INTRA-ARTICULAR FRACTURES OF THE CALCANEUM

PART II: OPEN REDUCTION AND INTERNAL FIXATION BY THE EXTENDED LATERAL TRANSCALCANEAL APPROACH

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The classification of intra-articular fractures of the calcaneum described in part I is related to an operative approach which allows accurate reduction and stable fixation of the fracture fragments. An extended lateral incision is used to avoid sural nerve damage and problems of soft-tissue healing.

In type 3 fractures, access to the lateral joint fragment requires an osteotomy of the lateral wall, but after this the lateral joint fragment can be rotated out of the subtalar joint to allow transcalcaneal reduction of the medial wall. Reduction of the body fragment and lateral joint fragment on to the sustentacular fragment allows the three fragments to be stabilised by a 3.5 mm Y-shaped reconstruction plate.

Our early results have been successful in terms of fracture reduction and the restoration of heel shape and joint congruity, but extended follow-up will be necessary to define the indications for this difficult procedure.

Operative treatment of calcaneal fractures is often complicated by soft-tissue problems including sural nerve damage and poor wound healing. Reduction and stable fixation are difficult. In part I of our study, we documented the pathological anatomy in 120 cases and presented a surgically-based classification (Eastwood, Gregg and Atkins 1993). From this we have developed a technique for open reduction and internal fixation for displaced intra-articular fractures. We describe this method and its evolution, and report our early results.

PATIENTS AND METHODS
Since November 1988, all displaced intra-articular fractures of the calcaneum referred to the senior author (RMA) have been considered for open reduction and internal fixation. Operation is indicated when there is significant derangement of the subtalar joint, rotation of the body fragment likely to upset hindfoot biomechanics, and broadening of the heel with displacement and compromise of the peroneal tendons. The main contra-indication is excessive comminution of the sustentacular fragment. The decision is also influenced by the patient's age and fitness, physical demands on the foot and the neurovascular status of the limb.

Our operative technique evolved slowly from that described by Stephenson (1987) who used a direct lateral approach, traditional reduction techniques and fixation with a screw and staple. We have operated on 43 displaced intra-articular fractures of the calcaneum, performing transcalcaneal reduction in 36. We abandoned staple fixation in 1989, and since then 30 fractures have been stabilised by means of a plate; the extended lateral incision was used in the last 23 cases. The mean age of the 36 patients was 41 years (16 to 68) and 34 were male. Two fractures were compound (grade 1) on the medial side.

Before operation, swelling is reduced by elevation, ice, and intermittent compression. A backslab is applied if necessary to prevent equinus deformity, but where possible, ankle and foot movements are encouraged. Plain radiographs and coronal CT scans are obtained.
and the fracture classified according to the composition of the fractured lateral wall of the calcaneum (Eastwood et al 1993). A lateral radiograph of the uninjured hindfoot is useful to demonstrate the normal anatomy.

**Operative technique.** The aim of the operation is to reverse the displacements of the three major fracture fragments, by reducing the body and lateral joint fragments separately on to the sustentacular fragment.

Either general or epidural anaesthesia is used. The patient is placed in a lateral position with the fractured heel uppermost. A thigh tourniquet is applied with the lower half of the leg draped free. One experienced assistant is required.

**Incision.** The incision begins almost in the midline posteriorly, about 5 cm proximal to the lateral malleolus and extends distally, slightly obliquely, just anterior to the tendo Achillis along the posterior edge of the heel and then anteriorly along the edge of the foot as far as the base of the fifth metatarsal (see Fig. 7). It is important to avoid any bruised skin around the heel (Eastwood and Atkins 1992). The L-shaped incision passes posterior to the sural nerve which is elevated with the anterior flap (Eastwood, Irgau and Atkins 1992).

**Approach to the fracture.** The incision is deepened on to the calcaneum; anteriorly the small abductor muscle of the foot is split in the line of its fibres to expose the calcaneocuboid joint. Posterosuperiorly, it is important to avoid damage to the tendo Achillis.

Dissection of the lateral wall of the calcaneum in a subperiosteal plane elevates a thick soft-tissue flap up to the subtalar joint. The peroneal tendons in their intact sheath are elevated with this flap, and the posterior subtalar joint is exposed by placing a lever over the talar neck and gently elevating the soft tissues.

Access to the fracture fragments depends on the composition of the lateral wall (Eastwood et al 1993). In a type 1 fracture the lateral wall at the level of the tip of the lateral malleolus is formed by the lateral joint fragment. The anterior border of this, anterior to the subtalar joint, is exposed using a hook or a small periosteal elevator. The fragment can then be rotated out of the subtalar joint, and hinged back and up on its preserved posterior soft-tissue attachments (A, Fig. 1).

By contrast, in a type 3 fracture the visible lateral wall may appear to be unfractured: it is entirely formed by the body fragment, and the lateral joint fragment is lying inside this (Fig. 2a). Guided by the CT appearances, an osteotomy of the lateral wall is performed and a flap turned down (Fig. 2b) to reveal the lateral joint fragment, which can then be dissected anteriorly and hinged out of the wound as described for type 1 fractures. In a type 3 fracture, particularly if it is an Essex-Lopresti tongue-type fracture, the axis of rotation of the lateral joint fragment may be sagittal rather than coronal.

In a type 2 fracture the lateral wall is formed by the body fragment below and the lateral joint fragment above, often with comminuted fragments, some of which will have been dissected off with the soft-tissue flap. A small osteotomy of the lateral wall may be required to reveal the entire lateral joint fragment, and allow it to be rotated out of the joint as described above.

**Reduction.** After any necessary osteotomy and the reflection of the lateral joint fragment, it is possible to see through the calcaneum to its medial side with the sustentacular fragment above and the body fragment below. These fragments are usually impacted and angulated in varus (Eastwood et al 1993). A small periosteal elevator is introduced into the medial wall fracture site, and this is reduced by gentle leverage with disimpaction and correction of the varus deformity (B, Figs 1, 3). The reduced position is held temporarily by passing a single Kirschner wire through the heel and the body fragment into the sustentacular fragment.

The lateral joint fragment is then rotated back into place and reduced on to the sustentacular fragment to restore the congruity of the posterior subtalar joint facet. This reduction is also held temporarily by a transverse Kirschner wire. The reduction is confirmed visually by inverting the hindfoot, and radiographically by lateral and axial views.

**Fixation.** In order for the operative approach for management of calcaneal fractures to succeed, stable fixation of the major fragments must be achieved. Precise screw positioning is essential but can be difficult particularly for screws 1, 7 and 8. The screws are described in the order in which they are normally inserted.

**Screw 1.** The lateral joint fragment is fixed to the sustentacular fragment using an AO 3.5 mm cortical lag screw and washer (Fig. 4). This screw passes through the subchondral bone of the posterior facet and is directed medially, anteriorly, and slightly upwards, aimed at the strong cortex of the sustentaculum tali. The direction of this screw is critical and it is helpful if an assistant palpates the sustentaculum from the medial side of the foot to provide an aiming point. A single screw is usually adequate.

When the posterior subtalar facet has been fixed, and the lateral wall replaced, an AO 3.5 mm Y-shaped reconstruction plate is contoured and shortened to allow fixation of the body fragment (Fig. 5). A number of screws are placed through the plate, until stable fixation is achieved. In most cases five screws are required, two into the sustentacular fragment, two into the body fragment and one anteriorly. Seven screw positions, however, are described (2 to 8, Fig. 6) since comminution or abnormality of fracture pattern may make any or all of them necessary.

**Screws 2 and 3.** These 3.5 mm cortical screws pass through the superior arm of the Y-plate and into the medial fragment below the sustentaculum tali. One or both of these screws may fail to obtain a good grip because of comminution. In such a case, a screw is needed in position 7.
In a type 1 or type 2 three-part calcaneal fracture, the lateral joint fragment can be rotated out of the subtalar joint (A), to allow access to the medial wall fracture (B).

In a type 3 fracture, the apparent lateral wall of the fractured calcaneum is formed by the lateral cortex of the body fragment. The lateral joint may be impacted into the body fragment. The lateral wall of the fractured bone exposed at operation may appear intact and an osteotomy of the lateral wall (arrow, Fig. 2a) is necessary to expose (C, Fig. 3) and reduce the other fragments. In this case, which was not operated on, there is significant comminution of the sustentacular fragment which would preclude fixation by our technique.

Exploded diagram to show transcalcaneal reduction of the medial wall of a type 3 fracture. The lateral wall fragment has been osteotomised and turned down (C), and the lateral joint fragment has been rotated out of the subtalar joint on its soft-tissue attachments (A). A small periosteal elevator (B) has been passed through the medial wall fracture site and levered downwards to reduce the displacement. In type 1 or 2 fractures this can be performed without turning down the lateral wall (see text).
Fracture fixation. Screw 1 is placed through the lateral joint fragment into the sustentacular fragment, securing a subtalar joint reduction.

A Y-shaped plate is shortened and contoured to the lateral surface.

Diagram to show the position and direction of screws 1 to 8 (see text).

Screws 4 and 5. These screws, which may be cortical or cancellous, are passed through the inferior limb of the plate into the body fragment, and obtain a good grip if they are angled towards its posteromedial corner. If they have a poor hold, screw position 6 is used.

Screw 6. This cancellous screw, if required, passes through the most posterior hole of the plate on the superior surface of the calcaneum, down into the body fragment.

Screw 7. This cortical screw, if required, passes medially, posteriorly and superiorly into the sustentaculum tali to reinforce its fixation. It is difficult to place but is important if either screws 2 or 3 fail to obtain a good grip.

Screw 8. This is the most anterior screw, placed just proximal to the calcaneocuboid joint. An oblique placement will cross and hold any anterior extension of the fracture line. If the anterior calcaneum is too comminuted for screw placement, the plate may be extended distal to the calcaneocuboid joint. A screw into the cuboid will then maintain calcaneal length.

Screws should not be left proud in the medial wall inferior to the sustentaculum tali as they may interfere with the action of flexor hallucis longus (Carr 1990). The wound is closed in two layers over a suction drain. When fixation is sound, active and passive movements are started immediately, but the patients remain non-weight-bearing for six weeks.

Bone grafting. In type 1 and type 2 fractures, there is rarely a significant defect after reduction. A major defect usually indicates inadequate reduction, either with a gap in the subtalar joint surface, or inadequate correction of displacement between the body and the sustentacular fragments.

In type 3 fractures, particularly where the lateral
Preoperative radiograph (a) and CT scan (b) of a type 2 fracture, with a postoperative radiograph (c) and CT scan (d). In this case, the lateral joint fragment was found at operation to be devoid of soft-tissue attachment. The plate and screws had been removed two days before the CT scan, which accounts for the soft-tissue swelling. The position of the incision can just be seen inferolaterally. The medial wall fracture and the subtalar joint surface have been reduced.

Lateral (a) and axial (b) views after reduction and fixation of a displaced calcaneal fracture. Böhler's angle is restored; the axial view shows good reduction of the medial side with screws well-positioned in the sustentacular fragment.

Figure 10a – CT scan of a severely displaced calcaneal fracture in a young working man. The lateral joint fragment is dislocated, and at operation, severe damage to the articular surface was found. Figure 10b – One year after fixation and four days after plate and screw removal. The medial wall fracture has been reduced, body alignment and heel width are restored, and the subtalar joint surface is reconstructed. The defect in the subtalar joint is due to severe local comminution at the time of fracture and there is evidence of early degenerative change on the lateral side of the joint.
joint fragment has impacted into the body fragment, there is often a defect between these two pieces. However when the osteotomised lateral wall has been replaced, the residual defect is usually small, and the cancellous bone reconstitutes rapidly. We have not used bone graft since we developed our new technique (see Fig. 11).

RESULTS
The extended lateral incision gave adequate exposure of the lateral wall, subtalar joint and calcaneocuboid joint in all 23 cases. The incision healed well (Fig. 7) despite early mobilisation, with no necrosis, infection or sural nerve damage.

The preoperative CT scan appearance and classification were always confirmed at operation. After osteotomy of the lateral wall, where necessary, it was always possible to rotate the lateral joint fragment out of the subtalar joint. In two cases, the soft-tissue attachments of the lateral joint fragment had been completely disrupted by the injury, but postoperative fracture healing was not impaired in either (Fig. 8).

Reduction of the medial wall was always possible through the transcalcaneal approach and replacement by rotation of the lateral joint fragment succeeded in reducing the posterior facet of the subtalar joint. When present, fragmentation of the posterior articular facet occasionally made anatomical reduction difficult to achieve.

In one early case, the varus angulation of the body fragment was not completely corrected, but there has been some remodelling to a normal hindfoot appearance. Such varus angulation of the body fragment can readily be overcome by careful reduction followed by adequate contouring of the plate. Plate fixation was adequate in the 30 cases in which it was used, but tended to be less secure in elderly osteoporotic patients. Extension of the plate distal to the calcaneocuboid joint was needed in only two cases. Since the Y-plate has been used, 30 consecutive cases have shown no loss of fracture reduction or fixation. All the fractures united and, despite the absence of bone graft, cancellous bone has reformed (see Fig. 11c). Radiographs confirm the restoration of Böhler’s angle and posterior subtalar joint congruity on oblique and axial views (Fig. 9). Heel height and width have been consistently restored.

In three patients from whom the plate has been removed, postoperative CT scans have confirmed fracture union. In one case the lateral joint fragment had been dislocated laterally and showed severe damage to the articular surface. The follow-up CT scan shows degenerative changes (Fig. 10).

DISCUSSION
Many different techniques of open reduction have been described for intra-articular fractures of the calcaneum (Palmer 1948; Burdeaux 1983; Stephenson 1987). Our technique is difficult; it requires full knowledge and understanding of the three-dimensional anatomy of the injury. We consider that the extended lateral incision and transcalcaneal approach minimise soft-tissue problems and make accurate reduction and secure fixation possible. The contraindications are gross sustentacular comminution (see Fig. 2a) or a very small sustentacular fragment. In these circumstances stable reduction and adequate fixation of the medial wall cannot be achieved.

Our early results are encouraging, but we do not suggest that the case for open reduction and internal fixation of these fractures is proven. We are conducting
a long-term follow-up of these cases, and will compare the results with those of similarly documented conservatively treated fractures. Only then will it be possible to provide a scientific evaluation of the indications for and merits of open reduction and internal fixation.

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REFERENCES


