Title

The effect of a heel-unloading orthosis in short-term treatment of calcaneus fractures on physical function, quality of life and return to work – a randomized controlled trial

Acronym

CALCFRO (**Calc**aneus **Fr**acture **O**rthosis)

Trial registration

The study needs to be approved by the Ethical Board of the Region of Southern Denmark. It needs to be registered at http://apps.who.int/trialsearch/, http://www.euroqol.org/register-to-use-eq-5d.html.

Protocol version

Version: 2.5
Date: 10/01/18

Economy and budget

The financial means are requested from Offerfonden (Rådet for Offerfonden| Adelgade 13 | DK-1304 København K | Telefon +45 3392 3334 | Fax +45 3920 4505 | E-mail offerfonden@civilstyrelsen.dk).

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Introduction

Region of Southern Denmark

Background and rationale

In the past decades, the scientific focus regarding calcaneus fractures was the choice of operative or non-operative treatment modality. Although the evidence is ambiguous [1], recent meta-analyses suggest that operative therapy is associated with a higher likelihood to resume pre-injury work, to reach a higher level of physical function and fewer problems when wearing shoes. However, non-operative therapy has significant less complications and infections [2,3]. Typically, aftercare includes non- or partial weight bearing, but protocols are different and often not very specific. In fact, there are no studies published comparing different procedures or special supporting devices. Recently, a heel-unloading orthosis ('Settner shoe' [4]) was introduced in aftercare for calcaneus fractures, allowing walking by shifting the load to the middle- and forefoot. This orthosis does not only enable early mobilization of patients suffering one-sided fractures, but also permits going following two-sided fractures, avoiding the otherwise necessary wheel-chair mobilization. The 'Settner shoe' can be applied in non-operative therapy and following operations. Specifically in calcaneus fractures, early regain of physical activity has been highlighted as one of the key factors for quality of life and the ability to return to work [2,3]. Thus, we hypothesize that mobilization with the 'Settner shoe' results in higher physical activity within the first 3 months and secondly improves ability to return to work in calcaneus fracture patients aged 18-60 years. Further outcome criteria are the American Orthopaedic Foot and Ankle Society's (AOFAS) ankle-hindfoot assessment, a 3-dimensional gait analysis, and the EQ-5D-3L questionnaire. It is the first trail applying a standardized aftercare in patients suffering from calcaneus fractures aiming to improve the non-operative part of treatment. Furthermore, the trial clarifies, whether the economical effort for the equipment acquisition is scientifically justified.

Objectives

We hypothesize that mobilization with the 'Settner shoe' results in higher physical activity within the first 3 months after calcaneus fractures.

Research questions

Does the application of a heel-unloading orthosis ('Settner shoe') independent of operative or non-operative therapy of a calcaneus fracture improve:

1.) the physical activity (active minutes per day)?
2.) the quality of life (EQ-5D-3L)?
3.) the foot function (AOFAS)?
4.) the time necessary for return to work in patients between 18 and 60 years?

Trial design

The study design is a parallel group, randomized controlled trial with open allocation including all patients with calcaneus fractures independent of kind of initial therapy.

Methods: Participants, interventions, and outcomes

Study setting

All patients treated for calcaneus fracture (DS920* 'Fraktur af hælben' according to the Danish SKS-browser) at the University Hospital Odense are prospectively screened for eligibility and included in the trial, if they fulfil the inclusion criteria as listed below. The follow-up period is 6 months.

Eligibility criteria

In Denmark, the treatment of calcaneus fractures is regarded as highly specialized, wherefore both decision-making and operations are done for the whole Region of Southern Denmark in the Department of Orthopaedics and Traumatology at the University Hospital Odense. Therefore, patients are screened by consultants of the local trauma section.

Inclusion criteria:

- Fracture of the calcaneus, which is classifiable according to the Sanders' classification (excludes avulsion fractures)
- Being able to understand Danish or English and answer the questionnaires
- Informed consent
- Age between 18 and 65 years

Exclusion criteria:

- Pathological fractures
- Immature skeletal system
- Other fractures with influence on weight-bearing
- A soft-tissue situation not allowing the equipment with a 'Settner shoe' within 3 weeks after treatment (either decision-making for non-operative therapy or open reduction and internal fixation)

Acquiring patient consent

The participants will be introduced to the study by the medical personnel in a room, where they will not be disturbed. It will be assured that patients are allowed (if they wish) to be introduced to the study accompanied by a family member or any other person(s) selected by the patient. Patients will be given an oral overview of the purpose of the study, a participant information document describing the study and potential risk together with a patient consent form, which the patients will sign if they decide to participate in the study. The patient can resign from participating in the study without giving a reason and without any consequences. Patients are included after the operation or after decision for non-operative therapy, but before discharge.

Interventions

After operation or decision for non-operative therapy, the schedule for the 2 groups are defined as follows:

Group 1 (treatment without 'Settner shoe'):
- mobilization without weight bearing for 6 weeks starting with the day of either decision-making for non-operative therapy or open reduction and internal fixation, if needed a cast or another kind of orthosis as a Static Walker are applied, then 4 weeks 15-20 kg, 2 weeks 35-45 kg, after that transition to full-weight bearing (always only if possible)

- X-ray after 6 and 12 weeks; depending on the results, the schedule for weight bearing may be adjusted to the need in case of delayed healing or complications related to implants

Group 2 (treatment with 'Settner shoe'):
- mobilization with the custom-made heel-unloading orthosis ('Settner shoe') without pads for 6 weeks, then 2 weeks one pad, 2 weeks 2 pads, 2 weeks 3 pads, after that full-weight bearing without any support (always only if possible)
- X-ray after 6 and 12 weeks; depending on the results, the schedule for weight bearing may be adjusted to the need in case of delayed healing or complications related to implants

The patients of both groups are informed about the aftercare at the time point of inclusion.

Outcomes

Primary outcome criterion

The number of active minutes per day following 3 months (time point 2) is primary outcome criterion.

Secondary outcome criteria

- active minutes per day at time point 1
- portion of highly active periods per day at time point 1 and 2
- the EuroQol 5D-3L questionnaire following 3 months (time point 2)

Explorative outcome criteria

- AOFAS
- 3-dimensional gait analysis
- time point of return to work of patients between 18 and 60 years
- range of motion (ROM)
  Pro- and supination (percent of healthy side or assumed normal mobility) are analyzed.
- pain
  The evaluation includes the medication and a visual-analogue scale (VAS).
- comparison between patients with and without operation

Patient characteristics beside outcome criteria

Epidemiology

- age
- sex
- body mass index
- ASA (American Society of Anesthesiologists) physical status classification system

Injury characteristics

- classification according to Sanders (figure 4)
- classification of open/closed tissue damage (table 1)
- polytrauma (ISS≥16, multiple injuries, monotrauma)
- indication for operation (dislocation, broadening, flattening of Böhler angle etc.) or conservative therapy (comorbidity, smoking etc.)

- the time between the fracture occurred and operation or decision making for non-operative therapy

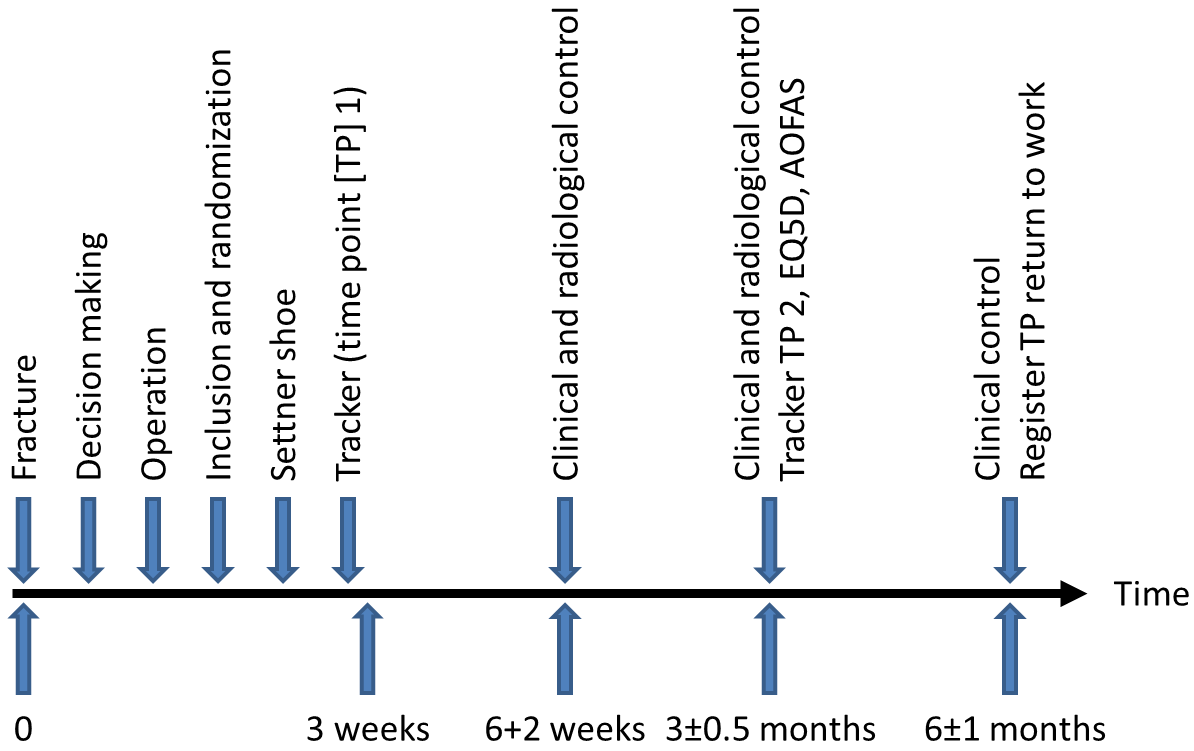
Healing and treatment characteristics

- bone healing after 3 months: union or delayed healing
  The decision is made based on conventional radiographs including the clinical description of complains.
- weight bearing after 3 months
  Is it possible or not?
- hindfoot axis (varus/valgus-deformity, Böhler angle, subtalar osteoarthritis)
  The decision is made based on conventional radiographs and a clinical evaluation.
- type of operation (approach, fixation method, graft)

Complications

- infection (I)
- deep venous thrombosis (DVT)
- nerve paresis/palsy/disturbed sensibility (N)
- subtalar posttraumatic osteoarthritis (PTOA)
- subtalar instability (SI)
- local mechanical irritation by plate/screws (LI)
- wound irritations (WI) as superficial healing problems or skin edge necrosis
- irritations associated to the use of the custom-made heel-unloading orthosis ('Settner shoe')

Participant timeline



Region of Southern Denmark

The clinical and radiological controls correlate with the usual guidelines for treating calcaneus fractures at the Odense University Hospital.

Sample size and power analysis

The sample size calculation was based on a 33% difference in activity, correlating with a clinical relevant difference. Setting the power to 80% and the 2-sided confidence interval to 95% the calculation according to the method of Fleiss with continuity correction resulted in 25 patients per group.

Recruitment

All consultants of the trauma section of the Department of Orthopaedics and Traumatology at the University Hospital Odense are involved in the recruitment process of the study.

Methods: Assignment of interventions (for controlled trials)

Allocation

In the period between treatment (either decision-making for non-operative therapy or open reduction and internal fixation) and consolidation of the soft-tissue situation, the patients are randomized for the aftercare with or without the custom-made heel-unloading orthosis ('Settner shoe'). As soon as the soft-tissue situation allows the adjustment, the patients are referred to an orthopaedic shoemaker, who equips the patient accordingly. The randomization is done using the tool provided by OPEN.

Blinding (masking)

The allocation is not blinded, because it will be obvious to the patient, whether a special shoe is worn or not. Furthermore, the treating trauma surgeon needs to initiate the prescription.

Methods: Data collection, management, and analysis

Management and collection

REDCap™ (Research Electronic Data Capture), a secure application for online surveys and databases, facilitates data management. The University Hospital Odense is an institutional partner of REDCap™, which was especially designed for biomedical research and fulfills all necessary safety features. This is supported by the OPEN initiative (Odense Patient data Explorative Network). REDCap™ used with the OPEN-platform supports also a randomization function, which is used for the study.

Statistical methods

Normally distributed numeric data sets are compared using the paired Student's t–test. Otherwise or in case of non-numeric data, nonparametric tests determine the significance of difference. For correlations, Spearman ρ is calculated. Incidences are compared using the chi square test. Otherwise or in case of non-numeric data, nonparametric tests as the Mann-Whitney U-test for two and the Kruskal-Wallis H-test for multiple variables determine the significance of difference. For correlations, Spearman ρ is calculated.

Methods: Monitoring

Data monitoring

When the study is accepted for OPEN, a data manager will automatically be assigned to the study. The data manager will support the data coherence. Furthermore, a yearly data monitoring will be done by a study nurse, who is assigned to the project.

Harms

Any adverse or severe adverse events will be registered during the trial. Expected are especially local mechanical irritations, which are listed in the chapter for registration of patient characteristics beside outcome criteria.

Ethics and dissemination

Ethics

The study needs to be approved by the ethical board of the Region of Southern Denmark (https://komite.regionsyddanmark.dk/wm258128).

Patient law/privacy

All data collected from patients are protected by the Act on Processing of Personal Data and Health Act according to Danish Data Protection Agency. The project will be reported to Datatilsynet (under "Regionens Paraply 2012-58-0018"). The database is established with OPEN, however, other possible related files are stored in a secure Sharepoint (https://secure.regionsyddanmark.dk/projektrum/ProTibExPla/SitePages/Startside.aspx).

Publication

Reporting will be conducted according to Consolidated Standards of Reporting Trials (CONSORT guidelines (http://www.consort-statement.org/) and published in a peer reviewed journal.

Appendices

Measurement of physical activity

For monitoring of activity, the patients are equipped with a Misfit™ Shine (Burlingame, CA, USA) at the ankle and an Axivity™ AX3 (Newcastle upon Tyne, UK) at the lateral femur of the unaffected side. If there is a fracture at both sides, the trackers are attached to the side with the less complicated fracture. The wear time is 7 days. At day 7±14 (discharge) and after 3±0.5 months patients are equipped, and activity signals are analyzed by calculating the mean of all acquired 24-hour-data during these two periods. Regarding the Misfit™ Shine, only the number of registered steps is recorded. Regarding the Axivity™ AX3, the portion of highly active periods per day and the number of active minutes, correlating with walking activity, have shown to be most discriminating in the preliminary validation study. Therefore, these parameters are selected. Reliability is checked using a wear-time analysis based on change of signal vector magnitudes and temperature monitoring.

Correlating with these two data points, the EuroQol 5D-3L questionnaire [5] and the AOFAS [6] are monitored.

Classification

Classification of calcaneus fractures according to Sanders

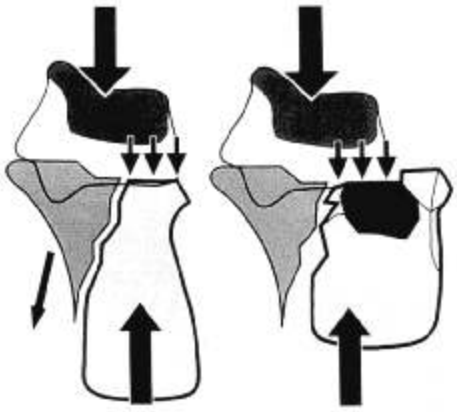


Figure 3: Axial load is necessary for calcaneus fractures, which should be treated with a heel-unloading 'Settner shoe'.

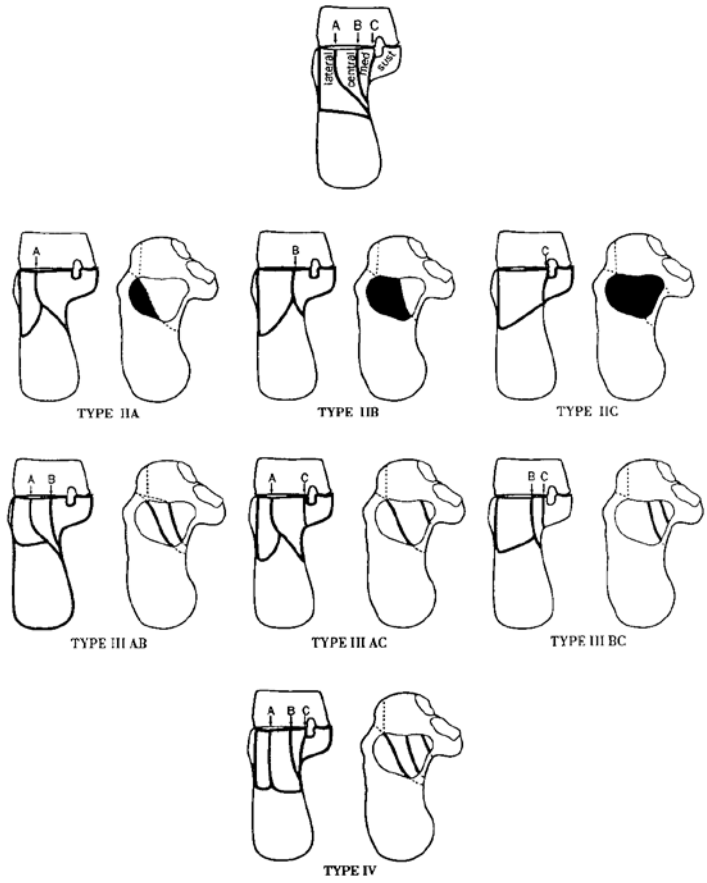


Figure 4: The fracture classification according to Sanders can group the calcaneus fractures that occur following axial load [7].

Classification of open fractures according to Gustilo-Anderson

Gustilo Grade	Definition
I	Open fracture, clean wound, wound <1 cm in length
II	Open fracture, wound > 1 cm but < 10 cm in length without extensive soft-tissue damage, flaps, avulsions
III	Open fracture with extensive soft-tissue laceration (>10 cm), damage, or loss or an open segmental fracture. This type also includes open fractures caused by farm injuries, fractures requiring vascular repair, or fractures that have been open for 8 hr prior to treatment
IIIA	Type III fracture with adequate periosteal coverage of the fracture bone despite the extensive soft-tissue laceration or damage
IIIB	Type III fracture with extensive soft-tissue loss and periosteal stripping and bone damage. Usually associated with massive contamination. Will often need further soft-tissue coverage procedure (i.e. free or rotational flap)
IIIC	Type III fracture associated with an arterial injury requiring repair, irrespective of degree of soft-tissue injury.

Table 1: The classification of open fractures according to Gustilo-Anderson [8].

Orthosis

The heel-unloading orthosis (‘Settner shoe’ [4]) can be used for conservative treatment and aftercare following surgery. It needs to be assembled out of pre-formed and size-adjusted parts. This is done by an orthopaedic shoemaker. The increase of weight bearing is achieved by pads. The first 6 weeks the shoe is worn without pads. Then, the first pad is applied. Every 2 weeks a further pad is put in the shoe, which is removed after 3 months. Preliminary data suggest that this heel-unloading orthosis reduce days of inability to work.

Figure 1: heel-unloading orthosis (‘Settner shoe’ [4])

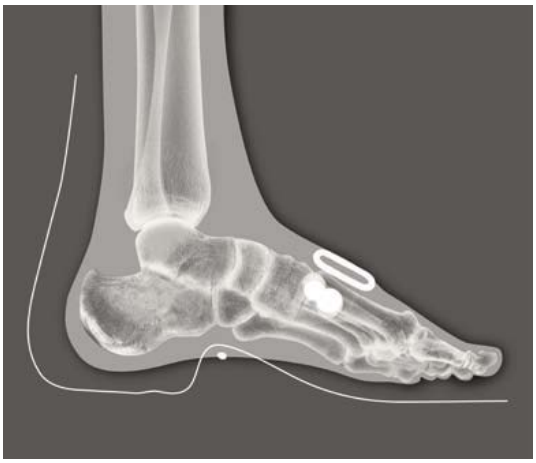


Figure 2: Principle of biomechanical unloading of the heel

3-dimensional gait analysis

All outcome calculations will be based on measurements taken during gait using a 3D Vicon MX movement analysis system with eight cameras operating at 100 Hz (Vicon, Oxford, UK) and two AMTI force-plates (AMTI, OR6-7, Watertown, MA, USA) embedded at floor level, operating at 1,000 Hz. A technician experienced in gait analysis and the Vicon system will attach reflective markers that reflect infrared light according to the Vicon Plug-in-Gait marker set and model [9].

Patient involvement

The Misfit™ Shine worn at the healthy ankle can be coupled with an android or OS X app, which not only provides objective data about patient mobility during early aftercare, but at the same time signals feedback to the patient. By this, the patients themselves can control their postoperatively increasing activity. This includes a scientifically supported evaluation by the study leader at the defined follow-up time points at 6 weeks and 3 months after therapy start. The usual activity data published for healthy people are not comparable to this group, because the physical activity from patients in a rehabilitation process is usually lower. This way, the patient gets trained to interpret the data acquired by the app.

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