

Radiological and Clinical Assessment of Calcaneal Fractures Treated with Open Reduction and Internal Fixation

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Abstract

Introduction: Calcaneal fracture has been one of the most challenging problems facing orthopedic surgeons all around the world as there have been no evidence-based guidelines for the same. This is a retrospective-prospective study to analyze the outcome of the displaced intra-articular fractures of calcaneum treated by open reduction and internal fixation (ORIF).

Materials and Methods: In this study, the outcome of 30 patients was analyzed radiologically by measuring Bohler's and Gissane's angle on X-ray and, clinically by American Orthopedic Foot and Ankle Society Hind Foot Scale (AOFAS) and Iowa Calcaneal Score (ICS) results.

Results: In our study, out of 30 subjects, 3 had excellent, 21 had good, and 6 had fair results. 28 subjects had Bohler's angle more than 10 degrees. 5 patients had superficial wound complications. After statistical analysis, a significant correlation was found between AOFAS and Bohler's angle ($P < 0.01$), ICS and Bohler's angle ($P < 0.05$), and no significant correlation was found between Gissane's angle and AOFAS.

Conclusion: ORIF of calcaneal fracture yield good clinical outcome if Bohler's angle $>10^\circ$ is achieved, without significant risk of complication.

Key words: Bohler's angle, Calcaneal fracture, Gissane's angle

INTRODUCTION

Treating calcaneal fractures have been a controversy as it has not been proved beyond reasonable doubt that surgical intervention alters the eventual outcome of many if not all calcaneal fractures which still continue to be among the most challenging problems facing orthopedic surgeons all around the world. The fatalism with the treatment of intra-articular fractures of calcaneal which existed was described by Cotton and Henderson (1916) and Bankarts (1942).¹ Till very recently, many orthopedic surgeons believed that

“the natural history” of the type of intra-articular fracture and the not “the intervening treatment” determined the final result. The perception was that these comminuted fractures which looked like unintelligible bag of bones on standard X-rays were “inoperable.” Reviews on this subject, however, have failed to demonstrate indisputable superior results of a single approach to the treatment of displaced intra-articular calcaneal fractures.^{2,3} However, with the advent of computer tomography (CT) and with improved methods of internal fixation the understanding, the treatment of these fractures has revolutionized. This is a retrospective-prospective study to assess the results of calcaneal fractures treated with open reduction and internal fixation (ORIF). The patients operated for calcaneum were assessed on the basis of radiological features and clinical outcome of the surgery. The study will also assess if there is any relation in the radiological findings and the subjective outcome.

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MATERIALS AND METHODS

This is a retrospective-prospective analysis of results of 30 patients treated by surgery for displaced intra-articular calcaneal fracture at the Seth G S Medical College, Mumbai, from June 2006 to December 2009 after the Institutional Ethics Committee approval.

All the fractures of the calcaneum were diagnosed on the basis of lateral and axial projection X-rays. Three-dimensional CT scan was done in all of the cases and fractures were classified as per Sanders classification into Type 1 to Type 4.

The inclusion criteria of our study were: (a) Patients presenting with displaced intra-articular fractures of the calcaneus; (b) age 18-65 years inclusive; (c) informed consent obtained. The exclusion criteria were: (a) Medical contraindication; (b) previous calcaneal pathology; (c) previous calcaneal surgery; (d) open calcaneal fracture; (e) injury >21-day-old.

All the patients were on strict limb elevation, crepe bandage application, and ice fomentation till appearance of “positive wrinkle test” which was approximately 7-10 days post injury. The cases of bilateral fracture of calcaneum were operated in single stage. If blisters occurred, the patient was operated after healing of blisters.

With the patient in lateral decubitus position and under tourniquet, lateral approach modified by Benirschke and Sangeorzan was used. A full thickness flap was raised subperiosteally. The peroneal tendons were lifted off in their sheath and subluxated over the fibula. The calcaneofibular ligament was sharply cut off from calcaneum leaving a cuff behind for repair later. Two K-wires were passed into the talus and one into fibula to retract the peroneal tendons and obviated need for manual retraction. Fractured lateral cortex was opened like a trap door; the depressed joint fragment was revealed and elevated against the undersurface of the talus. To facilitate the disimpaction of the fragment, heel was forced into marked varus with pointed clamp applied to tuberosity fragment while the joint reduction the tuberosity is manipulated with thick K-wire to correct varus and superior displacement allowing restoration of Bohler's angle. After confirmation on X-rays, the fragments are fixed with calcaneal plate and 3.5 or 4 mm screws (Figures 1-3). The wound was closed with a suction drain. Post-operative strict limb elevation was given, antibiotics for 48 h and ankle mobilization was started after 7 days. The patient was mobilized non-weight bearing for 6-8 weeks. After 8-10 weeks, gradual weight bearing is started and full weight bearing allowed within another 4-6 week of time if the patient is comfortable. Follow-up was done at 6 weeks,

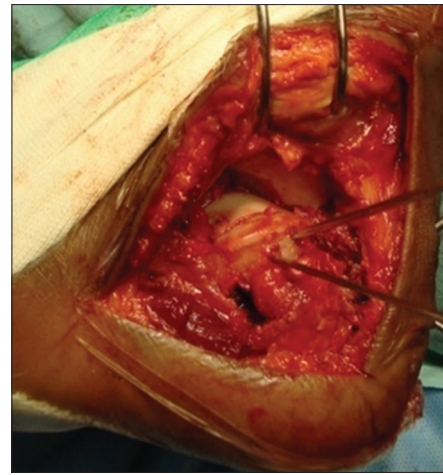


Figure 1: Articular reduction provisionally fixed with K-wires

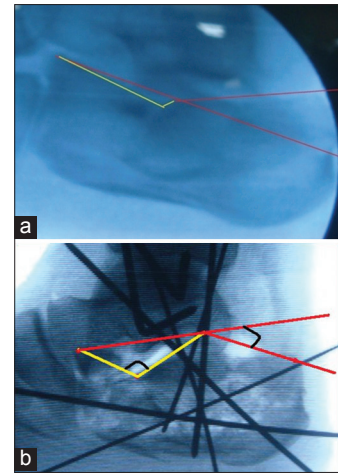


Figure 2: Intraoperative C-arm for assessing reduction, (a) Pre-operative, (b) intraoperative

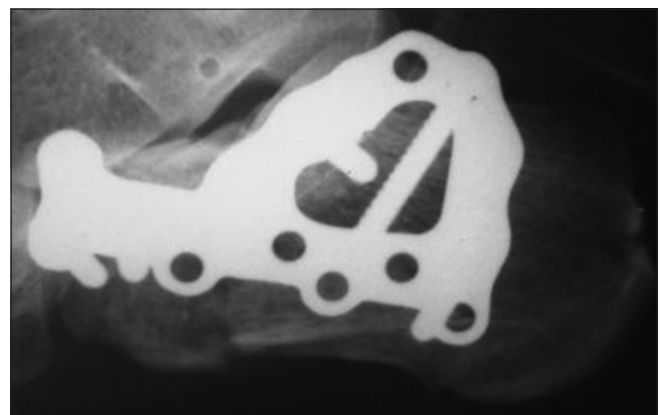


Figure 3: Final post of X-ray

and at every 3 months thereafter. At the follow-up, lateral and axial views X-rays were taken; and the Bohler's angle and Gissane angle were looked for.

Clinical results were assessed with Iowa Calcaneal Score (ICS) and American Orthopedic Foot and Ankle Society

Hind Foot Score (AOFAS). The subtalar motion was evaluated accordingly to the method of Morrey and Wideman where heel jog is estimated as percentage of normal. Furthermore, time required for walking full weight bearing was recorded.

RESULTS

In the present series, 30 calcaneal fractures were operated out of which 3 were Sander Type IV, 9 are Type III, and rest 18 were Type II (Table 1). Only 5 were females rest 23 were males.

The study had an average follow-up of 15 months (range 3 months to 5 years).

On clinical assessment with the AOFAS hindfoot score, the average score was 78.7 (range 55-97) and with ICS average was 78.3 (range 50-100). The AOFAS score of 90-100 was considered excellent, 75-89 as good, 50-74 as fair, and <49 as poor outcome. 80% of the patients had good or excellent results. As per Sanders classification, among the 18 Type II fractures, 2 had excellent, 15 had good, and 1 had fair results, whereas in Type III fractures, 1 had excellent, 6 had good, and 2 had fair results. All the 3 Type IV fractures had fair results (Table 2).

The Bohler's and Gissane's angles were calculated on follow-up lateral X-rays of calcaneum. The average Bohler's angle achieved was 24.6 (0-44). The average Gissane's angle achieved was 120 (100-150). According to statistical analysis (Pearson's correlation coefficient), there was a significant correlation between Bohler's angle and AOFAS score ($P < 0.01$) (Figure 4) and also between ICS and Bohler's angle ($P < 0.05$) (Figure 5). There was no significant

correlation between Gissane's angle and AOFAS score (Figures 6 and 7). Table 3 shows the results of this study.

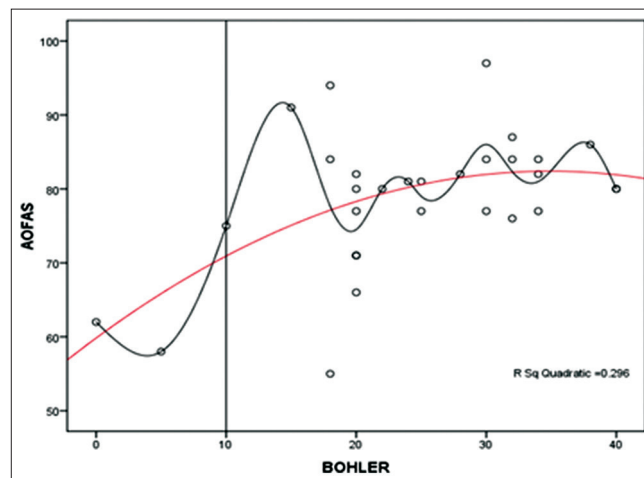


Figure 4: Relation of Bohler's angle with American Orthopedic Foot and Ankle Society

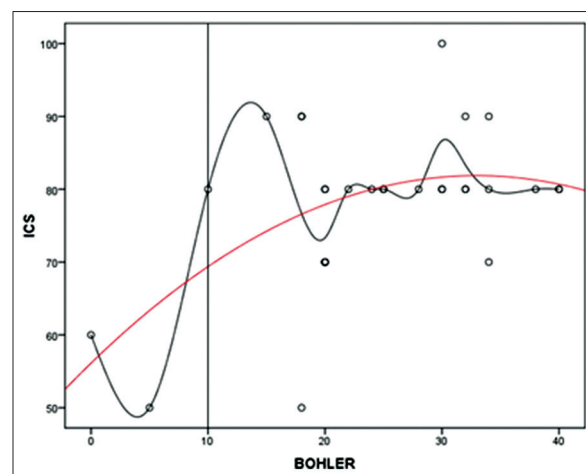


Figure 5: Relation of Bohler's angle with Iowa calcaneal score

Table 1: Type of fracture according to sanders classification

| Type of fracture | Number of cases (%) |
|------------------|---------------------|
| II | 18 (60) |
| III | 9 (30) |
| IV | 3 (10) |
| Total | 30 (100) |

Table 2: Type of fractures and AOFAS in study group

| Type of fracture | AOFAS<75 | AOFAS≥75 | Total |
|------------------|----------|----------|-------|
| II | 1 | 17 | 18 |
| III | 2 | 7 | 9 |
| IV | 3 | 0 | 3 |
| Total | 6 | 24 | 30 |

$\chi^2=14.38$, $P<0.001$. AOFAS: American Orthopedic Foot and Ankle Society

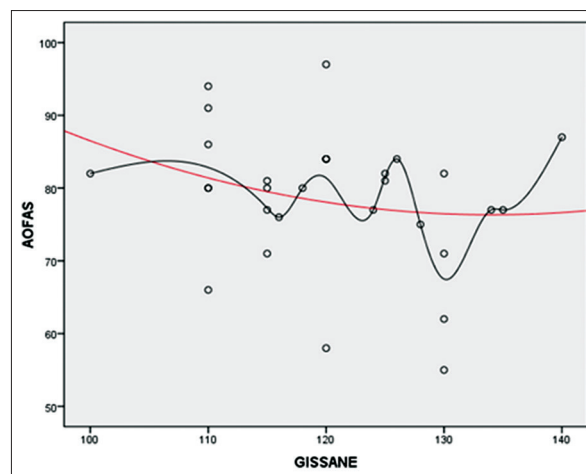


Figure 6: Relation of Gissane's angle with American Orthopedic Foot and Ankle Society

Table 3: Results of our study

| Type of fracture | Number of patients | Excellent results AOFAS>90 | Good results AOFAS 75-90 | Fair results AOFAS<75 | Bohler>10 | Bohler<10 |
|------------------|--------------------|-------------------------------|-----------------------------|--------------------------|-----------|-----------|
| II | 18 | 2 | 15 | 1 | 17 | 1 |
| III | 9 | 1 | 6 | 2 | 9 | 0 |
| IV | 3 | 0 | 0 | 3 | 2 | 1 |
| Total | 30 | 3 | 21 | 6 | 28 | 2 |

AOFAS: American Orthopedic Foot and Ankle Society

All the 24 cases with excellent and good result had good pain relief. 22 patients walked full weight bearing in 6 months duration, while 6 cases within 9 months due to delayed wound healing or associated injuries. There were 5 cases of post-operative wound dehiscence (Table 4). The dehiscence was at the angle of the incision for 2-3 cm. It was deep till subcutaneous tissue, but plate was not exposed. One patient had low-grade infection in form of sinus and is been treated with oral antibiotics and has been advised plate removal after bony union. None of the patients developed severe infection.

DISCUSSION

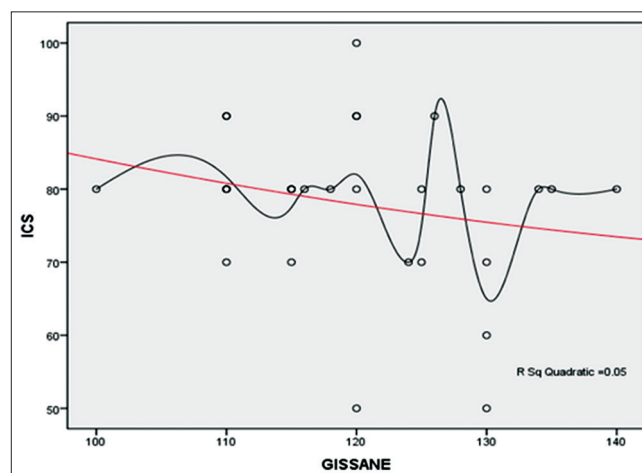
Calcaneal fractures deserve an aggressive well-planned surgical treatment similar to any other intra-articular fracture. Consistently, better results with surgical treatment have been reported in the recent literature. The meta-analysis done by Randle *et al.*,⁴ which studied operative versus non-operative results for calcaneum fracture in the literature, found a trend for operatively treated patients to have better outcomes with respect to pain, return to work, heel width, gait abnormalities, and radiographic outcomes. However, due to small number of subjects, no statistically significant difference was found. In addition, although a statistically significant difference was reported for pain-free walking distance and return to work in two studies, neither of these studies involved random assignment of treatment, allowing for potential selection bias. Thordarson and Krieger performed a randomized, prospective trial comparing operative with non-operative treatment.⁵ Follow-up assessment was consistent and, with use of the 100-point scoring system of the AOFAS, the functional score averaged 86.7% for the group that had been treated operatively compared with 55.0% for the group that had been treated non-operatively ($P < 0.0001$).

Table 5 shows analysis of few more articles on treatment of calcaneal fractures.^{2,6-14}

The result in our series is encouraging because they show an 80% overall excellent to a good outcome with ORIF. In contrast to other authors who recommend the systematic use of a bilateral approach for joint depression fractures,

Table 4: Complication and type of fracture

| Type of fracture | Delayed wound healing | Low grade infection | Bohler>10 | Bohler<10 | Total |
|------------------|-----------------------|---------------------|-----------|-----------|-------|
| II | 2 | 0 | 1 | 1 | 2 |
| III | 1 | 1 | 2 | 0 | 2 |
| IV | 2 | 0 | 2 | 0 | 2 |
| Total | 5 | 1 | 5 | 1 | 6 |

**Figure 7: Relation of Gissane's angle with Iowa calcaneal score**

all the fractures could be reduced through an extensile lateral approach.

Among the 18 Type II fractures, 2 had excellent, 15 had good, and 1 had a fair result. The bad result was due to inability to achieve Bohler's angle intraoperatively.

One of the bad results in Type III fracture may be due to low-grade infection. This patient is advised to remove plate after bony union.

All the 3 Type IV fractures had fair results. In one of them, Bohler's angle was $>10^\circ$ while, in other two, it is $>10^\circ$, but one of the patients had wound dehiscence.

The incidence of wound infection was in only one of the 30 patients. Five patients had wound dehiscence which readily resolved completely with daily dressing and delayed mobilization, of these, two were Type IV; two were Type III, and one Type II fracture. It is thought

Table 5: Various studies

| Author | Year | Type of study | Duration | Number of fractures | Intervention | Non-operative score | Operative score (a) | Bohler's non-operative | Bohler's post-operative (b) | Score significant | Angle significant | Relation an A and B | Results |
|-------------------------|------|-----------------------|-----------|---------------------|---------------------------------------|---------------------|-----------------------------|------------------------|-----------------------------|-------------------|-------------------|---------------------|---|
| Ibrahim <i>et al.</i> | 2008 | RCT | 15 years | 26 | ORIF | AOFAS=78.5 | AOFAS=70 | 10 | 16.9 | No (P=0.66) | No (P=0.07) | No | Comparable results |
| Buckley | 2002 | RCT | 2 years | 471 | ORIF | sf36=64.7 | sf36=68.7 | | | Yes (without WCB) | | Yes | Physical therapy without WCB operative results significant better (P=0.001) |
| Longino and Buckley | 2001 | RCT | | 40 | ORIF and BG | | | | | No | No | | Similar to ORIF without BG |
| Schepers <i>et al.</i> | 2007 | Case series | Long term | 61 | Percutaneous | | AOFAS=83 | | | | | | Percutaneous has good results |
| Gavlik <i>et al.</i> | 2002 | Case series | 1 year | 10 | Arthroscopy and percutaneous fixation | | AOFAS=93.7 | | | | | | Good results with their technique |
| Magnan <i>et al.</i> | 2006 | Case series | | 54 | Orthofix fixator | | MFS | 6.98 | 21.94 | | Yes (P=0.01) | | Similar to ORIF |
| Stulik <i>et al.</i> | 2006 | Case series | | 287 | K-wire | | CNS=83.9 | | | | | | Similar to ORIF |
| Wu <i>et al.</i> | 2005 | Case series | 1 ½ years | 35 | ORIF | | AOFAS=88.1 (II), 78.8 (III) | 5.6 | 28.2 | | | | ORIF better |
| Li <i>et al.</i> | 2008 | RCT (K-wire vs. ORIF) | 1 year | 71 | K-wire versus ORIF | | AOFAS | | | | Yes | | Comparable results; less wound problems with K-wire ORIF better |
| Laughlin <i>et al.</i> | 1996 | Case series | 2 years | 21 | ORIF | | MFS | | | | | No | ORIF better; no correlation in Bohler's angle and outcome |
| Hutchinson and Huebner | 1994 | Case series | 3 years | 47 | ORIF | | | | | | | | ORIF better than conservative |
| O'Farrell <i>et al.</i> | 1993 | RCT | 15 months | 24 | ORIF | | | | | | | | Comparable results |
| Kennedy <i>et al.</i> | 2005 | RCT | | 36 | | AOFAS, sf-36 | | | | | | | ORIF better; correlation in Bohler's angle and outcome |
| Our study | | Case series | 15 months | 30 | ORIF | | AOFAS=78.7 | | 24.7 | | | Yes (P<0.001) | ORIF better; correlation in Bohler's angle and outcome |

RCT: Randomized control trial, ORIF: Open reduction and internal fixation, MFS: Maryland foot score, CNS: Creighton-Nebraska Health Foundation Assessment Score, AOFAS: American Orthopedic Foot and Ankle Society, WCB: Worker's Compensation Board

Table 6: Studies on radiological assessment of calcaneal fractures^{10,12,14}

| Author | Year | Type | Duration | Number of points | Intervention | Results | | | | | | | | | | | | | | | |
|-----------------------|------------------------------|--------------------------|-----------|------------------|---------------------------|---|-------|--------------------|---------|---|-------------|------|---|------------------------------|------|---|-------------------------|--------------|---|-------------------------|---------|
| Janzen and Douglas | 1992 | | | | | A poor clinical outcome, caused by loss of subtalar motion, was more common when CT showed incongruity or degeneration of the posterior facet ($P=0.04$) and when Bohler's angle was decreased ($P=0.0006$). Other CT findings, such as loss of calcaneal height and tendon abnormalities, did not correlate with clinical outcome | | | | | | | | | | | | | | | |
| Richards and Bridgman | 2001 | Review | | | | There was no systematic, blinded assessment of the change in radiology by the operative intervention. Overall, there was weak evidence to support ORIF. In conclusion, there are only three randomized, controlled studies involving small numbers of patients, which showed improved plain radiographic anatomical alignment, in the post-operative but not conservative group. | | | | | | | | | | | | | | | |
| Paul <i>et al.</i> | 2004 | case series | 6.5 years | 70 | ORIF | <table><tr><th>Group</th><th>Fracture/treatment</th><th>Results</th></tr><tr><td>1</td><td>Undisplaced</td><td>Good</td></tr><tr><td>2</td><td>Displaced<10° conservatively</td><td>Poor</td></tr><tr><td>3</td><td>Displaced>10° operative</td><td>Satisfactory</td></tr><tr><td>4</td><td>Displaced<10° operative</td><td>Poorest</td></tr></table> <p>They did not directly compare the results of operative with non-operative treatment because patients were not randomized before treatment. However, they are of the opinion that operative treatment which does not result in approximate anatomical reconstruction has more disadvantages than non-operative management of these injuries.</p> | Group | Fracture/treatment | Results | 1 | Undisplaced | Good | 2 | Displaced<10° conservatively | Poor | 3 | Displaced>10° operative | Satisfactory | 4 | Displaced<10° operative | Poorest |
| Group | Fracture/treatment | Results | | | | | | | | | | | | | | | | | | | |
| 1 | Undisplaced | Good | | | | | | | | | | | | | | | | | | | |
| 2 | Displaced<10° conservatively | Poor | | | | | | | | | | | | | | | | | | | |
| 3 | Displaced>10° operative | Satisfactory | | | | | | | | | | | | | | | | | | | |
| 4 | Displaced<10° operative | Poorest | | | | | | | | | | | | | | | | | | | |
| Loucks and Buckley | 1999 | Prospective cohort study | 2 years | 95 | ORIF versus non-operative | <p>A. Open reduction and internal fixation did successfully increase Bohler's angle, yet this increase in angle did not correlate with improved clinical outcome scores</p> <p>B. Those fractures with a marked initial loss of Bohler's angle (<0°) had the worst outcomes. A large initial displacement (increasing energy absorbed), regardless of treatment, resulted in a poorer outcome. This suggests that Bohler's angle has significant prognostic value in terms of predicting long-term morbidity associated with these devastating injuries.</p> | | | | | | | | | | | | | | | |

CT: Computed tomography, ORIF: Open reduction and internal fixation

that there is thrombosis of the vessels at the anastomosis between lateral peroneal and planter vessels at initial trauma, and internal fixation is thought to jeopardize the already damaged soft-tissue coverage on the lateral side, the incidence of wound complications can be reduced by proper timing and technique of surgery. Because of the small number of patients, it is difficult to correlate achievement of Bohler's angle with wound infection.

Although for some authors bone grafting seems to play an important role, most of the others do not prefer it. In our study, none of the patients required bone grafting.

In our study, we found a significant correlation between Bohler's angle and AOFAS score ($P < 0.01$) and Bohler's angle and ICS ($P < 0.05$), whereas there was no significant correlation between Gissane's angle and AOFAS.

In 28 fractures, the Bohler's angle was <10° and two had <10°. Both patients where Bohler's angle was <10 had fair results. Similar results were shown by Paul *et al.* (Table 6).¹⁵⁻¹⁷

The bad results in the current study were mainly represented by the three Type IV fracture, one patient of Type II fracture with technical failure to achieve Bohler's angle and two Type III fractures with wound complications.

The shortcomings of this study are its small cohort size, lack of control group, and short follow-up period. Currently, we prefer treating calcaneal fractures with use of rigid calcaneus-specific fixation plates.

CONCLUSION

In this study, ORIF of calcaneal fractures showed excellent to good results in 80% of the patients. The results are poor as comminution increases. A single lateral extensile approach is sufficient to reduce all fractures. Only one of the 30 fractures had wound infection with this approach. Additional bone graft was not required. Intraoperative achievement of Bohler's angle determines the outcome. Thus, ORIF of fractures of the calcaneum can only be

expected to benefit those patients with nearly anatomical reconstruction. We recommend to open reduce and internally fix the displaced intra-articular fracture of the calcaneum.

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