MINI-SYMPOSIUM: THE FOOT

(ii) The hindfoot: Calcaneal and talar fractures and dislocations—Part I: Fractures of the calcaneum

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Summary While extra-articular calcaneal fractures are usually treated simply with good results, the management of intra-articular calcaneal fractures remains controversial. Despite advances in surgical techniques and a good understanding of possible complications making operative treatment relatively "safe", doubts remain about the efficacy of surgery in reducing the two main problems of persistent pain and subtalar osteoarthritis. Further randomised controlled trials may be required to confirm or refute the potential benefits of surgery.

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Introduction

The calcaneum is the most frequently injured tarsal bone comprising 1–2\% of all fractures and about 75\% of those affecting the foot. The management of calcaneal intra-articular fractures and dislocations, particularly surgical, remains highly controversial. There have been significant advances in relation to understanding the fracture mechanism,\textsuperscript{1} classification,\textsuperscript{2} surgical approaches,\textsuperscript{3} operative techniques and the management of the soft tissues before, during and after surgery.\textsuperscript{4} A recent study has given some support to surgery,\textsuperscript{5} particularly in Sanders grade II and, to a lesser extent, grade III fractures, but some reservations have been expressed.

Fracture patterns and mechanism

Calcaneal fractures may be either extra-articular (25\%) or intra-articular (75\%). The fracture pattern is dependent on:
- the direction and amount of force applied,
- the position of the foot relative to the ankle,
- the neuromuscular system,
- the bone quality, which may be affected by the patient’s age.

Extra-articular fractures

These usually affect the anterior process, the calcaneal tuberosity, the body of the calcaneum...
(not involving the subtalar joint) or, rarely the sustentaculum tali. They are generally simple injuries which may be treated conservatively but some may require further investigation and surgery.

**Anterior process fractures**

There are two principle types of anterior process fracture:

- affecting the upper and lateral part of the lateral process with simple avulsion of the bifurcate ligament. Conservative treatment is usually appropriate.
- a larger intra-articular fracture affecting the calcaneocuboid joint due to forced abduction of the forefoot or evasion in dorsiflexion resulting in compression. This may be associated with intra-articular fractures of the subtalar joint and should be investigated by CT scan with a view to operative treatment. These are easily missed and may cause long-term discomfort.

**Fractures of the body**

These are generally simple fractures involving the posterior and inferior parts of the body lying behind the posterior facet of the subtalar joint. They are normally conservatively treated and have a good prognosis, but occasionally the heel pad is affected, which may give rise to more protracted symptoms and require further treatment.

**Fractures of the calcaneal tuberosity**

The foot is in plantarflexion at the time of the injury with the force going directly upwards through the tuberosity, resulting in avulsion of the tendo Achilles or a fracture of the medial process. The fracture line runs from a point inferior to the posterior facet of the subtalar joint a variable distance into the body. Undisplaced fractures are satisfactorily treated in an equinus below knee cast, an anterior equinus slab or a functional brace but displaced fractures require open reduction and internal fixation. This can be quite difficult in the occasional case presenting late.

**Intra-articular fractures**

These form the vast majority of calcaneal fractures and are a significant challenge. From the patient’s perspective, the aims should be:

- adequate pain relief both immediately and in the longer term,
- adequate restoration of subtalar joint function,
- early return to work,
- reduction of the risk of long-term subtalar osteoarthritis.

**History and examination**

Such fractures usually follow falls from a height greater than 2 m and are most commonly unilateral. They may be associated with more proximal injuries, particularly lumbar fractures and are sometimes seen in polytrauma patients, often with associated talar fractures or dislocations.

With compression, the longitudinal arch may be reduced or abolished with broadening of the hindfoot. Bruising laterally or on the plantar surface of the foot after 24–48 h may be associated with the development of blisters and occasionally compartment syndrome. Open fractures, with or without dislocation, are rare.

**Radiography**

Properly performed plain radiographs can yield as much information as more complex investigations. They should include an AP view of the foot and ankle, a lateral views of the ankle and calcaneum and an axial view. Brodens views taken either preoperatively or intraoperatively with the foot internally rotated 45° and inclined 10°, 20°, 30° and 40° to the posterior facet give an excellent view of the subtalar joint.

Boehler’s angle, formed by the intersection of lines drawn from the posterior tuberosity and anterior process should be measured. It is normally 25–40° (Fig. 2). Gissane’s angle should also be

![Figure 1 Skin bruising.](image-url)
measured; the angle of inclination of the subtalar joint intersecting with a line drawn from the superior process of the calcaneum (Fig. 2).

CT scanning has become the investigation of choice for preoperative planning and occasionally intraoperative assessment.9

Classification

The Sanders classification2 is widely accepted (Fig. 3) but not universally.10 Problems usually arise because of incorrectly or inadequately performed CT scans and the most useful ‘cuts’ are taken in the coronal plane inclined 25° through the sustentaculum tali (Fig. 4) which may be occasionally fractured in isolation (Fig. 5). 3D reconstructions may be useful, particularly when the talus or cuboid is subtracted. Joint assessment with a radiologist often yields the greatest information.

Management of intra-articular calcaneal fractures

This is either conservative or operative. A variety of ‘semi-conservative’ techniques have been described which are of historical interest.11,12 More recently minimally invasive techniques have been developed using either intraoperative X-ray or CT scan guidance9 but their position in management awaits clarification.

Conservative

This should not be considered as the easy option. All patients with intra-articular fractures should be admitted to hospital and, while awaiting investigation, have the limb rested, with ice packs applied with or without compression (eg. ‘Flowtron’ boots), and with elevation preferably on a Braun frame.

The following may be considered for conservative treatment:

- Sanders grade I fractures with insignificant displacement of the fracture fragments i.e. less than 2 mm.
- Those with contra-indications for surgical treatment such as poorly controlled diabetes, peripheral vascular disease, heavy smokers,13 ethanol and drug addiction and patients who may be potentially unreliable or poorly compliant with treatment.
- Age is a relative contraindication but it is unusual to offer surgery to those over 60.

When the swelling and pain have settled, the fracture is managed in a below knee lightweight cast or, preferably a functional brace for a 4–6
week period, non-weight bearing for a further 2 weeks dependent on radiographic appearance with physiotherapy mobilising the subtalar, ankle and other adjacent joints.

Operative
Why is surgical treatment of these injuries so controversial? They are intra-articular, occur in a major weight-bearing joint, and have important effects on hindfoot mechanics, significantly altering the relationship between the ankle and subtalar joints and the midfoot and forefoot. They result in effective Achilles tendon shortening and variable lateral impingement, principally affecting the peroneal tendons. The controversy arises from historical concern regarding complications of surgical treatment. However, with sensible preoperative planning (including timing), careful management of soft tissues and bony structures intraoperatively, early active and passive mobilisation of the joints postoperatively and careful patient selection, complications can be minimised.

The decision to offer surgery to individual patients depends on the Sanders classification of the fracture. However, the plain radiographs and CT scans, including the 3D reconstructions, help clarify the primary and secondary fracture lines (Fig. 6) for each individual injury. In general terms, grade II and III fractures should undergo open reduction and internal fixation (ORIF) and grade IV fractures may alternatively undergo calcaneal body reconstruction with a primary subtalar fusion.

The aims of surgery are:

- reconstruction of the subtalar joint, particularly the posterior facet,
- restoration of calcaneal height,
- restoration of calcaneal width,
- if necessary, reconstruction of the calcaneocuboid joint,
- if necessary primary subtalar fusion (selected grade IV cases).

Surgery is carried out when the swelling has subsided and the ‘wrinkle sign’ is present (Fig. 7), usually between 5 and 14 days after the injury. After 3 weeks, partial bone healing has often occurred making reduction more difficult with an increased risk of wound complications.

The operation is performed under general or regional anaesthetic with the patient in the lateral (unilateral fracture) or prone (bilateral) position with a thigh tourniquet. An extended lateral approach with an L-shaped incision as described by Sanders and Eastwood et al. is currently the preferred technique. A medial approach is seldom

Figure 4 CT coronal view of calcaneal fracture.

Figure 5 CT scan coronal view showing sustentaculum tali fracture.
required. The skin incision starts about 3–4 cm above the level of the ankle between the distal fibula and the Achilles tendon and curves at about 90° passing down the lateral border of the foot to about 1 cm short of the fifth metatarsal base taking care to avoid the local 'bruised area' (Fig. 8). The sural nerve is at risk at both the proximal and distal parts of the incision. A complete flap is elevated down to the periosteum until the peroneal tendons are identified and retracted. Three stout K-wires are inserted in the distal fibula, the talus and the cuboid as retractors to expose the whole of the calcaneum. The subtalar joint is opened by dividing the calcaneo-fibular ligament and by removing local soft tissue. The lateral component of the articular surface is usually rotated inferiorly and lies deep to the lateral wall of the os calcis. Opening the lateral wall allows visualisation of this fragment and its reduction to the main medial fragment (Sanders II) or fragments (Sanders 111/11V). This part of the calcaneum should be temporarily fixed with two or more K-wires. Frequently the main body fragment needs to be depressed and shifted medially to allow room for the reduction of the lateral articular fragment(s) and wall. Then the distal part of the calcaneum extending down to the calcaneo-cuboid joint is approached. This fragment(s) is normally rotated away from the operator vertically by the local strong ligaments and may also be vertically split. The superior soft tissue has to be released carefully to derotate the fragment(s) prior to the insertion of two or more K-wires. Once this has been achieved, there are usually proximal and distal segments with the wires being utilised like the joysticks of an aeroplane to restore the angle of Gissane. Check radiographs using an image intensifier, in particular Brodens views, confirm the adequacy of the reduction. The plate and screws of choice may be applied and may include a Y reconstruction plate, a calcaneal plate either with or without locking screws (Fig. 9). In grades II and III, a bone graft is rarely required but with grade IV fractures, screws are inserted across the subtalar joint after removing the articular cartilage and inserting a cortico-cancellous autologous bone graft. Further check radiographs are taken at this stage. The peroneal tendons are relocated and the wound closed over a single drain with sutures of choice that should be retained for 3 weeks. A backshell cast may be applied for comfort for 48 h during which time the
limb is elevated. The drain is then removed and the patient mobilised non-weight bearing for 6–8 weeks with crutches when radiographs are performed to assess whether full weight bearing may commence. Early active and passive motion of the ankle, subtalar, and adjacent joints should be encouraged by the physiotherapist.

Surgical complications have been well covered in a recent article. They include:

- **Wound complications including infection, haematoma and dehiscence**: Superficial infection occurs in up to 27% with deep infection and osteomyelitis in up to 2.5%. The latter is more commonly seen following open fractures. Haematoma occurs more frequently when drains are not utilised. Wound dehiscence usually starts at the angle of the incision. These may be reduced by careful timing of surgery and with careful handling of the soft tissues. Additional risk factors include diabetes, peripheral vascular disease and smoking.

- **Compartment syndrome**: This may occur after conservative or operative treatment. The incidence varies from 10% to 50%. Early recognition and surgical treatment by fasciotomy is essential to prevent serious long-term complications including contractures and pain.

- **Neurological injury**: The sural nerve is at greatest risk but the medial and lateral plantar nerves may be damaged when drilling or inserting screws or wires from the lateral side or when using a medial approach.

- **Malunion with or without adequate subtalar reduction**: This, of course, is much commoner after conservative treatment. The types of malunion have been classified by Stephens and Sanders.

- **Metalwork problems**: These are relatively uncommon but may present as prominence of the screws or plate and may occasionally cause peroneal tendon impingement, which may require removal.

- **Subtalar osteoarthritis**: This occurs in conservatively or operatively treated fractures. The principle reason for surgery is to try and reduce its incidence and there is a trend towards support for this from the current literature. Each case should be treated on its individual merits.

### Practice points and research directions

- Calcaneal fractures are the commonest injuries of the tarsal bones.
- Sanders CT scan classification is a useful method of assessing the fracture pattern and deciding on management.
- Despite rapid and excellent advances in surgical treatment there remains no convincing evidence that this should be the treatment of choice.
- The strongly held belief by many surgeons of the advantages of surgical treatment can only be confirmed or refuted by properly evaluated randomised controlled trial.

### References


