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## Treatment of calcaneal fractures: the available evidence

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**Abstract** Calcaneal fracture is the most common of the tarsal fractures and represents 1%–2% of all fractures. The fractures may be divided into extra-articular (not affecting the joint) and intra-articular (involving the talo-calcaneal and calcaneal cuboid joints) types. The management of heel fractures includes non-operative and operative treatments, but no clear consensus has been reached. The choice of operative treatment is still controversial with many factors influencing the final clinical outcome. Many studies have assessed the outcome of treatment of calcaneal fractures, but there is a general disagreement on their management. The objective of this study

was to collect and evaluate the scientific evidence reported in the literature supporting the different treatments for calcaneal fractures.

**Key words** Evidence-based medicine • Calcaneal fractures • Heel fractures • Os calcis fractures • Treatment outcome

### Introduction

Calcaneal fracture (os calcis or heel fracture) is a complex injury that represents 1%–2% of all fractures. It is the most common of the tarsal fractures and it plays a fundamental role in foot biomechanics, weight bearing, foot pain and foot wear. Men are more often affected than women and the incidence is higher in young and middle-aged subjects [1]. The fracture generally occurs by high-energy trauma. A common fracture mechanism is an axial stress to the talo-calcaneal joint caused by a fall from a height of more than 1 meter or by a road accident. It can be bilateral and associated with other fractures, and it can be seriously disabling if it can be the most severe cases [2].

Calcaneal fractures may be divided into extra-articular (not affecting the joint) and intra-articular (involving

the talo-calcaneal and calcaneal cuboid joints) types [3]. Moreover, they can be classified according to the mechanism of injury, the anatomic characteristics, and the findings at plain x-rays and computed tomography (CT). The best evaluation of these fractures is traditional imaging, including plain x-rays in anteroposterior (AP), lateral and oblique views of the foot, Harris view of the heel and Broden's views of the hindfoot. CT scan best assesses heel fractures, provides a three-dimensional image and may be useful to understand fracture details and to plan a correct surgical approach [2].

The management for heel fractures is a real challenge for the orthopaedic surgeon: it varies widely and no clear consensus has been reached [2, 4, 5]. Conservative treatment is well accepted for extra-articular fractures and it is based on cryotherapy, cast immobilization, early range of motion, early compression of the plantar arch. The choice

of operative treatment is still controversial and many factors influence the final clinical outcome. Operative management includes closed reduction and internal fixation with pins, wires, screws or plates, with different medial or lateral incisions (or both), and arthrodesis [2].

Even if the outcomes of calcaneal fracture treatments have been assessed in several studies, there is a general disagreement on the most appropriate management of these injuries, in particular for displaced intra-articular fractures. The aim of this study was to collect and evaluate the scientific evidence supporting the different treatment in the management of calcaneal fractures.

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## Materials and methods

A bibliographic search was conducted to identify articles comparing different treatments for calcaneal fractures. We searched for meta-analyses, systematic reviews, guidelines and randomized controlled trials (RCTs) that compared two or more devices in the management of calcaneal fractures. Our search strategy included the following databases: Cochrane Musculoskeletal Injuries Group specialised register, the Cochrane Central Register of Controlled Trials, Health Technology Assessment (HTA), PEDro, MEDLINE (1966 to December 2006), EMBASE (1980 to December 2006), CINAHL (1982 to December 2006), AMED (1985 to 2006), DARE, TRIPdatabase, and the National Research Register (UK). The search was completed in December 2006. All RCTs and quasi RCTs included in the study regarded patients with calcaneal fractures evaluated by x-rays with or without CT or MRI with a follow-up at least of six months. We searched for any nonoperative or operative treatment, such as plaster cast immobilization, early mobilization, impulse compression to closed reduction with pin fixation, open reduction and internal fixation with K wires, screws or plates through different approaches, using or not bone graft, and arthrodesis. The outcome measures included assessment of pain, ability to wear shoes, return to work, quality of life, range of motion, walking ability, imaging evaluation and complications. The following terms, selected from the National Library of Medicine's medical subject headings (MESH) database, were searched: human; calcaneus; fractures, bone; heel; os calcis; and treatment outcome.

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## Results

Our research identified only 8 quasi RCTs and RCTs (Table 1), 1 systematic review, 1 meta-analysis and no guidelines. Of the 8 RCTs, 4 were reported in the 1990s. The remaining 4 more recent studies described different outcomes from the same large multicenter trial.

## RCTs

In 1992, Erdmann and colleagues [6] reported a randomized controlled trial that compared conservative treatment with intermittent compression of the foot as therapy for displaced intra-articular calcaneal fractures in 23 patients. Intermittent compression of the plantar venous plexus was performed through a pneumatic plantar impulse device for 1 week. They were randomized as follows: 12 patients to the impulse compression group and 11 to the control group. After 1 week, all patients were discharged with a plaster cast for 1 month with no weight-bearing. Patients were evaluated at 1, 2, 3, 6 and 12 months for pain, measured on a visual analogue scale (VAS, 0–10), subtalar movement, walking distance, return to work and weight bearing. The authors reported a significant improvement in subtalar movement in the pumped group, but no difference in walking distance or weight bearing between the groups.

One year later O'Farrel et al. [7] reported a quasi-randomized controlled trial of 24 patients with displaced intra-articular calcaneal fractures, and compared operative versus nonoperative treatment. Conservative treatment consisted of elevation, compression of the foot, physiotherapy at 7 days and gradual weight bearing as tolerated. Operative treatment consisted of open reduction and internal fixation with plate and early mobilization. Average follow-up was 15 months for the operative group and 14 months for the nonoperative group. The authors reported better results in the operative treatment group, in terms of footwear problems, longer pain-free walking distance, return to work, subtalar range of movement, and Bohler's angle.

Conservative and operative treatments for displaced intra-articular fractures of the calcaneus were also compared by Parma et al. in a quasi-randomized controlled trial also published in 1993 [8]. Overall, 31 patients were randomized to the conservative treatment group, and received foot elevation, ice packs, physiotherapy and early foot movement, while 25 patients were treated with open reduction and internal fixation with Kirschner wire followed by cast immobilization for 6 weeks. Weight bearing was allowed at 6–8 weeks. The patients were evaluated for pain, ankle joint range of movement (ROM), subtalar joint movement, function, walking ability, return to work, return to normal recreation, shoe wear, and use of analgesics. No significant differences in outcomes were found between the operative and nonoperative groups at 1-year follow-up.

Thordarson and Krieger also carried out a randomized controlled trial of operative versus nonoperative management in 30 patients with displaced intra-articular cal-

**Table 1** Selected clinical trials comparing treatments for displaced intra-articular calcaneal fractures

Reference	Year	Patients	Treatments	Outcome measures	Results
Erdmann et al. [6]	1992	23 (24 fractures)	Impulse compression vs. no impulse compression	Pain (VAS), subtalar movement, walking distance, return to work, weight bearing	Significant improvement in subtalar movement in the pumped group; no difference in walking distance and weight bearing between the 2 groups
O'Farrel et al. [7]	1993	24	Operative vs. nonoperative treatment	Footwear problems, pain-free walking distance, return to work, subtalar range of movement, Bohler's angle	Better results from operative treatment compared with nonoperative treatment (in particular, return to work and ability to wear shoes)
Parmar et al. [8]	1993	56	Operative vs. nonoperative treatment	Pain, ankle joint ROM, subtalar joint movement, function, walking ability, return to work, return to normal recreation, shoe wear, use of analgesics	No significant difference in outcome between operative and nonoperative treatment groups
Thordarson et al. [9]	1996	30	Operative vs. nonoperative treatment	Outcome assessment questionnaire (pain, daily activity, walking limitations, shoe wear, exercise, work); Bohler's angle	Better results of operative treatment compared with nonoperative treatment (in particular, return to work and ability to wear shoes)
Buckley et al. [10]	2002	424 (471 fractures)	Operative vs. nonoperative treatment	SF-36, VAS, Bohler's angle, complications	Not statistically significant differences in functional results between operative and nonoperative treatment. Patients between 20 and 29 years, patients who were not receiving Worker's compensation, women, patients with a light workload, with a higher Bohler's angle, with a single fracture, with a simple displaced intra-articular fracture had better results with operative treatment than with nonoperative treatment
Howard et al. [11]	2003	424 (459 fractures)	Operative vs. nonoperative treatment	Complications	Patients treated surgically were more likely to develop complications
Barla et al. [12]	2004	41 women (43 fractures)	Operative vs. nonoperative treatment	SF-36, VAS, Bohler's angle	Better results from operative treatment compared to nonoperative treatment
O'Brien et al. [13]	2004	319 (351 fractures)	Operative vs. nonoperative treatment	SF-36, VAS, personal gait satisfaction score	Not statistically significant differences in personal gait satisfaction scores between groups

VAS, analogue score; ROM, range of motion

canal fractures [9]. Nonoperative treatment consisted of ice packs, foot elevation and a bulky Jones dressing, followed by a removable posterior splint and early foot

motion. Weight bearing was allowed at 8 weeks as tolerated. Operative treatment included a standardized lateral approach with reduction and internal fixation with screws

or a plate with screws; a posterior splint was applied. Weight bearing was allowed at 10 weeks. Average follow-up was 17 months for the operative group and 14 months for the nonoperative group. The patients were evaluated through a new functional outcome assessment questionnaire (score, 0–100) on pain (30 points), daily activity limitations (10 points), shoe wear (10 points), walking (20 points), exercise (10 points), and work (20 points). Bohler's angle was also measured. The authors demonstrated significantly better results from operative treatment than from nonoperative treatment.

In the period 2002–2004, four reports were published on the results of a large multicenter randomized clinical trial designed by the Canadian Orthopaedic Trauma Society and carried out between 1991 and 1997. The trial compared nonoperative management and operative treatment in displaced intra-articular calcaneal fractures. In Buckley et al. [10], 424 patients (471 calcaneal fractures) were randomized to 2 groups: 218 patients (262 fractures) to the nonoperative treatment group, with elevation, ice, rest and early mobilization; 206 (249 fractures) to the operative group with open reduction and internal fixation with plate, screws or wires using a standard lateral approach. Bone graft was used according to the preference of the surgeon. All patients respected a period of 6 weeks of non-weight-bearing and none used a cast. After 6 weeks the physiotherapy protocol began. The patients were evaluated at 2, 4, 6, 12, 26, and 52 weeks and after 2 years. At 1- and 2-year follow-up, the patients were assessed through SF-36, a general health-outcome measure, and VAS. CT was performed pre-operatively, postoperatively and after 2 years to assess the reduction. The authors demonstrated that operative treatment provides no improvement in functional results compared to nonoperative treatment for displaced intra-articular calcaneal fractures. However, statistical analysis demonstrated that patients who were not receiving Worker's Compensation, women, patients between 20 and 29 years of age, with a light workload, with a higher Bohler's angle, with a single fracture, with a simple displaced intra-articular fracture were more likely to have better results with operative treatment than with nonoperative treatment. More reduction is anatomic and better outcome can be predicted. Nonoperative treatment could be recommended to patients over 50 years of age, males, those who are receiving Worker's Compensation, and those with heavy workload occupation. The higher energy fractures, with a lower Bohler's angle, have worse results compared with those after a low energy trauma.

Howard et al. [11] assessed complications following management of displaced intra-articular calcaneal fractures, which are a significant cause of morbidity. The population consisted of 424 patients (459 fractures). Two

hundred and eighteen patients (233 fractures) were randomized to the nonoperative treatment group and 206 patients (226 fractures) were assigned to the operative group with open reduction and internal fixation using a standard lateral approach. All patients respected a period of 6 weeks of nonweightbearing and none used a cast. The patients treated with open reduction and internal fixation were more likely to develop complications.

The long-term outcomes of treatments for displaced intra-articular calcaneal fractures were assessed specifically in women by Barla et al. [12]. The study considered 41 women (43 calcaneal fractures), of which 21 received nonoperative treatment and 20 had open reduction and internal fixation. The patients were evaluated at 2, 4, 6, 12, 26, and 52 weeks and at 2 years through the SF-36 and VAS, and Bohler's angle was measured as a prognostic factor of long-term outcome. The SF36 ( $p=0.04$ ) and VAS ( $p=0.10$ ) indicated significantly better results in the operative group compared to the nonoperative group.

There also was a statistically significant improvement of Bohler's angles in the operative group ( $p=0.001$ ).

Finally, the patients' personal satisfaction with gait over a 2- to 8-year follow-up was reported by O'Brien et al. [13]. This study assessed how fracture type, treatment and patient demographics influenced gait satisfaction after displaced intra-articular calcaneal fractures. Three hundred and nineteen patients (351 calcaneal fractures), randomized to either nonoperative treatment or operative treatment, were available for analysis. Personal gait satisfaction scores were not significantly different between the two treatment groups.

#### Systematic review and meta-analysis

The Cochrane Collaboration systematic review by Bridgman et al., published in 2006 [3], aimed to identify and evaluate the most appropriate treatments for intra-articular calcaneal fractures. The authors identified 6 randomized trials, of which 4 were included, 1 was excluded and 1 was ongoing. The selected trials regard 2 different comparisons: operative versus nonoperative treatment and impulse compression versus no impulse compression. The authors concluded that there is only limited evidence that open reduction and internal fixation with plate or K wires may be superior to nonoperative treatment. The clinical trials available in the literature are small and of poor methodology. The same conclusion was made for impulse compression management.

Randle and colleagues [14] published a meta-analysis in 2000 on the issue of whether calcaneal fractures should be treated surgically. The authors selected 6 RCTs that

compared operative versus nonoperative treatment for displaced intra-articular calcaneal fractures with follow-up of at least 12 months reporting functional and clinical outcomes. The surgical technique was different across the six studies: from Kirschner wires only to a single bone screw, a lag screw and plate, plate and screws with or without bone graft. The length of immobilization of operated patients varied from 5 days to 6 weeks. The weight bearing as tolerated began at 6 weeks in three studies and by 8 weeks in the others. The conservative treatment groups did not differ much: rest, ice packs, no immobilization or immobilization with compression bandage or removable splint, early mobilization and weight-bearing at 6–10 weeks. The authors concluded that there was a trend to better results in the operative groups regarding pain, return to work, gait abnormalities and radiographic findings. However, they could not make any treatment recommendations for displaced calcaneal fractures on the basis of the studies included in the meta-analysis.

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## Discussion

Controversy over the better treatment for displaced intra-articular calcaneal fractures has been described throughout history. Many retrospective and a few small prospective studies reported better results from operative treatment than from conservative management [10]. The meta-analysis of Randle et al. [14] reported a trend for a better outcome from surgical management of calcaneal fractures, but the authors underlined the weak strength of the evidence for deciding on the optimal treatment for this type of fracture. However, the ideal meta-analysis is obtained analyzing randomized controlled trials (RCTs), while these 6 studies consisted in prospective trials not correctly randomized and retrospective comparative studies. Non-randomized trials could have potential bias, so they cannot provide statistically significant data.

Our research strategy identified a few randomized trials evaluating treatment of displaced intra-articular calcaneal fractures. Most of these trials have poor quality, small sample, short follow-up, several types of bias, different outcome measures (often not validated), and are often methodologically not correct.

The 2006 systematic review of the Cochrane Database [3] underlined there is no strong evidence regarding the optimal treatment for displaced intra-articular fractures. The evidence summarized in this review [3, 7, 9] suggests that surgical treatment with internal fixation with a plate and early movement may lead to better results than conservative treatment. Better results were seen in particular

for return to work, ability to wear shoes and return to normal activities; Bohler's angle was also improved in the operative groups. The clinical trials had a follow-up no longer than 2 years, so no data on joint degeneration in the 2 groups were provided. The authors concluded that the small number of patients included in these trials only permits suggesting preliminary findings. This review noted the existence of an ongoing randomized clinical trial of Buckley [10], but there is no reference to the overall results. It is surprising that a review published in 2006 in the Cochrane Database of Systematic Reviews seems updated not before 2002 (a note claims update in 2003). From this multicenter prospective randomized controlled trial many other studies derived, each of them regarding a particular aspect of the studied problem. We report each of them, underlying the good quality of the multicenter trial, for its design, sample size and follow-up. The authors demonstrated there is no statistically significant improvement from operative treatment compared with nonoperative treatment. However, patients between 20 and 29 years of age, patients who were not receiving Worker's Compensation, women, patients with a light workload, with a higher Bohler's angle, with a single fracture, with a simple displaced intra-articular fracture had better results with operative treatment than with nonoperative treatment.

Although the 4 RCTs [10–13] deriving from the large multicenter study gave important data on the operative treatment of displaced intra-articular calcaneal fractures, they provide no definitive evidence on the best management of displaced intra-articular calcaneal fractures, in particular for the varying severity of the fractures. These studies considered all types of fractures in the same group. It could be useful to study the same type of fracture, classified through the same classification system, to better understand the real outcome derived from different treatments. Moreover, no randomized controlled trials comparing different surgical treatments or different forms of conservative management are available. So, particular attention should be given to these comparisons.

In summary, methodologically correct trials are necessary to confirm whether the trends and conclusions from previous trials are valid. Long-term follow-up is necessary to study the degenerative effects on joint of the different treatments even if a large multicenter clinical trial, well designed and conducted, suggests important evidence, it is not possible at the moment to provide a definitive conclusion regarding the better results of operative management of displaced intra-articular calcaneal fractures, compared with conservative treatment. There is a real need for well designed studies to obtain strong evidence for the management of these fractures, to define timing, selection and role of different surgical techniques.

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