ORIGINAL ARTICLE

# Calcaneal fractures: An audit of radiological outcome

Tashfeen Ahmad, Zehra Abdul Muhammad, Bilal HumayunMatin, Azeem Tariq Malik, Talal Aqueel Quadri

## Abstract

**Objective:** To assess radiological outcome of management of calcaneal fractures.

**Methods:** The retrospective study was conducted at Aga Khan University Hospital, Karachi, and comprised data of calcaneal fractures managed between February , 2008 and February, 2014 Cases were identified through medical records, and X-rays were reviewed through digital radiology archive. Bohler's angle, Gissane's angle, calcaneal height and width were assessed digitally on pre-operative and post-operative X-ray images.

**Results:** Of the27 patients, only 1(3.7%) was female. The cause of fracture was fall from height 15(56%), road traffic accidents 7(26%) and bomb blasts5(19%). Tongue type fractures were 16(59%) and 11(41%) were joint depression type. There was a significant mean increase in Bohler's angle ($p<0.001$) and mean decrease in calcaneal width ($p=0.023$). Gissane's angle and calcaneal height increased marginally ($p>0.05$ each).

**Conclusion:** Measurable improvement in anatomical parameters is possible with surgery, which is a prerequisite for good functional results.

**Keywords:** Calcaneal fracture, Essex-Lopresti classification, Imaging, Radiology, Articular fracture, Surgical technique. (JPMA 65: S-171 (Suppl. 3); 2015)

## Introduction

Calcaneal fractures account for 1-2 % of all fractures in adults[1,2] and are uncommon in children,[3,4] yet they tend to be the most commonly fractured bone in the foot which has an impact on daily activities and causeshigh morbidity. Approximately 75% calcaneal fractures are intra-articular[5] and most commonly happenafter high-energy trauma to the heels such as fall from height, road traffic accidents (RTAs)[6] and, to a lesser extent, avulsion fractures or by direct blow. Though less commonly injured, being one of the weight-bearing bones, it tends to have a large impact on functionality if not treated appropriately. Although undisplacedfractures are generally managed non-operatively, there is a recent trend towards operative management comprising open reduction and internal fixation (ORIF) or minimally invasive fixation.[7-10]

Data on internal fixation of calcaneal fractures in Pakistan is scarce. The current was planned to determine the extent of improvement in radiological parameters with internal fixation of calcaneal fractures.

## Materials and Methods

The retrospective study was conducted at Aga Khan University Hospital (AKUH), Karachi, and comprised data of calcaneal fractures managed between February, 2008 and February, 2014. Data for calcaneal fractures was drawn from patient's medical records with the help of International classification of Diseases version-9 (ICD-9) codes. Patients who were lost to follow-up or had less than a 6 -week follow-up, and who had incomplete data or unclear X-rays to permit satisfactory measurements were excluded. Fractures were classified according to Essex-Lopresti classification (Table-1).[11] Radiological treatment outcomes comprised Böhler's angle, Gissane's angle, calcaneal height[12] and width that was measured on lateral and axial views of plain radiographs taken as routine care preoperatively, postoperatively and at last follow-up visit. Normal Bohler's angle was considered 20°-40°[13] and Gissane's angle 130°-145°.[14]

The widest distance between displaced lateral and medial cortices was then measured and a line was drawn perpendicular to both lines and measured as the calcaneal width.

## Results

A total of 54 cases of calcaneal fractures were identified of which 27(50%) didn't meet the inclusion criterion. The final study sample, as such, stood at 27(50%). The overall mean age was 38 years, and all except 1(3.7%) were males. The cause of fracture was fall from height 15(56%), RTA 7(26%) and bomb blasts 5(19%). Tongue type fractures were 16(59%) and 11(41%) were joint depression type. All fractures were comminuted with 10(37%) being open and 17(63%) being closed (Table 2).

Surgical management accounted for 80%cases compared to 20% that were managed conservatively by closed

Department of Surgery, Aga Khan University, Karachi, Pakistan.

**Correspondence:** Tashfeen Ahmad. Email: tashfeen.ahmad@aku.edu

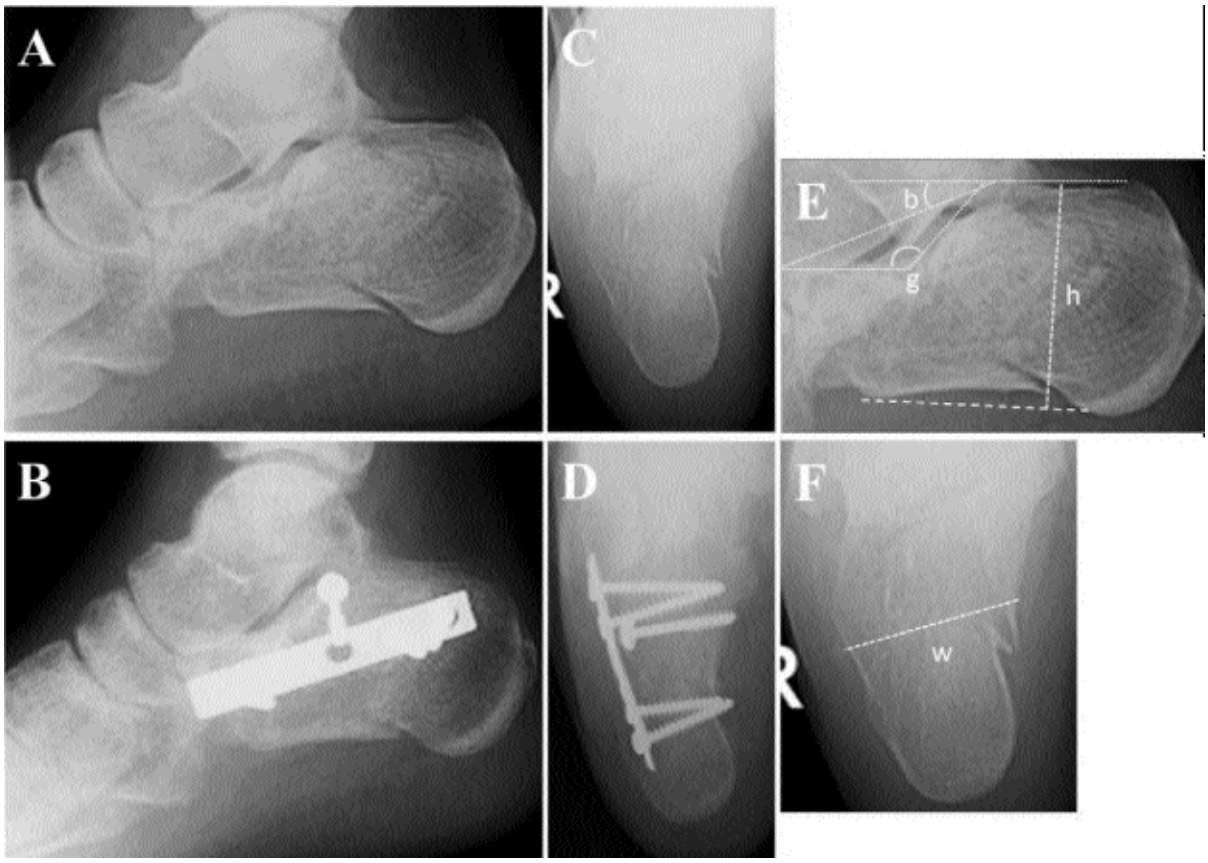


**Figure-1:** (A-F) Pre-operative (A-lateral,B-axial) and post-operative (C-lateral,D-axial) X-rays and the measurement (E-lateral,F-axial) method (b=Bohler's angle;g=Gissane'sangle, h=height, w=width). Post-operative final X-rays showing healed fracture with increase in Bohler's angle and reduction in Gissane's angle, increase in height and decrease in width. Fixation of the body has been done with semitubular plate and the sustentacular fragment with latero-medial lag screw.

**Table-1:** Essex-Lopresti Classification of Calcaneal Fractures.[11]

| |
|---|
| Extra-Articular Fractures (25%) |
| Intra-Articular Fractures (75%) |
| ■ Tongue fracture |
| ◆ Primary fracture line through posterior facet |
| ◆ Secondary fracture line: |
| ◆ Runs straight back to the posterior border of the tuberosity from the crucial angle (of Gissane) |
| ◆ This produces one large posterior, superior and lateral fragment |
| ◆ It can be displaced, "like a see-saw, down at the front and up at the back" |
| ◆ The displaced key fragment can be maneuvered using the long lever |
| ◆ The fragment may be flexed by the continuing pull of the Achilles tendon |
| ■ Joint depression fracture |
| ◆ Primary fracture line through posterior facet |
| ◆ Secondary fracture line |
| ◆ Runs across the body just behind the joint, and deviates dorsally to exit the bone just posterior to the articular facet, creating a fragment separate to the tuberosity -the thalamic portion |
| ◆ Which contains the major portion of the posterior articular facet of the calcaneus |
| ◆ This also acts in a see-saw fashion, down at the front and up at the back |
| ◆ More common than the tongue fracture |
| ◆ The displaced fragment buried in the bone can only be reduced by an open approach |

**Table-2:** Fracture characteristics (n=27).

| Characteristic | | Number |
|---|---|---|
| Mechanism | Fall | 15 |
| | Road traffic accident | 7 |
| | Bomb blast | 5 |
| Type | Closed | 17 |
| | Open | 10 |
| Classification | Joint depression | 11 |
| | Tongue type | 16 |

reduction and cast/splint application. Surgical management comprised of K-wire, percutaneous screws, semitubular plate (Figure-1), and, more recently, calcaneal locking plates (Figure-2). Mean follow-up was 16±2.5 weeks (range: 6-22 weeks).

There was a significant mean increase in Bohler's angle ($p<0.001$) and mean decrease in calcaneal width ($p=0.023$) (Table-2). Gissane's angle and calcaneal height

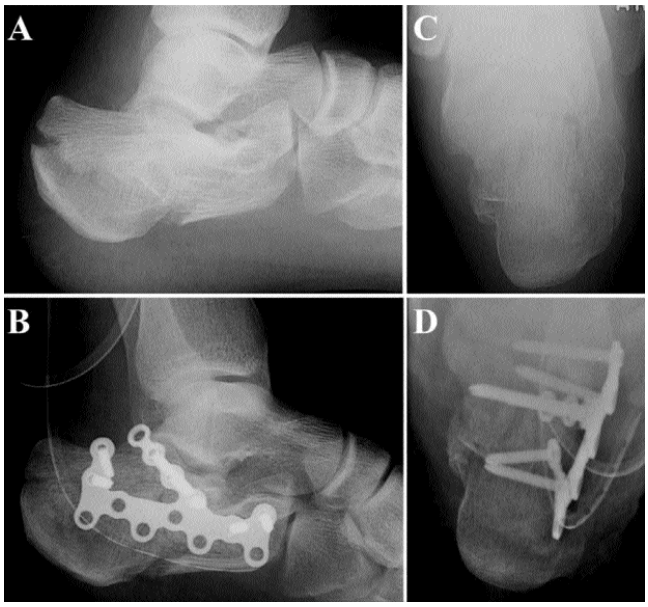


**Figure-2:** (A-D) Pre-operative (A-lateral, B-axial) and post-operative (C-lateral, D-axial) X-rays. Fixation has been done with calcaneal locking plate having obliquely aligned screw slots for the subarticular bone below the posterior facet (these screws also catch the medial sustentacular fragment as seen on the axial view), and slots for the anterior process and posterior tuberosity.

**Table-3:** Radiological outcome.(Mean ± SD).

| | Pre-operative | Post-operative | Last follow-up |
|---|---|---|---|
| Bohler angle (°) | 15±7 | 23±9* | 23±7* |
| Gissane Angle (°) | 115±27 | 121±7 | 120±8 |
| Calcaneal Width (mm) | 50±10 | 45±10# | 45±9# |
| Calcaneal Height (mm) | 42±6 | 44±4 | 43±5 |

* p<0.01; # p<0.05

increased marginally (p>0.05 each).

## Discussion

Data is limited from this part of the world on calcaneal fractures, especially regarding radiological outcome. A study[15] reported functional outcome to be 48% good to excellent and 52% fair to poor, but these are combined results of ankle and foot fractures. Similar results have been reported by others, and the high rate of fair/poor results is generally attributed to severity of fractures, making it difficult to restore normal anatomy. Calcaneal fractures generally occur from axial loading. As the talus drives into the calcaneus, the force results in joint depression, the body fragment bursts so that the mediolateral width increases, and calcaneal height is reduced, resulting in reduced pitch which makes the gastro soleus slack and thus weak. Subtalar joint articular surface involvement is often the reason for poor outcomes, as it results in stiffness and pain on heel inversion and eversion, thus adversely affecting gait. Although conventional radiographs are good to assess the angles and dimensions, congruity of the subtalar articular surface is only partially evident on the lateral film. Thus, computed tomography (CT) scan has become a method of choice, and Sanders has developed his classification based on coronal CT scan appearance.[16] Due to cost, CT scan was not done in many of our patients, hence Sanders classification was not used. In the absence of CT scan, Broden's view is a practical method to assess subtalar articular surface. This is done in anterior-posterior (AP) direction with the ankle rotated internally by 30°-40°, taking four exposures at 10°, 20°, 30° and 40° cephalad tilt. This view can be obtained intraoperatively using fluoroscopy.

Recently, emphasis is being placed on surgical management aimed at correction of calcaneal height in order to restore calcaneal pitch, anatomical reduction of the subtalar joint under direct vision and rigid fixation.[7-10] This is on the pretext that functional results will improve, and several studies have shown good outcome with surgery. Our study focussedon surgical outcome in terms of improvement in radiological parameters reflecting anatomic restoration. The results showed improvement in Bohler and Gissane's angles and calcaneal width, and a non-significant increase in calcaneal height. Moreover, the improvement was sustained over time, and the last follow-up X-ray showed minimal loss of correction. However, operative management has its own complications. Thus, hematoma, wound marginal necrosis and infection are well-known complications with conventional extensile approach, thus recently modified extensile and minimally invasive (sinus-tarsi) approaches are gaining popularity.[17]

Being a retrospective study, our study has some limitations. We could not correlate radiological with functional outcome as this is best done prospectively. Many patients did not have complete set of X-rays in our digital archive; some may have had X-rays done outside which could not be included in the study. Furthermore, the cases included had been managed non-operatively as well as operatively; the data presented regarding change in measurements pertains to the operated cases. Outcome of non-operatively managed cases is best done through analysis of function which, as described above, was beyond the scope of the present study.

We recommend careful assessment of pre-operative X-rays to recognise the different parameters which require

correction during surgery of calcaneal fractures, and planning of the operative procedure accordingly. Operative fixation may be by closed reduction and percutaneous K-wire or screw fixation, open reduction and reconstruction/semitubular/locking plate fixation, or more recently, calcaneal locking plate, and choice of procedure and approach is dependent on fracture configuration and skin condition. Our results confirm the notion that surgical correction can restore anatomy considerably, and can be expected to improve outcomes.

## Conclusion

Measurable improvement in anatomical parameters is possible with surgery, which is a pre-requisite for good functional results, and the improvement is sustained until healing.

## References

1. Zwipp H, Rammelt S, Barthel S. [Calcaneal fractures - the most frequent tarsal fractures]. Ther Umsch 2004; 61: 435-50.
2. Slätis P, Kiviluoto O, Santavirta S, Laasonen EM. Fractures of the calcaneum. J Trauma 1979; 19: 939-43.
3. Schindler A, Mason DE, Allington NJ. Occult fracture of the calcaneus in toddlers. J Pediatr Orthop 1996; 16: 201-5.
4. de Beer JD, Maloon S, Hudson DA. Calcaneal fractures in children. S Afr Med J 1989; 76: 53-4.
5. Brauer CA, Manns BJ, Ko M, Donaldson C, Buckley R. An economic evaluation of operative compared with nonoperative management of displaced intra-articular calcaneal fractures. J Bone Joint Surg Am 2005; 87: 2741-9.
6. Järvholm U, Körner L, Thorén O, Wiklund LM. Fractures of the calcaneus: a comparison of open and closed treatment. Acta Orthop Scand 1984; 55: 652-6.
7. Rajkumar P, Henderson AA. Surgical treatment of displaced intra-articular fractures of the os-calcis. Foot Ankle Surg 2003; 9: 3-6.
8. Clare MP, Sanders RW. Open reduction and internal fixation with primary subtalar arthrodesis for Sanders type IV calcaneus fractures. Tech Foot Ankle 2004; 3: 250-7.
9. Zwipp H, Rammelt S, Barthel S. Calcaneal fractures - open reduction and internal fixation (ORIF). Injury 2004; (35 Suppl 2): SB46-54.
10. Kocis J, Stoklas J, Kalandra S, Cizmár I, Pilný J. [Intra-articular calcaneal fractures]. Acta Chir Orthop Traumatol Cech 2006; 73: 164-8.
11. Essex-Lopresti P. The mechanism, reduction technique, and results in fractures of the os calcis. Br J Surg 1952; 39: 395-419.
12. Böhler L. Diagnosis, pathology, and treatment of fractures of the os calcis. J Bone Joint Surg Am 1931; 13: 75-89.
13. Gissane W. Discussion on "Fractures of the os calcis". Proceedings of the British Orthopaedic Association. J Bone Joint Surg Am 1947; 29: 254-5.
14. Qiang M, Chen Y, Zhang K, Li H, Dai H. Measurement of three-dimensional morphological characteristics of the calcaneus using CT image post-processing. J Foot Ankle Res 2014; 7: 19. doi: 10.1186/1757-1146-7-19.
15. Sarfraz AH, Masood F, Awais SM. Study of occurrence, demography and pathomorphology of ankle and foot fractures and evaluation of the treatment outcome of calcaneal fractures. Ann King Edward Med Uni 2014; 20: 96-103.
16. Sanders R, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. Clin Orthop Relat Res 1993; 290: 87-95.
17. Hsu AR, Anderson RB, Cohen BE. Advances in surgical management of intra-articular calcaneus fractures. J Am Acad Orthop Surg 2015; 23: 399-407.