Percutaneous Fixation of Displaced Calcaneal Fracture

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ABSTRACT

Purpose: To review the techniques and outcomes of percutaneous fixation, with the modified Essex-Lopresti technique, in isolated, displaced tongue-type calcaneal fractures.

Methods: This is a retrospective review of 24 patients who received percutaneous calcaneal screw fixation in our hospital, from April 2003 to June 2009. One patient had bilateral fixation performed. All patients had a series of X-rays of the injured foot, which included anteroposterior, axial, lateral, and Broden's views. Preoperative and post-operative Bohler's and Gissane's angles were measured. The patients' conditions were continuously assessed in serial follow-ups, and the Maryland Foot Score was used to evaluate the clinical outcome.

Results: Bohler's and Gissane's angles were fully restored in 13 and 17 out of 25 fractures, respectively. The mean duration of post-operative hospital stay was 4 days. There were no major post-operative complications. Sixteen patients were able to resume their original jobs. The Maryland Foot Score rated 13 patients as excellent, 9 (36%) as good, and 3 (12%) as fair. There were no patients rated as poor. The three patients with fair results complained of pain and stiffness at the subtalar joint.

Conclusion: Percutaneous fixation of displaced tongue-type calcaneal fractures is an effective treatment with acceptable clinical outcome, short hospital stay, minimal skin complications, and quick recovery.

Introductions

Traditionally, calcaneal fractures were only treated by compression wrapping. In 1975, Soeur and Remy\(^1\) reported on their operative experiences with calcaneal fractures. They proposed a classification system based on the number of bony fragments as determined by plain axial films, which indicated that the posterior main fragment could be broken into three fragments. After the development of new imaging techniques, Sanders et al\(^2\) described the modification of this system using coronal and transverse computed tomography (CT) scans and concluded that displaced intra-articular fractures require an anatomic reduction with stable internal fixation to maximise the chances of good joint function.
Posterior facet displacement is considered the key prognostic factor, as illustrated by a prospective study. This has been emphasised by a retrospective matched series conducted by Buckley and Meek, who suggested that a posterior facet reduction within 1 mm is required to produce results superior to closed or non-operative treatment. The correlation between accurate posterior facet reduction and optimal final outcome has also been described by Sanders et al.

Controversies have been existing concerning the standard operative treatment for calcaneal fractures. In the past, several reports encouraged open reduction and internal fixation as the treatment for displaced calcaneal fractures. However, some catastrophic complications, including wound complications and sural neuritis, were questioned. The percutaneous technique may take advantage of minimising complications from open procedures. The purpose of the current study was to review the techniques and clinical outcomes after percutaneous fixation of calcaneal fractures.

**Materials and Methods**

From April 2003 to June 2009, 24 male patients with displaced tongue-type calcaneal fractures received percutaneous screw fixation in our hospital. Exclusion criteria include multiple injuries, fractures with comminution or having more than one primary fracture lines. A standard series of plain X-rays of the ankle and foot were taken. The anteroposterior view allows the assessment of the calcaneocuboid joint. The lateral view facilitates the measurement of both Bohler’s and Gissane’s angles, which indicates the severity of the injury and may have a prognostic value. The axial view allows the primary fracture line to be delineated more clearly as whether single or multiple fracture lines exist. Broden’s view was obtained with the foot in neutral flexion and 40° of internal rotation and the X-ray beam centred over the lateral malleolus, angled at 40°, 30°, 20°, and 10° towards the head of the patient, visualising the posterior facet from anterior to posterior portion, to define the fracture pattern of the articular surface and exclude associated injuries. When in doubt, CT scanning was performed in detecting minimally displaced or comminuted fractures, and the axial view was particularly useful in the evaluation of the antero-inferior part of the posterior facet.

Clinical outcome included length of hospital stay, complications, ability to return to work, and evaluation using

<table>
<thead>
<tr>
<th>Bohler's angle</th>
<th>Gissane's angles before and after reduction</th>
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<tbody>
<tr>
<td>Calcaneal fracture</td>
<td>Bohler (pre)</td>
</tr>
<tr>
<td>Bohler (in degrees)</td>
<td>Gissane (in degrees)</td>
</tr>
<tr>
<td>1 10</td>
<td>30</td>
</tr>
<tr>
<td>2 1</td>
<td>-3</td>
</tr>
<tr>
<td>3 14</td>
<td>-3</td>
</tr>
<tr>
<td>4 28</td>
<td>26</td>
</tr>
<tr>
<td>5 0</td>
<td>12</td>
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<tr>
<td>6 0</td>
<td>11</td>
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<td>7 40</td>
<td>34</td>
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<tr>
<td>8 18</td>
<td>26</td>
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<tr>
<td>9 30</td>
<td>26</td>
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<tr>
<td>10 N/A</td>
<td>16</td>
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<td>11 0</td>
<td>14</td>
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<td>12 14</td>
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<td>20 0</td>
<td>28</td>
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<td>21 0</td>
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<td>22 20</td>
<td>29</td>
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<tr>
<td>23 0</td>
<td>15</td>
</tr>
<tr>
<td>24 -2</td>
<td>14</td>
</tr>
<tr>
<td>25 6</td>
<td>10</td>
</tr>
</tbody>
</table>

Grey box indicates satisfactory angle restoration.

Pre = preoperative; post = post-operative.
the Maryland Foot Score\(^7\) during the last follow-up before discharge from the outpatient clinics was recorded.

### Operative technique

Under general or spinal anaesthesia, the patients were in prone position. Split-legs operative table was used to facilitate lateral X-ray imaging by C-arm fluoroscopy (Figure 1).

The first step was to insert a 3-mm Steinmann pin superolateral to the Achilles tendon (Figure 2). The pin was inserted into the tongue fragment with manipulation to restore the posterior facet, as described by Essex-Lopresti.\(^8\) The tenaculum-type bone-holding forceps helps surgeons to apply manual traction and compression force throughout the operation in restoring the height, width, and alignment of the calcaneum. We recommend using a pair of artery forceps to bluntly dissect off the surrounding tissues after stab incisions are made to avoid injuring underlying neurovascular bundle and tendons.

A guide pin was inserted parallel to the Steinmann pin, through the tongue fragment and across the fracture site, in fixing the superomedial fragment. Lateral and axial X-ray screening was performed to confirm correct placement of the guide pin. A self-tapping 4.5-mm cannulated screw was inserted after drilling.

The Steinmann pin was removed, and the same entry site was used for the placement of the second guide pin across the fracture line, similar to the first pin. The second screw was then inserted.

In patients with excessive heel widening, another bone clamp was used to compress the primary fracture line, and the fracture was subsequently fixed with one to two transverse cannulated screws. This screw can only be applied if there is no comminution of the lateral wall. Careful fluoroscopic screening was essential to avoid screw penetration into the sinus tarsi.

### Post-operative management

Active range of movement exercises of the ankle and foot were commenced on post-operative Days 1–2. Patients were referred to outpatient physiotherapy on discharge. Full weight-bearing walking was initiated at 6–8 weeks depending on the progress of bone healing. Patients had first follow-up at 2 weeks for wound assessment; second follow-up at 6 weeks for plain radiographic evaluation of fracture healing and whether weight-bearing walking should be initiated; and subsequent follow-ups at 3 months, 6 months, and 1 year.

### Results

The average age of the patients was 47 years, ranging from 27 years to 60 years. Injury mechanisms included falling from height in 19 patients and slipping in five patients. Five patients had bilateral involvement, with one being operated bilaterally.

For radiographic evaluation, bone union was present in all 24 patients. Bohler’s and Gissane’s angles were fully restored in 13 and 17 out of 25 fractures, respectively (Table 1).

The average length of post-operative hospital stay was 4 days, ranging from 1 day to 13 days. All except two patients were discharged from acute ward within the first week after operation.

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**Table 2**
Patient evaluation on last follow-up using Maryland Foot Score

<table>
<thead>
<tr>
<th>MARYLAND FOOT SCORE (100 marks)</th>
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</thead>
<tbody>
<tr>
<td>Excellent 90–100</td>
</tr>
<tr>
<td>Good 75–89</td>
</tr>
<tr>
<td>Fair 50–74</td>
</tr>
<tr>
<td>Failure &lt; 50</td>
</tr>
</tbody>
</table>

1. **Pain (45 marks)**
   - None: 45
   - Slight: 40
   - Mild: 35
   - Moderate: 30
   - Marked: 10
   - Disabled: 5

2. **Function (55 marks)**
   1. **Gait (40 marks)**
      - Walking distance
        - (no limit: 10)
        - slight limit: 8
        - moderate: 5
        - severe: 2
        - indoor only: 0
      - Stability
        - (normal: 4)
        - weak feel: 3
        - occasional give way: 2
        - frequent give way: 1
        - orthotic device used: 0
      - Support
        - (none: 4)
        - cane: 3
        - crutches: 1
        - wheelchair: 0
      - Limp
        - (none: 4)
        - slight: 3
        - moderate: 2
        - severe: 1
        - unable to walk: 0
      - Shoes
        - (any type: 10)
        - minor concession: 9
        - flat laced: 7
        - orthotics: 5
        - space shoes: 2
        - none: 0
      - Stairs
        - (normal: 4)
        - with banister: 3
        - any method: 2
        - unable: 0
      - Terrain
        - (normal: 4)
        - problems on hills: 2
        - problems on flat surfaces: 0
   2. **Cosmesis (10 marks)**
      - Normal: 10
      - Mild deform: 8
      - Moderate: 6
      - Severe: 0

3. **Motion (5 marks)**
   - Normal: 5
   - Slight decrease: 4
   - Marked decrease: 2
   - Ankylosed: 0

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*Figure 3.* Restoration of Bohler’s and Gissane’s angles.
There were no wound complications and no sural nerve or peroneal tendons injury. No osteomyelitis was reported. One patient was noted to have loss of reduction with a persistent 3-mm fracture gap in post-operative X-rays. Screw revision was performed 1 month later, and subsequent X-ray and CT imaging showed that the fracture had finally united with minimal displacement. Removal of implant was performed 1 year after the initial injury. This patient had a fair result using the Maryland Foot Score, and finally, returned to his original job as a waiter.

The mean length of follow-up was 2 years, ranging from 17 months to 28 months. Sixteen out of 24 patients (67%) were able to resume their original jobs, including four construction site workers, four decoration workers, and others being waiter, bus repairer, clerk, electrician, and security guard. Three patients have changed jobs, and three have quit their original jobs. Two patients originally had no job.

Four patients were pain free on the latest follow-up. There were 16 patients with mild pain, four patients with moderate pain, and none with severe pain. Twenty-three patients were walking undaided. There were 10 patients with subjective ankle stiffness, four with reduced ankle movement, 12 with reduced ankle eversion and inversion, and none with ankle instability. Twenty-four operated limbs had normal calcaneal height, width, and length, compared with those of the contralateral side, excluding one patient with a bulging lateral wall of the calcaneum.

The Maryland Foot Score rated 13 patients (52%) as excellent, 9 (36%) as good, and 3 (12%) as fair (Table 2). The three patients with fair results complained of pain and stiffness of the subtalar joint.

### Discussion

Although there is no consensus on the best treatment for calcaneal fractures, in general, it is well accepted that treatment should aim at anatomical restoration of the joint articular surface and width-height-length of the heel to achieve functional recovery.\(^9,10\) It is also advantageous for the subsequent reconstruction if the hindfoot anatomy is reasonably reconstructed.

It is common that open fixation of calcaneal fractures may be associated with wound and neurovascular complications. To reduce such complications, Essex-Lopresti\(^8\) introduced the concept of percutaneous reduction of the displaced calcaneal fragment. Gissane later reported a modified instrument for spike placement, concluding that percutaneous reduction was useful only in tongue-type but not joint-depression-type calcaneal fractures.\(^11\)

### Table 3

<table>
<thead>
<tr>
<th></th>
<th>Excellent to Good</th>
<th>Fair</th>
<th>Fail</th>
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</thead>
<tbody>
<tr>
<td>Current study (n=25)</td>
<td>88</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Tornetta 1998 (n=22)</td>
<td>87</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Tornetta 2000 (n=41)</td>
<td>85</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Pillai A (n=15)</td>
<td>77</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Schepers Tim (n=50)</td>
<td>79</td>
<td>21</td>
<td>0</td>
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Figure 4. Post-operative outcome.
Tornetta\textsuperscript{12,13} observed that the outcome of percutaneous fixation was superior to the results using open reduction and internal fixation by means of an extended lateral approach by the same surgeon (87\% vs. 77\%), proposing two main contributing factors. First, careful patient selection implies better reduction of the intact facet as a whole with no intra-articular step-off. Second, the use of a percutaneous technique avoids large incisions and stripping required for formal open reduction, thus decreasing the amount of scar formation and possibly residual stiffness. The series conducted by Tornetta\textsuperscript{14} advocated the use of two 6.5-mm cannulated screws in parallel for fixation of the tongue fragment. This method has been modified in our study by using 4.5-mm cannulated screws instead to minimise screw head impingement.

Radiographic evaluation was performed by measuring preoperative and post-operative Bohler’s angle and the crucial angle of Gissane. In our study, Bohler’s angle was fully restored in 13 out of 25 fractures and crucial angle of Gissane in 17 out of 25 fractures (Figure 3).

By using the Maryland Foot Score, there were 13 (52\%) excellent, 9 (36\%) good, and 3 (12\%) fair results. The numbers of good or excellent clinical results were comparable to the results in a series of tongue-type calcaneal fractures using similar percutaneous fixation technique in the literature (Table 3).

In our review, the introduction of the Essex-Lopresti percutaneous technique helps to decrease scar formation resulting in reduced residual stiffness with improved clinical and cosmetic outcomes (Figure 4). Four patients still encountered reduced ankle motion, which are possibly because of post-traumatic soft tissue compromise with residual swelling and pain, muscle weakness after a period of immobility, or less likely, development of an extensive degenerative arthritis that may extend beyond the subtalar joint. Wound complications are minimised when compared with open reduction and internal fixation, which includes wound dehiscence and flap necrosis.\textsuperscript{15} Fixation by screws allows early mobilisation and avoidance of prolonged bracing. Operation time is less dependent on skin conditions, and hospital stay is short with early return to normal life. In our study, we did not encounter any complications except for one patient with loss of fracture reduction, which required screw revision. Most patients could return to their original work.

Patient selection is important for the success of this operative technique. Preoperative radiological analysis of fracture pattern is necessary. Use of intra-operative fluoroscopy facilitates correct anatomical implant placement. Before screw insertion, the use of bone clamps helps to provide traction and temporary stabilisation of the reduced fracture fragments. For Chinese patients, application of smaller 4.5-mm screws can provide adequate fixation stability while diminishing the chance of screw head impingement. For fractures with an intact lateral wall, we recommend the insertion of one to two additional transverse screws in fixing the primary fracture line.

In conclusion, percutaneous fixation of displaced tongue-type calcaneal fractures is an effective treatment with short hospital stay, minimal skin complications, and acceptable clinical outcome.

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References