Limited open reduction and internal fixation of displaced intra-articular fractures of the calcaneum


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The extended lateral L-shaped approach for the treatment of displaced intra-articular fractures of the calcaneum may be complicated by wound infection, haematoma, dehiscence and injury to the sural nerve. In an effort to reduce the risk of problems with wound healing a technique was developed that combined open reduction and fixation of the joint fragments and of the anterior process with percutaneous reduction and screw fixation of the tuberosity. A group of 24 patients with unilateral isolated closed Sanders type II and III fractures was treated using this technique and compared to a similar group of 26 patients managed by the extended approach and lateral plating. The operation was significantly shorter (p < 0.001) in the first group, but more minor secondary procedures and removal of heel screws were necessary. There were no wound complications in this group, whereas four minor complications occurred in the second group. The accuracy and maintenance of reduction, and ultimate function were equivalent.

The management of displaced intra-articular fractures of the calcaneum remains controversial. Groups of patients have been identified who had a better outcome after operative than after non-operative treatment, with an anatomical reduction being among the key factors. If operation is chosen, the options range from lateral plating via the extended lateral L-shaped approach to percutaneous reduction and internal fixation either with pins or screws, or external fixation. The extended lateral approach allows ample visualisation of the fragments and subsequent ease of reduction and fixation, using specially designed large plates with locking screws for additional stability. The potential disadvantages are devascularisation of the lateral wall of the calcaneum and of the fragment of the posterolateral joint facet, the large surgical field open to contamination, the vulnerable edges of the fasciocutaneous flap, the creation of a dead space between the lateral wall of the calcaneum and the flap, and the increased length of the operation due to the meticulous technique required for preparation and closure of the wound. These factors can contribute to increased problems of wound healing, infection and articular degeneration, which may prejudice the outcome. The advantages of the percutaneous techniques are the rarity of iatrogenic soft-tissue injury and the theoretical absence of devascularisation of the bone. However, there is greater difficulty in achieving and maintaining anatomical reduction and fixation, and percutaneous pins are prone to infection. In an attempt to eliminate the disadvantages of the extended lateral exposure while maintaining the ability to reduce the joint fragments accurately, a new technique has been developed which combines a straight lateral subtalar approach for open reduction and fixation of the posterolateral joint fragments and those of the anterior process, with percutaneous reduction and fixation of the fragment of the tuberosity. In a retrospective study we compared a group of patients treated with lateral plating via the extended approach to a group managed by a limited subtalar approach using combined percutaneous and open fixation. We assessed the quality of the reduction, the duration of the operation, the rate and nature of complications, the time to healing and the early outcome, in order to determine whether the new approach and technique resulted in fewer wound complications while allowing the same accuracy of reconstruction.

Patients and Methods

Between 1995 and 2006, 160 displaced fractures of the calcaneum in 139 patients were treated by operation at our institution, 59 using the extended approach and lateral plating, 58 by the new limited approach, and 43 with other different techniques. From the total
of 160 fractures we excluded open fractures (ten), bilateral fractures (43), patients with multiple fractures (14), those treated by primary subtalar arthrodesis (four), Sanders type IV fractures (nine), extra-articular fractures (seven) and those managed by a different operative technique or surgeon (12). There were 11 lost to follow-up, leaving 50 patients with 50 unilateral displaced intra-articular closed fractures of Sanders type II and III operated on by the senior surgeon (MW, Fig. 1). These were divided into two groups according to the technique used for reduction and fixation. The groups compared well with respect to gender, age and fracture subgroups (Table I). The first consisted of 26 consecutive patients treated until 2001 with open reduction via an extensile lateral L-shaped approach. The fractures were fixed with a lateral eight-hole 2.7 mm AO reconstruction plate (Synthes, Oberdorf, Switzerland) with separate transverse screws for fixation of the posterolateral joint fragment (Fig. 2). The wound is closed by resutting the periosteum at the angle of the approach, and by interrupted subcuticular and skin sutures over a suction drain.

**Operative technique**

**Lateral plating via the L-approach.** The patient is placed in the lateral position with a thigh tourniquet. The incision starts halfway between the tendo-Achillis and the peroneal tendons at the level of the ankle joint, and runs distally in a straight line towards the edge of the heel, where it curves 90° to continue horizontally to the base of the fifth metatarsal. Proximally the sural nerve is identified and protected. At the level of the lateral wall of the calcaneum the incision is carried in a straight line perpendicular to the bone. Starting in the ‘angle’ of the incision, the periosteum is dissected sharply off the calcaneum, taking care to create a fasciocutaneous flap without disturbing the skin or the subcutaneous fat. The fracture is then reduced and fixed with a lateral eight-hole 2.7 mm AO reconstruction plate (Synthes, Oberdorf, Switzerland) with separate transverse screws for fixation of the posterolateral joint fragment (Fig. 2). The wound is closed by resutting the periosteum at the angle of the approach, and by interrupted subcuticular and skin sutures over a suction drain.

**Technique via a short lateral subtalar approach.** The patient is placed in the lateral position with a thigh tourniquet. A 5 mm Schanz screw is inserted into the posterolateral tuberosity of the calcaneum. With gentle manual distraction and varus-valgus levering, a closed reduction of the tuberosity is attempted. Usually the joint fragment does not reduce spontaneously. A medium-sized distractor (Synthes, Oberdorf, Switzerland) is then placed from an additional Schanz screw in the anterolateral aspect of the distal tibia to that in the calcaneum. Gentle distraction is applied to overcome the shortening of the soft tissues. An incision 4 cm to 5 cm long is made from the tip of the lateral malleolus to the level of the calcaneocuboid joint in a straight line towards the base of the fourth metatarsal. Proximally, the interval between the peroneal tendons and the sinus fat pad is entered, carefully preserving the integrity and the dorsal attachments of the fat pad. Distally, the fascia of the extensor brevis muscle is incised longitudinally in line with the skin incision and the muscle split in line with its fibres as far as the calcaneocuboid joint if necessary. The resulting window gives access to the posterior facet, the anterior process and the calcaneocuboid joint (Fig. 3). The surfaces of the fragments are cleaned and the impacted posterolateral fragment is elevated and everted, preserving its soft-tissue attachments. This gives access to free up the impacted medial wall, between the posteromedial sustentacular fragment and the tuberosity. The distraction is released and the tuberosity levered medially into a slightly over-reduced position behind the sustentacular fragment. Reduction of the fragments of the posterior facet is then possible, and they are fixed either temporally with a Kirschner (K)-wire, or definitively with one or two transverse screws. The reduction is then continued along the angle of Gissane to the anterior process and its cuboid facet. In simple fracture patterns screw fixation alone is usually sufficient. In complex fractures stabilisation is obtained with a straight four- or five-hole 2.7 mm AO plate (Synthes) placed laterally, fixing the posterior joint block to the anterior process. The tuberosity fragment is
then levered into its anatomical position. The whole construct is stabilised with four 3.5 mm screws, introduced through a transverse incision at the posterior part of the heel distal to the insertion of the tendo Achillis. Two parallel screws are directed upwards to end with their tips in the posteromedial and the posterolateral joint fragments, about 5 mm short of the joint. Two additional parallel screws are directed into the dorsal portion of the anterior process of the calcaneum (Fig. 4). The bulge in the lateral wall is reduced manually and secured with a transverse screw if needed. The joint alignment is checked fluoroscopically and the adequacy of reduction, stability of the construct and unrestricted subtalar movement are verified. The wound is closed by careful re-approximation of the divided fascia and interval, and by running sutures to the skin over a suction drain if needed.

Reduction of the joint was assessed as satisfactory when there was 1 mm or less of residual displacement. After operation the patients were put in a short leg cast without weight-bearing for six weeks, followed by increasing partial weight-bearing for another six weeks, either in a cast or in an ankle boot. Anteroposterior and lateral radiographs of the ankle and axial views of the heel were obtained post-operatively, at six and 12 weeks, at one year, and at the latest follow-up. Loss of reduction was defined as the appearance of ≥ 2 mm of displacement of the joint or the body of the calcaneum, or a change of 5° or more in Böhler's angle on any of the follow-up radiographs. CT was used occasionally after operation, but did not add relevant information to that already obtained from intra-operative inspection, fluoroscopy and post-operative radiographs, and was therefore not used routinely. The American Orthopaedic Foot and Ankle society (AOFAS) ankle/hindfoot score was calculated. The clinical results were graded as 90 excellent, 80 good, 70 fair, > 70 poor. The follow-up and radiological review was carried out by all of the authors. For the purposes of this study all the notes and radiographs were again reviewed by the second author (OL).

**Statistical evaluation.** The unpaired *t*-test was used to compare the delay to operation, the duration of the operation, the length of hospital stay and the AOFAS score. The Mann-Whitney *U* test was used to compare the time to healing. Fisher’s exact test served to compare the number of complications, the rate of subsequent subtalar arthrodesis and removal of metal.

### Table I. Fracture subgroups

<table>
<thead>
<tr>
<th>Sanders type</th>
<th>II A</th>
<th>II B</th>
<th>II C</th>
<th>III AB</th>
<th>III BC</th>
<th>Calcaneocuboid involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard†</td>
<td>11/26</td>
<td>8/26</td>
<td>1/26</td>
<td>5/26</td>
<td>1/26</td>
<td>13/26</td>
</tr>
<tr>
<td>New‡</td>
<td>13/24</td>
<td>6/24</td>
<td>1/24</td>
<td>3/24</td>
<td>1/24</td>
<td>11/24</td>
</tr>
</tbody>
</table>

* standard = extended lateral L-type approach, lateral plating
† new = limited lateral subtalar approach, combined percutaneous and open screw fixation
**Results**

Normal alignment of the calcaneum, including heel height and width as judged clinically and radiographically, and adequate restoration of the joint surface with incongruity of < 2 mm, was obtained in all the patients of both groups. The mean follow-up was for 25 months (11 to 16) in the extended-exposure group, and 31 months (12 to 65) in those with a limited exposure. Radiological follow-up was for 19 (11 to 76) and 31 months (12 to 65), respectively. The overall results according to the AOFAS score are listed in Table II, and the details are given in Table III (Fig. 5). In the limited-exposure group a short lateral plate was used in three patients. A significant reduction of the operating time was found in this group, but an increase in the rate of removal of metal, which was required in three of 26 patients (12%) in the standard group with removal of the lateral plate and in ten of 24 patients (42%) in the second group who required removal of the postero-inferior screws. Comparing the delay to operation, we excluded the extremes, which were due to logistical reasons and not to swelling of the hindfoot. No significant difference was found.

On average, the new approach saved 52 minutes of operating time. This was felt to be due to its smaller extent and easier handling during preparation and closure.

**Complications.** The complications are listed in Table IV. There were four complications in the extended-exposure group. One patient had a wound dehiscence which healed spontaneously within four weeks without antibiotics. In another a haematoma was evacuated on the second postoperative day, followed by uneventful healing. Two patients had dysaesthesia of the sural nerve, which...
resolved within two to three months. Four further patients had prolonged diffuse moderate hindfoot pain on weight-bearing without swelling or delayed osseous healing. They were diagnosed as having minor forms of complex regional pain syndrome (CRPS). They were treated with analgesics, physiotherapy, restriction of activity and compression stockings, and eventually had a good result after nine to 18 months. Tenderness of the scar was present in these four patients and in the two with sural nerve irritation.

In the limited-exposure group there were no perioperative complications. One patient complained of minor plantar dysesthesia two weeks after operation. This was attributed to pressure by the cast, and resolved within six months. At three months ten patients complained of tenderness of the postero-inferior scar. In five, the screw heads were not completely flush with the bone. In all ten patients the tenderness resolved after removal of the screws. All of the remaining 14 patients stated on specific questioning and palpation that the scar felt uncomfortable. Three of them had prominent screw heads, but no tenderness. No further screws were removed. Loss of reduction of 2 mm or more of height, width or joint congruity or loss of more than 5° of Böhler’s angle did not occur in any patient in either group.

Discussion
Different surgical approaches and techniques of fixation have been used with varying success. A majority of authors have preferred the extended lateral L-type approach with lateral plate fixation. Good to excellent results have been obtained in 60% to 85%.4,5,21,25

However, the extensive nature of this approach bears the risks of problems with skin healing. It worsens the traumatic devascularisation of the central and anterior part of the lateral wall, as 45% of the calcaneal vascularity is derived from vessels entering at this site.26,27 The frequency of the general complications ranges from nil up to 33% with wound problems,4,8,10,28-34 32% with infection31 and 10% with sural nerve injury and a CRPS.33 In an attempt to reduce these complications, various authors have proposed less invasive approaches. Several studies have advocated percutaneous techniques in selected fractures, mainly of the tongue-type with an intact posterior facet,35-40 and have found fewer soft-tissue complications. Although we had few complications with the extended approach and only one with the limited approach, all of which healed without further treatment, they still represented a threat to a successful outcome. The improvement with the less invasive technique was not statistically significant, as the groups were too small to allow this.

Extensive studies of the extended lateral approach have been published.7-9 Eastwood et al7 dissected the distal course of the sural nerve in 20 cadaver limbs. They assessed the mean position of the main nerve trunk at various points related to bony landmarks of the lateral hindfoot, and concluded that dorsolateral incisions may damage both the main trunk and the major anterior branch. From this investigation they derived their extended lateral transcalcaneal approach, which was used without any problems with wound healing or sural nerve damage in 23 cases.8 Subsequently, Eastwood and Atkins9 compared the modified Kocher or direct lateral incision with their extended lateral incision in two groups of 20 patients. They found that the extended lateral incision was associated with significantly fewer problems with wound healing or sural nerve damage than the direct lateral incision. In a further investigation10 they studied the vascular supply of the skin of the posterolateral heel, emphasising that any approach that exposed the sural nerve will cause ischaemia of the posterior skin. They then reviewed 150 consecutive patients after the use of their approach and found 15 complications involving infection and wound healing, but no damage to the sural nerve.

Gupta et al41 studied wound healing and post-operative CT alignment of 32 calcaneal fractures of Sanders types I to III operated on with a modified Palmer lateral approach.42 They found adequate restoration of the anatomy and one
The main problem with percutaneous fixation is a secondary loss of reduction of 3° to 20° in Böhler’s angle.\(^\text{16,46,47}\) In our experience, Böhler’s angle varies on sequential radiographs if the rotation of the hindfoot is not standardised. However, with identical rotation Böhler’s angle was a precise indicator during the exposure is not standardised. However, with careful intra-operative attention to fitting the screw heads flat to the bony surface, and with the usual disappearance of the symptoms, it has become unusual to remove the implants.

Newer studies have shown promising results for minimally-invasive treatment even in complex fractures. Nehme et al\(^\text{18}\) presented good results and no complications with arthroscopically-assisted percutaneous reduction and screw fixation in 15 fractures in 13 patients. Fröhlich et al\(^\text{12}\) compared the results of 34 fractures treated with lateral plates to 94 fractures with percutaneous reduction and fixation with transverse and oblique screws. After one to four years of follow-up the results in the percutaneous group were slightly better, with 80% subjectively and 72% objectively good and very good results. Wound healing was a minor problem and occurred mainly in patients with comorbidities such as diabetes and alcohol abuse. In a large series Forgong\(^\text{11}\) presented the results after one year of 265 fractures treated with percutaneous reduction using a distractor with pins in the talus, calcaneal tuberosity and cuboid. Once Böhler’s angle was restored, side-to-side compression with a Böhler-type clamp was applied to reduce the widening of the calcaneal body. The posterior joint was reduced with percutaneous manipulation via a K-wire, and fixed with a malleolar screw. The entire calcaneum was then fixed with large cancellous screws from posterior to anterior. Forgong\(^\text{11}\) found 90% good and very good results, with 4% loss of reduction, 2% failure of technique and 3.7% of wound complications. Tornetta\(^\text{30}\) used percutaneous reduction and fixation in 41 patients, five of whom had pin-track infections, and two fractures lost reduction. He stated that percutaneous fixation was most useful for tongue-type fractures in which the displaced portion of the posterior facet remained intact to the tuberosity. Stulik et al\(^\text{16}\) reviewed 287 fractures treated with percutaneous reduction using posterior traction, K-wire manipulation, elevation of the joint fragment through a plantar window, and K-wire fixation for six to eight weeks. Nearly anatomical reduction was
obtained in 74%. There were pin-track infections in 7%, deep infections in 1.7%, loss of reduction in 4.5% and a need for flap cover in 1%. Good and excellent results were obtained in 70%. Ebraheim et al49 treated 106 fractures via a sinus tarsi approach using one or multiple pins. Complications were infection in 8.5% and other complications in 9.4%. Although our subtalar approach is similar to their sinus tarsi approach, we had no complications. We attribute this difference to their use of percutaneous pins and to the inclusion of Sanders type IV fractures.

Park et al50 used a limited posterior incision in 103 fractures. Fixation was obtained mainly with partly-threaded small cancellous screws or Steinmann pins. Complications attributable to surgery through a posterior approach were
found in 13 patients. These included minor wound problems, tarsal tunnel syndrome, and calcaneal bony spur. Disruption of the wound margins developed in four feet. With a mean follow-up of 28 months they noted 90% good to excellent results. They recommended their technique for displaced intra-articular fractures having three or four large fragments without further comminution, and without a displaced fracture of the calcaneocuboid joint.

Our technique fulfils the requirements of both anatomical restoration of the joint surface with rigid fixation via the subtalar approach, and restoration of the overall alignment of the calcaneal anatomy. It does not have the disadvantages of the extended approach, as it lies in the internervous plane and respects soft-tissue planes, leaving minimal space for a haematoma. The approach offers a window large enough to reduce and fix the joint, and to control reduction of the tuberosity of the calcaneum. Percutaneous fixation with axial screws is stable enough in fractures without comminution or osteoporosis. We prefer screws to pins, as with axial screws is stable enough in fractures without comminution or osteoporosis. We prefer screws to pins, as pins could avoid this disadvantage, but they carry a 7% risk of pin-track infection. Loss of reduction did not occur in our patients.

This technique of fixation with transverse and axial screws is best suited to fractures in good bone with large and solid fragments. In multifragmentary fractures of the anterior process the axial screws will not gain enough purchase to stabilise the construct adequately. Simple split fractures of the anterior process can be fixed with transverse screws, thereby creating a large single anterior fragment, which may be sufficiently stabilised with axial screws. In more comminuted fractures of the anterior process a short lateral plate can be used to fix the anterior fracture to the reconstructed posterior facet. Multifragmentary fractures of the tuberosity itself, and short tuberosity fragments, are very difficult to fix solidly, and so these fractures were excluded from this study.

Operative treatment of calcaneal fractures through both extended and limited exposure requires a good understanding of the three-dimensional anatomy. The limited-exposure technique is more demanding with respect to the ability to navigate fragments and implants with little visual control. More fluoroscopic time is needed to check the proper position of the percutaneous screws and the overall alignment of the calcaneum. However, although the learning curve is steep, it has now become our standard technique for all the calcaneal fractures requiring operative treatment, because its advantages largely outweigh the disadvantages.

The strengths of our study are the comparison of similar groups with respect to number of patients, fracture type, patient selection and post-operative management, and the fact that all the patients were operated on by the same surgeon. The weaknesses are the relatively small numbers of patients owing to the exclusion criteria and the retrospective nature of the study.

Anatomical reduction and fixation of displaced Sanders II and III intra-articular fractures of the calcaneum was as reliably accomplished with a short lateral subtalar approach and combined direct and percutaneous fixation as with a standard extended approach using lateral plating.

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References

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