required for full recovery from this fracture,[3–7] the follow-up was relatively short in some of the studies.[9,28,29] It seems

Table 5 Included trials and results.

Study	Comparison	Patients	Follow-up	Outcome measures	Results		Notes
Thordarson *et al*.[17]	Foot pump	$n = 13$	–	Foot volume reduction (whilst patients were awaiting operative management)	Significant ($P = 0.02$) progressive decrease of foot oedema at 48 h, when the foot pump was used		All feet had positive 'wrinkle test' and were awaiting surgery
	Control	$n = 15$					No clinical follow-up postoperatively reported
Erdmann *et al*.[18]	Impulse compression (IC)	$n = 12$	1,2,3 and 6 months and 1 year	Subtalar movement	13.9° (95% CI: 3.2–24.6) mean difference at 3 and 12 months, in favour of IC group 1.40 VAS units (95% CI: 0.02–2.82) less pain at 12 months, in favour of IC group 4 months versus 7 months, in favour of IC group		'Conservative' management of fractures
	Control	$n = 11$		Pain (VAS)			If Bohler's angle $<20°$, closed reduction using Gissane spike (4 in IC group, 3 in control group)
				Return to work Walking distance	No difference		
O'Farrell *et al*.[29]	ORIF	$n = 12$	15 months		ORIF	Non-operative	Quasi-randomized (surgeon)
	Non-operative	$n = 12$	14 months	Return to work Pain-free walking distance Footwear problems Subtalar joint ROM	8/12 4 km Fewer if ORIF 26°	3/12 1 km 12°	
Parmar *et al*.[27]	ORIF (K-wires)	$n = 25$	1 year	Pain level, pain site, pain pattern, heel width, ankle joint movement, subtalar joint movement, function, sural nerve symptoms, walking ability, return to work, return to normal recreation, use of analgesia, shoe-wear, and compensation	Little differences between ORIF and non-operative groups		Quasi-randomized (year of birth). Of 80 patients, 24 had follow-up less than 1 year and were excluded
	Non-operative	$n = 31$					
Thordarson and Krieger[9]	ORIF	$n = 16$	17 months		ORIF	Non-operative	Sanders II,III fractures only
	Non-operative	$n = 14$	14 months	Calcaneal functional assessment score	86 ± 10.1	55 ± 22.1	No patient receiving workers' compensation
				Bohler's angle	From 11° to 26° at follow-up	From 9° to 8° at follow-up	

Continued

Table 5 *Continued*

Study	Comparison	Patients	Follow-up	Outcome measures	Results		Notes
				Complications	One superficial wound infection		Trial stopped due to unfavourable outcomes of non-operative management
Buckley *et al.*[10]	ORIF	$n = 206$	2–8 years for 309 patients (27% lost to follow-up)		ORIF	Non-operative	Bilateral, fractures, spinal injuries, included.
	Non-operative	$n = 218$		SF-36	68.7	64.7 ($P = 0.13$)	
				VAS	68.6	64.3 ($P = 0.12$)	Better results with surgery for those not receiving worker's compensation
				Need for subtalar fusion	3.4%	17% ($P < 0.001$)	
				Complications			
				• Deep infections	4.4%	–	
				• Thromboembolism	1.6%	0.4%	
				• Compartment syndrome	1.2%	0.8%	Anatomic or near anatomic reduction had positive effect on outcome
Ibrahim *et al.*[28]	ORIF	$n = 15$	182 months		ORIF	Non-operative	Since the original study[27] 46 patients were alive and 26 (57%) agreed to participate at long-term follow-up.
	Non-operative	$n = 11$	178 months	AOFAS	70 ± 16.1	78.5 ± 14.4 ($P = 0.11$)	
				Foot Function Index	26.9 ± 23.0	24.4 ± 30.0 ($P = 0.66$)	
				Calcaneal fracture score	63.5 ± 24.9	70.1 ± 29.2 ($P = 0.41$)	
				Bohler's angle	$16.9^\circ \pm 7.9^\circ$	$10.4^\circ \pm 9.4^\circ$ ($P = 0.07$)	The outcome measures not included in the original study design.
					No correlation to functional outcome		
				Height of calcaneum (mm)	38.2 ± 4.1	37.2 ± 4.7 ($P = 0.57$)	Radiographs available on 16/26 patients.
				Grade of osteoarthritis of subtalar joint	No difference ($\chi^2 = 2.15$, $P = 0.54$)		

Non-op.: non-operative management; ROM: range of movement.
*Same patients' population.

Table 6 Ongoing trials.

Study	Comparison	Patients	Follow-up	Outcome measures	Notes
UK Heel fracture trial[30] (UK)	Operative versus non-operative management (displaced intraarticular calcaneal fractures)	Target: 150 (75 each group), >14 years	2 years	Kerr Calcaneal Fracture Score	Anticipated closing date 1 January 2010
				Complications	
				AOFAS score	
				Quality of life (SF-36)	
				Health status	
				Gait and foot pressure analysis	
CRONOS trial[31] (Netherlands)	Closed reduction versus ORIF versus non-operative study (intra-articular calcaneal fractures)	Target: 150	2 and 5 years	AOFAS score	Anticipated closing date: 1 July 2013
		18–70 years		Complications	
		Sanders type II–IV		Returning to work	
		Closed fractures		Patient satisfaction (VAS)	
				Quality of life (SF36)	
				Need for secondary arthrodesis	

CRONOS: closed reduction, ORIF, non-operative study.

realistic that a minimum of 2 years follow-up would be required to assess the outcome of calcaneal fractures. Pooling data analysis could not lead to clinically useful findings, because of heterogeneity in the presentation of outcome measures in different studies (Table 4). Furthermore, 'displaced calcaneal fractures' do not represent a homogenous disorder. Given the biased randomization process in some studies,[18,27–29] the two groups created and compared may have included fractures of variable severity in dis-similar patient populations. This implies that conclusions are only tentative.

The use of an impulse compressive device ('foot pump') seems to be beneficial in the initial management of calcaneal fractures. It has been associated with oedema reduction prior to surgery[17] and with improved subtalar range of movement, less pain and quicker return to work in patients managed non-operatively.[18]

Two studies[9,10] reported complication rates, but none managed to provide evidence of their significance and to identify whether possible benefits from surgery outweigh its risks. Our results are in agreement with a published meta-analysis,[1] which concluded that evidence is not

sufficient to prove superiority of operative over non-operative management of calcaneal fractures.

The only large-scale trial,[10] recruiting 424 patients, showed no difference in outcomes between patients receiving operative and non-operative management. However, it had marked methodological flaws, and therefore the evidence is weak. Operative management was superior in some patient groups after stratifying the data removing patients receiving workers' compensation was demonstrated, but the analysis of this variable was not included in the original design of the study. The one surgeon who performed 73% of surgeries also performed radiographic assessment of accuracy of post-operative reduction in the operatively managed group. Patients with bilateral fractures (47 patients) and other injuries (133 patients), including spinal injuries (13 patients), were included in the analysis. As VAS and general health measurements were used to evaluate outcome, it has to be assumed that, in patients with bilateral calcaneal fractures, each fracture contributed equally to the functional result, which might be inaccurate. Furthermore other injuries, and especially spinal injuries, may have influenced outcome. Exclusion of patients undergoing secondary subtalar arthrodesis (significantly more common after non-operative management) from final analysis excludes, by definition, 'failures'. On the other hand, anatomic reduction was associated with favourable outcomes. This might have an implication on clinical practice: it is important to obtain near anatomic reduction when operative management is undertaken. This is consistent with the findings of another study,[20] which suggested that operative management of Sanders type II and III fractures[8] achieved significantly better restoration of Bohler's angle (mean 26°), possibly leading to better functional results.

Several studies,[20–26] not included in the original trial design,[10] were published. According to those, patients treated operatively were more likely to develop complications.[24] Men, who participated in heavy labour work, receiving worker's compensation, with Bohler's angle less than 0°, were more likely to undergo secondary subtalar fusion if initially managed non-operatively.[22] The sub-population with bilateral calcaneal fractures has no difference in demographic features from those with unilateral fractures.[23] Personal gait satisfaction scores were not significantly different between those managed with ORIF and those managed non-operatively. In patients managed with ORIF, improved personal gait scores were reported in those younger than 30, did not receive worker's compensation, had jobs requiring a moderate work-load before injury, and had Bohler's angles restored to above 0°.[26] Operative management showed statistically significant better results when compared with non-operative management in women,[18] and the amount of subtalar joint motion 12 weeks after displaced

intra-articular calcaneal fracture was significantly related to patient satisfaction at 2 years, regardless of the method of management.[24] Economic analysis showed that, when indirect costs, such as the time lost from work, were included, operative management was less costly.[21]

Overall, limited evidence from four trials[9,10,27,28] suggests that ORIF with a plate and screws, followed by early post-operative mobilization, may be superior to non-operative management in terms of return to work and ability to wear the same shoes, but not for pain. Radiographic studies showed an improved Bohler's angle in the operative management group.[9,28] Limited evidence from a small trial of poor methodological quality also suggested that ORIF using Kirschner wires followed by 6 weeks plaster cast immobilization may not be superior to non-operative management.[29] Impulse compression[18] may be beneficial in terms of residual pain and range of subtalar joint movement. Given the small number of fractures studied, these findings should be regarded as preliminary.

There is still a need for a carefully designed large-scale study comparing ORIF and non-operative management of displaced intra-articular calcaneal fractures. The main issue is whether the possible benefits from operative management of calcaneal fractures outweigh the risks associated with surgery. Two ongoing multi-centre randomized trials[30,31] may satisfy this need. Furthermore, other forms of operative management that have been presented in the literature, such as external fixation[11–13] or minimally invasive internal fixation,[14–16] can be compared with 'conventional' ORIF through an extensile lateral approach. A trial investigating the superiority of internal fixation versus primary subtalar fusion for Sanders type IV fractures[8] could be of value. There is also a need for a placebo-controlled double-blind randomized-controlled trial of impulse compression versus placebo. Also, trials are required to help define the best non-operative way of managing extra-articular calcaneal fractures. All studies should be fully randomized with adequate allocation concealment and blinded assessment both at baseline and follow-up. Outcomes should include pain, walking ability, shoe wear, joint movement, complications, return to daily activities/work, disease specific outcomes, general health and quality of life outcomes, radiographic evaluation and health economic outcomes. Adequate follow-up is required to determine the effect of treatment on outcomes such as subtalar arthritis and need for subtalar fusion. This might also include the effect of the primary treatment on the outcome of the secondary fusion.

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