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Original Research Article

Role of Bohler's Angle and Gissane's Angle in Predicting the Functional Outcome in Surgically Treated Calcaneal Fractures

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ABSTRACT

The displaced intra-articular fractures of the calcaneum should be treated by anatomical reduction and rigid internal fixation, to allow early movement and get a better functional outcome. We included 40 patients in our prospective and retrospective study. The patients were followed up clinically and radiologically at 12weeks, 6 months, and 1year, with respect to height of calcaneum, width of the calcaneum, range of movements at subtalar joint, tubero-talar angles. The mean Post op Bohler's angle was 26.16˚ and Gissane's angle was 119.76˚. In our analysis, we confirmed correlation between the Bohler's angle size and patient satisfaction in terms of their functional outcome.

Keywords: Bohler's Angle, Gissane's Angle, Calcaneal Fractures, Broden's View.

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INTRODUCTION

The purpose of this study was to correlate the changes in Bohler's angle and Gissane's angle postoperatively, with the improved functional outcome in surgically treated calcaneal fractures. We believe that displaced intra-articular fractures of the calcaneum should be treated on the same principles as any other injury of the weight bearing joints; that is by anatomical reduction and rigid internal fixation, to allow early movement and get a better functional outcome.[1]

MATERIALS AND METHODS

We included 40 patients in our study, who were treated surgically for calcaneal fractures. This was a prospective and retrospective study, from February 2014 to June 2015. For retrospective cases, from February 2010 to February 2014, the patients were communicated through phone calls, letters etc. Ethical approval was obtained. Informed written consent was taken from the patients before the commencement of study.

Sample Size Calculation: N = 4*p*(1-p)/d^2 (n = sample size, p = prevalence, d = allowable error) Roy W et al (2010) mentions prevalence of calcaneal fracture is 2% We took allowable error at 5%. Putting values N N = 4*0.02*0.98/0.05^2 = 31.36 Approximated to 32. Hence we took sample size to 40. = 4*0.02*0.98/0.05^2 = 31.36 A thorough history and clinical examination was done. The swelling of the heel and status of the skin was recorded. Roentograms of the calcaneum were taken on admission which included lateral and axial views. CT scans were taken to further evaluate the fracture pathology. The patient was temporarily put on a below knee slab with adequate limb elevation until the swelling subsided and there were wrinkles seen on the lateral aspect of the heel. The patient was then posted for open reduction internal fixation with 6 holed 3.5mm contoured recon plates or calcaneal plates. The lateral extensile approach was used for all the patients. All the surgeries were conducted in the same centre by 3 orthopaedic surgeons who were all well trained in the procedure. After the surgery, Short leg splint 3-5 days post op. Early active ROM exercises started once wound gets healed. 2nd post op week active ankle and subtalar ROM exercises are started. Weight bearing is after 12 weeks of fixation. The patients

were followed up clinically and radiologically at 12weeks, 6 months, and 1year, with respect to height of calcaneum, width of the calcaneum, range of movements at subtalar joint, tubero-talar angles. At every follow up clinical examination was done to assess status of the surgical wound, pain, swelling, tenderness, range of motion of subtalar joint, stability of the fracture and clinical union. Roentgenograms were taken in Lateral and axial views to look for signs of radiological union. The functional outcome was measured by the "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle Hindfoot scoring system" at twelve month.

Statistical Analysis

Statistical Package for Social Sciences (SPSS, Inc., Chicago, Illinois) version 18.0 was applied to confirm statistical significance of the data thus collected. Descriptive statistics was used to describe the sample in terms of socio-demographic and clinical characteristics. Parametric test (chi square, student t test) and Non-parametric tests (χ and Mann-Whitney U) was be used to compare between groups. In this study, a level of significance (α) of < 0.05 (2-tailed) was taken to consider a result (group difference) statistically significant.

RESULTS

All the operated patients had an increase in the Bohler's angle and decrease in the Gissane's angle with a statistically significant p value. The mean pre op Bohler's angle was 11.52˚ and Gissane's angle was 126.8˚. The mean Post op Bohler's angle was 26.16˚ and Gissane's angle was 119.76˚. The p value for the increase in Bohler's angle was 3.13×10^{-18}. The p value for the decrease in Gissane's angle was1.10×10^{-12}.In our analysis, we confirmed correlation between the Bohler's angle size and patient satisfaction in terms of their functional outcome. This fact, proved and verified by a lot of other authors, confirms the role of Böhler's angle and Gissane's angle size as a predictive factor for subsequent late complications.[2,3]

Table 1: Results as per AOFAS scoring

Results	Excellent	Good	Fair	Poor
N (%)	0	16 (64%)	7(28%)	2 (8%)
Mean±SD	0	83.5±2.03	73.28±1.25	54±8.48

Of the 25, 16 had good results with mean AOFAS score of 83.6, 7 had fair results with mean score of 73.28 and 2 had poor results with mean score of 54. Of the patients with good results, 2 patients underwent implant removal after union of fracture at one and a half year from surgery.

The technique of plate fixation with a lateral approach is good with regards to fracture union and functional outcome. It also shows that anatomical reduction in terms of the correction in Bohler's and Gissane's angle plays an important role in determining the good functional outcome.

Radiography

The initial radiographic evaluation of the patient with a suspected calcaneal fracture should include a lateral x-ray of the hindfoot (*to assess height loss and rotation of posterior facet*), an anteroposterior and oblique x-ray of the foot (*to assess anterior process and calcaneo-cuboid involvement*), a Harris axial heel view (*to assess varus of tuberosity and width of heel*), Broden's view (*to evaluate congruency of posterior facet*) and an ankle series. Routine lumbar spine x-rays should also be obtained. If the x-rays reveal an intraarticular component to the calcaneal fracture, obtaining a CT scan is indicated.

Lateral Radiographs

Traction trabeculae extending from the inferior cortex of the calcaneus combine with compression trabeculae supporting the posterior and anterior articular facets. The area between these trabeculae creates a space seen on the lateral x-ray known as the neutral triangle. Also demonstrates two important angles, the tuber angle of Bohler, and the crucial angle of Gissane.

The tuber angle of Bohler is indicated by a line drawn from the highest point of the anterior process of the calcaneus to the highest point of the posterior facet and a line drawn tangential to the superior edge of the tuberosity. The angle is normally between 20 and 40 degrees; a decrease in this angle indicates that the weight-bearing posterior facet of the calcaneus has collapsed and the degree of proximal displacement of the tuberosity, thereby shifting body weight anteriorly. The crucial angle of Gissane is formed by two strong cortical struts extending laterally, one along the lateral margin of the posterior facet and the other extending anterior to the beak of the calcaneus. These cortical struts form an obtuse angle usually between 95 and 105 degrees and are visualized directly beneath the lateral process of the talus. Loss of height of posterior facet will increase the angle.

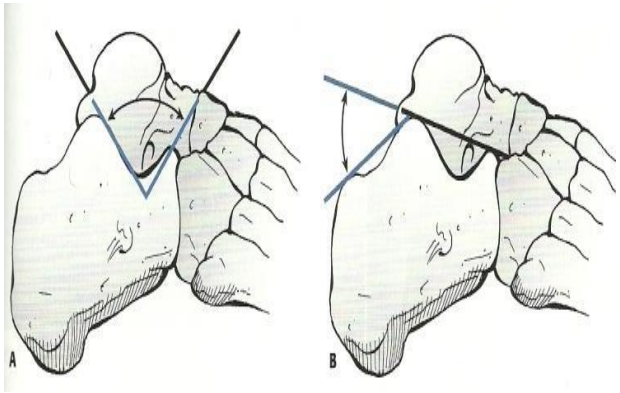

Fig.1: A. Gissane's angle B. Bohler's angle

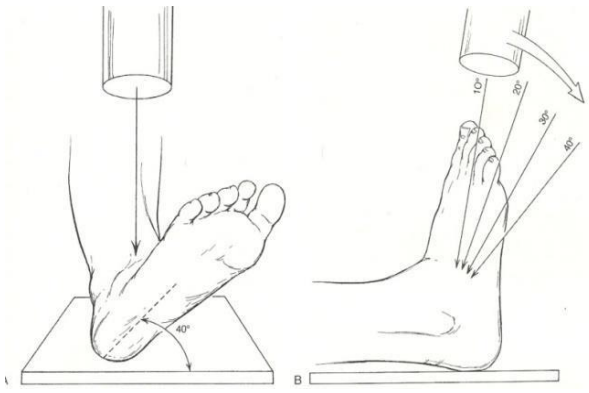

Fig.2: Broden's view

If only the lateral half of the posterior facet is fractured and displaced, a split in the articular surface will be seen as a *double density*, and Bohler's and Gissane's angles may appear to be normal.

The lateral x-ray also indicates whether the fracture is of the joint-depression or tongue type. The pitch of the calcaneus decreases and therefore so does the longitudinal arch, as measured by the calcaneus first metatarsal angle. The length of the calcaneus posterior to the lateral talar process, called the Achilles tendon fulcrum, shortens.

Other Radiographic Views Broden's view, is a means of demonstrating the articular surface of the posterior facet on plain x-rays. This view is obtained with the patient lying supine and the x-ray cassette under the leg and the ankle. The foot is in neutral flexion and the leg is internally rotated 30 to 40 degrees. The x-ray beam then is centered over the lateral malleolus, and four x-rays are made with the tube angled 40, 30, 20, and 10 degrees toward the head of the patient. These x-rays show the posterior facet as it moves from posterior to anterior; the 10-degree view shows the posterior portion of the facet, and the 40-degree view shows the anterior portion.

Computed Tomography Scanning

CT images are obtained in the axial, 30-degree semi-coronal, and sagittal planes. The coronal views provide information about the articular surface of the posterior facet, the sustentaculum, the overall shape of the heel, and the position of the peroneal and flexor hallucis longus tendons. The axial views reveal information about the calcaneocuboid joint, the anteroinferior aspect of the posterior facet, and the sustentaculum. Sagittal reconstruction views provide additional information as to the posterior facet, the calcaneal tuberosity, and the anterior process.

CLASSIFICATION

Calcaneal fractures can broadly be classified based on involvement of subtalar joint into:

1. Extra-articular fractures (25%)
2. Intra-articular fractures (75%)

Classifications Based on Plain Radiography

Although described as early as 1851 by Malgaigne, Essex-Lopresti in 1952, popularized the concept of two distinct intra-articular fracture patterns:

1. Joint-depression type fracture, in which the fracture line exits behind the posterior facet and anterior to attachment of Achilles tendon, and articular fragment was separate from the adjacent tuberosity.

2. Tongue-type fracture- in which the secondary fracture line exits distal to Achilles tendon, and articular fragment remained attached to a tuberosity fragment. Sanders developed a CT scan classification system based on the number and location of articular fracture fragments alone. The classification was found to be useful in determining both treatment methods and prognosis after surgical fixation.

The classification is based on images in the coronal plane.

1. Type I fractures include all nondisplaced articular fractures (less than 2 mm), irrespective of the number of fracture lines.

2. Type II fractures include two-part fractures of the posterior facet. **Three types:** IIA, IIB, and IIC based on the location of the primary fracture line.

3. Type III fractures were three-part fractures that usually featured a centrally depressed fragment. Three types: IIIAB, IIIAC, and IIIBC, again based on the location of the primary fracture line.

4. Type IV fractures or four-part articular fractures, were highly comminuted and often had more than four articular fragments.

A prospective, randomised, CT-based study comparing operative versus non-operative treatments for type-II and -III fractures, revealed that the former type of treatment followed by early mobilisation produced superior results[4], as was seen in our study.

In a meta-analysis published in 2000, Randle et al. stated that "there is a trend for surgically treated patients to have better outcomes; however, the strength of evidence for recommending operative treatment is weak." They concluded that, before a strong recommendation could be made for operative treatment, a randomized trial with controls and validated outcomes was needed.[5]

In 2015, De Boer AS et al. concluded that the operatively treated patients (ORIF and percutaneous treatment) reported better functional outcome scores (Foot Function Index and American Orthopaedic Foot and Ankle Society hindfoot scale) than did the non-operatively treated patients[11] AOFAS scoring system (American Orthopaedic Foot and Ankle Society)

DISCUSSION

The calcaneum is the most commonly fractured tarsal bone. The prognosis for an extra-articular fracture is uniformly good, but that for an intra-articular fracture is very varied. The management of every aspect of intra-articular calcaneal fractures is controversial. There are many systems for classifying displaced intra-articular fractures, but there is no consensus amongst surgeons as to which is the most practical one.

Although some studies with more than 100 cases have demonstrated good results after open reduction and internal fixation of intraarticular calcaneal fractures[6-8], the best choice of treatment remains controversial because prospective randomized studies have not shown convincingly better results after surgery.[9,10] However, in the largest prospective randomized trial described to date, Buckley et al. found better results in some subgroups of patients after surgery.[11]

In our study we found that, surgically treated calcaneal fractures do have a better functional outcome and measurement of Bohler's angle and Gissane's angle plays and important role in predicting the functional outcome, as there occurs an increase in Bohler's angle and a decrease in Gissane's angle following anatomical reduction.

CONCLUSION

Fractures of the calcaneum are one of the common fractures affecting present generation and treatment modality has to be decided carefully. We are of opinion that Bohler's angle and Gissane's angle are important predictors of postoperative functional outcome.

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