INTRODUCTION
Calcaneal fractures are the most common injury to the tarsal bones. Most of them occur in males of working age group. If improperly treated, it can result in long lasting pain and disability and many patients fail to return to their original occupation after the trauma. The most common mechanism of injury is fall from height followed by RTA (Road traffic accident).

Fractures of the calcaneus need proper radiographic evaluation. Lateral radiograph of the hindfoot is the most common initial radiographic view that would suggest the presence of intra-articular fracture. Harris axial view is difficult to obtain in the acute setting of trauma as it results in significant pain to the patient. Apart from the Bohler’s and Gissane’s angles, the radiograph should be carefully studied for presence of displacement of articular surface at the subtalar joint. All patients suspected or diagnosed to have a displaced intra-articular fracture of the calcaneus should undergo Computerised Tomography (CT) scan of hindfoot. The fracture should be evaluated in three planes—saggital, coronal and axial. Sagittal view is good to assess articular surface displacement along the long axis of the calcaneus. Coronal view is useful in classifying the fracture according to the Sanders’ type, assess vertical alignment (heel varus/ valgus) and displacement of the sustentaculumtali fragment. Longitudinal alignment has to be studied in the axial view.

The principles of treatment of intra-articular fractures applies to calcaneal fractures as well. Failure to reduce the articular surface will result in arthritis of subtalar joint. Subtalar arthrodesis is not always successful in relieving the symptoms of patients. Achieving articular surface congruence and restoring the normal hindfoot alignment should be the principle aim of the treatment rather than accepting articular step and planning to do a arthrodesis at a later date if symptoms persist. Open reduction and internal fixation using the lateral ‘L’ shaped incision is the most widely performed procedure. It gives excellent exposure to the articular surface. However, there is a high incidence of wound healing complications following this approach. To overcome the problem, many techniques like limited open reduction, arthroscopy assisted fixation, triangular traction technique, Ilizarov fixator and calcaneal nail have been described. The sheer number of the procedures described gives a message that there is no consensus among different authors regarding the ideal fixation method.

SURGICAL TECHNIQUE
Minimally invasive reduction and percutaneous screw fixation is a very useful technique. It involves 4 steps:

a) Dis impaction
b) Reduction
c) Re impaction
d) Fixation

A Steinmann pin of size 4.5mm was inserted from medial side at the posteroinferior part of calcaneal tuberosity. The Steinmann pin ran mediolaterally. The entry point was made on the medial aspect to avoid injury to the neurovascular bundle running beneath the flexor retinaculum. An assistant held the forefoot. Traction was applied along the long axis of the calcaneum with alternating varus and valgus stress to disimpact the fracture fragments and gain space.

Once space was achieved, the next step was reducing the fracture fragments especially the posterior facet. In a joint depression fracture, a stab incision was given in the sole of the foot and a 3mm or 4mm bone punch was advanced through the primary fracture line into the body of calcaneus under image guidance. The entry point was widened by drilling. The surgeon had a prior knowledge of the position of articular depression in the coronal plane by studying the preoperative computerized tomography scan i.e., he knew whether the majority of depressed posterior facet is lying medially, centrally or laterally. If...
positioning the bone punch is difficult, then a guide wire was placed under image guidance so that it lies just below the depressed posterior fragment. The position of guide wire was confirmed in lateral view and Harris axial view. Then a cannulated drill bit was used to create a track for advancement of bone punch. Care was taken to avoid entering the subtalar joint. Guide wire was removed and bone punch was introduced along the same direction. Reduction was done by slowly tapping the bone punch until the depressed facet was elevated. This elevation as evident in lateral view was confirmed in both axial and Broden’s view.

In tongue-type fractures, a 4mm Steinmann pin was inserted lateral to Achilles tendon into the tuberosity fragment. This pin was used as a lever to rotate and elevate the fragment. In complex fractures, both these techniques were combined as necessary.

The next step was to compress the heel in order to impact the lateral wall. This maneuver locked the reduced fragments in position. Temporary fixation was done using either K-wires or guide wires. Cannulated cancellous screws were placed as necessary to maintain reduction. In most of our patients, we used minimum of 3 screws, two of them running in posteroanterior direction, the third running from lateral to medial direction lying just below the posterior facet in the lateral view and engaging the sustentaculum tali in the axial view. Care was taken to avoid intra-articular screw placement. Additional screws were placed as necessary.

TECHNIQUE OF MINIMALLY INVASIVE REDUCTION AND PERCUTANEOUS FIXATION (FIG 1-13)

Fig 1. Preoperative radiograph of hind foot - lateral view
Fig 2. Steinmann pin insertion medio laterally
Fig 3. Disimpaction of fracture by alternative varus and valgus force
Fig 4. Fluoroscopic lateral view of hindfoot after disimpaction
Minimally invasive fixation of calcaneal fractures

Fig 5. Preoperative radiograph of hind foot - lateral view

Fig 6. Articular surface depression elevated using bone punch

Fig 7. Reimpaction of fracture

Fig 8. Provisional fixation using k-wires

Fig 9. Provisional fixation using k-wires

Fig 10. Percutaneous screw placement
CASE EXAMPLE (FIG 14-22)
20 year old male patient with history of fall from 12 feet height presented to emergency department.

Postoperative Protocol
Patients were given bulky dressing in the operation theatre and wound was inspected on second postoperative day. Intravenous antibiotics were given starting 30 mins before
procedure and continued for 48 hours, followed by oral antibiotics for 2 weeks. Patients were kept non-weight bearing. During this period active toe movements, limb elevation and isometric exercises of the calf were encouraged. After 2 weeks, sutures were removed and physical therapy was initiated with active and passive range-of-motion exercises at the ankle, subtalar and midtarsal joints. Tiptoe walking was initiated in unilateral fractures. In cases of bilateral calcaneal fractures,
walking was initiated only after 10 to 12 weeks. Exercises were supervised for 30 minutes and the patients were advised to continue active exercises at least two times for 30 minutes every day. Patients were restricted to tiptoe walking with the help of walker until 6 weeks. Patients were advised to keep the limbs elevated while sitting and lying down. At 6 weeks follow-up, radiographs were repeated and partial weight bearing encouraged as tolerated. Physical therapy was continued and patient was encouraged to full bearing and return to occupation at the earliest.

RESULTS

Between May 2009 to June 2010, we operated on 22 displaced intra-articular calcaneal fractures by the minimally invasive technique. All are closed fractures. The mean age of the patients was 31.5 years with a SD of 11.71 years. The range is 20 to 60 years. 17 fractures occurred in males and 5 in females. The ratio was 3.4: 1 (M: F). 13 (59.1%) fractures were due to fall from height while 9 (40.9%) were due to RTA. Mean delay from trauma to surgery was 8.55 days with a SD of 3.291 (range 4 to 14 days).

According to the Sanders’ types, we had 7 fractures of type 2 (31.8%), 9 of type 3 (40.9%) and 6 of type 4 (27.3%). Mean duration of surgery was 1.26 hours with a SD of 0.419. Health Foundation Assessment scale (hereafter will be mentioned as CNF) for fractures of the Calcaneus was used to assess functional outcome at 6 weeks (1.5 months), 3 months, 6 months and 1 year (Table 1).

### Table 1

<table>
<thead>
<tr>
<th>Duration</th>
<th>Mean CNF Score</th>
<th>SD</th>
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<tbody>
<tr>
<td>1.5m</td>
<td>31.18</td>
<td>4.349</td>
</tr>
<tr>
<td>3m</td>
<td>60.36</td>
<td>5.980</td>
</tr>
<tr>
<td>6m</td>
<td>84.77</td>
<td>2.525</td>
</tr>
<tr>
<td>12m</td>
<td>91.14</td>
<td>2.253</td>
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None of the patients developed any wound healing complication and all of them returned to their original occupation. The average time taken to return to occupation was 13.5 weeks.

CONCLUSION

We find that minimally invasive reduction and percutaneous fixation is a fruitful alternative to open reduction and internal fixation especially for displaced intra-articular calcaneal fractures although larger studies are required to confirm the same.

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**REFERENCES**