



ISSN (P): 2521-3466
ISSN (E): 2521-3474
© Clinical Orthopaedics
www.orthoresearchjournal.com
2022; 6(4): 12-17
Received: 17-08-2022
Accepted: 23-09-2022

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Management of calcaneal fractures using the minimally invasive, the ilizarov ring fixation technique

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DOI: <https://doi.org/10.33545/orthor.2022.v6.i4a.376>

Abstract

Introduction: The calcaneal fractures usually result from high energy trauma such as fall from height, road traffic and industrial accidents. Calcaneal fractures constitute about 2% of all skeletal fractures. These fractures are usually displaced and intraarticular in about 60 to 75% of cases and the treatment varies accordingly, however there is still controversy regarding the treatment of calcaneal fractures.

Materials and Methods: The current study retrospectively analyzed 30 cases of calcaneal fractures using the minimally invasive, the ilizarov ring fixation technique at the Postgraduate Department of Orthopaedics, Government hospital for Bone and Joint Surgery Barzulla, an associated hospital of GMC Srinagar from date June 2020 to June 2021.

Results: There were 12 (40%) excellent, 9(30%) good, 5(16.66 %) fair and 4(13.33%) poor. We achieved good alignment in all cases except 4 (13.33%) feet and had varus deformity at the last follow-up. Superficial pin tract infection occurred in 5 (16.66%) fractures which was controlled with local antibiotics and frequent pin care. The range of movement of the subtalar joint was $>25^\circ$ in 23 (76.66%) patients. In 7 (23.33%), the range of movement of the subtalar joint was $<25^\circ$.

Conclusion: Based on these observations, we can say that this subtalar joint spanning Ilizarov frame is a useful device in treating intra-articular calcaneal fractures helping patients in gaining an early range of motion at foot and ankle joints, early weight-bearing with reduced incidence of subtalar arthritis. It provides a good functional foot outcome with a low risk of postoperative complications.

Keywords: Calcaneus, calcaneal fractures, foot, fractures, high energy fractures, ilizarov

Introduction

The calcaneus is the most frequently fractured tarsal bone, accounting for 1-2% of all skeletal fractures^[1]. The principal trauma mechanism is fall from heights^[2]. Recent studies have shown that 75% of foot function is affected by calcaneal fractures^[3]. The shape of the fracture is determined by the position of the foot at the time of the fracture, quality of the bone, and the strength of the fracture. Approximately 75% of calcaneal fractures are intra-articular fractures involving the subtalar joint^[4].

Historically, these fractures lead to poor outcomes and are associated with unsatisfactory clinical and functional results due to their complexity and the difficulty in keeping the joint congruent and perfectly reduced, without causing major damage to the hind-foot structures during the surgical procedure.

Such fractures can cause considerable disability due to complications associated with pain and chronic joint stiffness. For treatment of calcaneal fractures, there remains a controversy regarding the selection of conservative treatment or surgical treatment.

There are several surgical treatment methods, but the effects vary. The modern era of surgical revolution had devised many innovative techniques to reduce complications and improve patients outcome but the management of fractures still face the heat of controversy regarding how to classify and treat them. Whether to do open reduction followed by internal fixation or use hybrid techniques of indirect reduction using various external fixation methods. The main purpose of the operation is to restore the consistency of the subtalar joint, as well as the length, width, and height of the calcaneus. Therefore, management of calcaneal fractures is a challenge for any orthopedic surgeon^[5].

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The reported complications of conservative management support the selection of open reduction and internal fixation (ORIF) as the treatment of choice for virtually all displaced calcaneal fractures [6-10]. The ideal goal of ORIF include reduction of the articular surfaces of the subtalar and calcaneocuboid joints, restoration of the calcaneal width, height, and length, and correction of varus and lateral translation [10-12]. Recreation of the calcaneal anatomy and joint congruency will restore the normal foot and ankle kinematics [10]. However, deep infection, skin necrosis, peroneal tendonitis, and screw penetration into the subtalar articular surface arising from ORIF will affect the final results. Furthermore, open reduction of comminuted calcaneal fracture is technically difficult and does not necessarily guarantee the anatomic restoration or maintenance of the subtalar joint and calcaneal shape [13-15]. Moreover, 21% of patients with complications need further surgery, according to a study of 190 calcaneal fracture cases reported by Folk *et al.* [16]. Minimally invasive technology has been promoted and developed to avoid frequent and repeated problems of open reduction, ensuring good reduction and reduction of rates of complications. Such methods include percutaneous external fixation, percutaneous arthroscopic-assisted technology, and percutaneous balloon angioplasty. One such technique, closed reduction and external fixation can stabilize most displaced joint fractures. This greatly reduces the risk of open surgery via preoperative CT. It has been included in many preliminary studies on the application of external fixation for calcaneal fractures [17]. In cases of calcified fractures of the calcaneus or extensive soft tissue damage, percutaneous fixation is a good choice. External fixation can reduce tissue exposure, restore anatomy of calcaneum, and allow early weight bearing. Several authors have consequently developed minimally invasive or percutaneous techniques for the treatment of intra-articular calcaneal fractures [18-20] and number of reports have described the use of external fixators to treat such fractures [21-28]. Paley and Fischgrund [28] described open reduction and circular external fixation of intra-articular calcaneal fractures whereas Besch [22] described closed reduction and use of a hinged external fixator. Emara and Allam [23] and McGarvey [25] described techniques using indirect reduction and Ilizarov external fixators. We conducted this study to find whether the Ilizarov technique could improve foot function and restore calcaneal anatomy (calcaneal length, height, width, and Bohler's angle) with minimum intraoperative and postoperative complications.

Inclusion criteria

- Calcaneal fracture Type II, III, and IV Sanders type.

Exclusion criteria

- Sanders Type type 1
- Patients with concomitant fractures in the same or other limb or spine
- Open fractures other than Gustilo Anderson Type 1.

- Patients with severe lacerated wounds

Patient characteristics

There were 23 males and 7 females, with a mean age of 42.3 years (range 22 to 67 years). 17 (56.66 %) of fractures resulted from fall from height and 13 (43.33%) from road traffic accidents. According to Sanders classification [29], there were 9 (30%) fracture calcaneus Type II, 15 (50%) Type III and 6 (20%) Type IV.

Table 1: Demography of patients

		No. of patients	Percentage
Gender	Male	23	76.66
	Female	7	23.33
Age group	22-35 Years	10	33.33
	36-50 Years	14	46.66
	51-67 Years	6	20
Laterality	Right	11	36.66
	Left	17	56.66
	Both	2	6.66
Mode of trauma	Fall from height	18	60
	Road accidents	10	33.33
	Others	2	6.66
Type according to Sanders classification	Type II	8	26.66
	Type III	17	56.66
	Type IV	5	16.66

Standard antero-posterior, lateral, and axial plain radiographs of the ankle were obtained. The length, height, and Bohler's angle of the calcaneus as well as the width were measured preoperatively and at the last follow-up. Bohler's angle (figure 1) was measured using the highest points of the calcaneal tuberosity, subtalar joints, and anterior process. The length of the calcaneus (distance L) was measured on the lateral view from the most posterior point of the tuberosity to the center of calcaneocuboid joint. The center of calcaneocuboid joint was measured as the center point of a vertical line drawn parallel to the calcaneal cuboid joint, from the most superior and inferior points on the anterior calcaneus. The height of the calcaneus (distance H) was also measured on the lateral view by a line perpendicular on the calcaneal axis to the highest point of the posterior facet. The calcaneal axis was drawn from the most inferior point of the calcaneal tuberosity to the most distal and inferior part of the calcaneus along the calcaneocuboid joint. The width of the calcaneus (distance W) was measured on the axial view as the length of a perpendicular line connecting two parallel lines drawn tangent to the widest part of the calcaneal tuberosity. Computed tomography (CT) scans of fracture calcaneus in both axial and coronal planes were also obtained. Patient with acute injuries were treated immediately after obtaining radiographs and CT scan; however, patients approaching with blisters and severe swelling were managed conservatively to wait for subsidence of swelling.

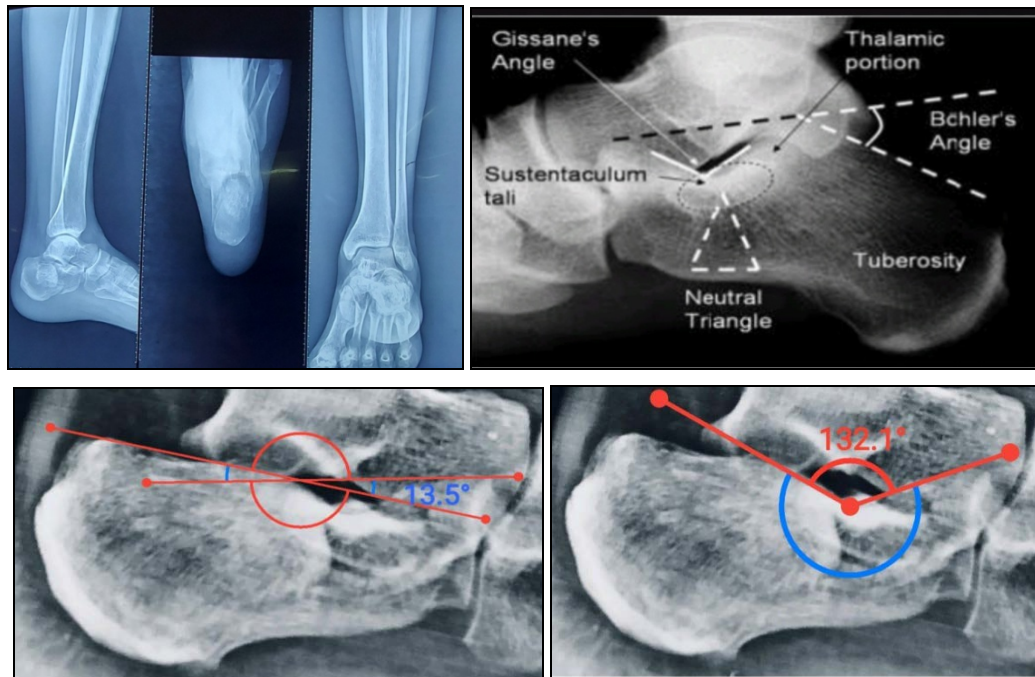


Fig 1: Preoperative pic and calculation of bohlers and gissane angle

Surgical technique

Under spinal anesthesia, the patient was placed on the operating table in supine position with elevation the affected extremity above the contralateral limb using sterile drapes. The foot was positioned to hang out about 6-9 cm over edge of table. No tourniquet was used. In first step, two olive wires were placed in talus medially and laterally parallel to the subtalar joint in the coronal plane. The first olive wire is directed from anterolateral to the posteromedial direction to avoid malleolar/deltoid capture, the second olive wire is directed anteromedial to posterolateral orientation or parallel to first at the base of Talar neck. In second step, half ring attached anteriorly and wire tensioned up to 90 kg. Third step comprises putting Ilizarov wires in calcaneum, which may also include mitigation of elevated tuberosity and tendoachilles by using Steinmann pin/K-wire and manipulation of any impacted fragments by using K-wire as a joystick. However, in a standard case without much elevated tuberosity or any impacted fragment we used 3 wires ; first and second one to correct varus, which were placed nearly parallel to talar wires and perpendicular to calcaneal length in axial view in anterior

half and posterior half of calcaneum respectively and the last one placed in same transverse plane but posterosuperior to first one and anterosuperior to second one, forming a rough isocetes triangle as seen from lateral side, this third wire helps to maintain reduction of sustentaculi and appear more arched in radiographs. In next step, these 3 wires now were attached to another half ring, which can be attached to previously applied half ring through small rods. In the final step, subtalar distraction was applied under image intensifier. The reduction was then confirmed using lateral, axial and broden's views taking maximum care to avoid any misinterpretation due to superimposition by rings. Since Ilizarov is a customizable implant, other permutations and combinations can be tried according to fracture geometry using distraction technique for example calcaneocuboid joint reduction can be addressed using more wires in metatarsals too. Considering the limitations of this technique, special attention should be given to the posterior facet of subtalar joint which is quite unforgiving owing to large number of forces converging on it and open reduction as a backup must be kept ready.



Fig 2: Clinically pictures of ilizarav ring frame and its application

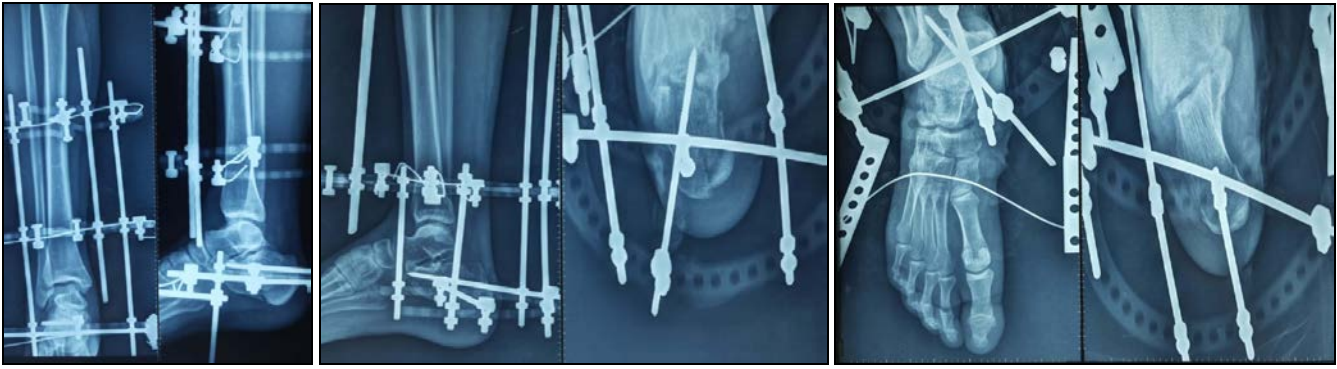


Fig 3: Post-operative radiographs

Post-operative follow-up

Limb elevation and active toe movements, active knee movements were immediately started as tolerated by patients. Postoperatively, pin care instruction (using normal saline

solution three times a day) was advised. Follow-up lateral and axial calcaneal X-rays were done at 4, 8, and 12 weeks and then yearly till the last follow-up.



Fig 4: Follow up radiograph and dorsiflexion and plantar flexion after fracture has healed.

Results were assessed both clinically and radiologically. Patients were encouraged to partially bear weight as tolerated at the follow-up of 6 weeks. Under short-acting general anesthesia, the fixator was removed when the patient shows adequate bone formation, which usually occurs between 8 and 12 weeks. The mean timing for removal of the frame was 11.2 weeks. Complete weight-bearing and gait exercises were allowed. We used the clinical rating system of the American Orthopaedic Foot and Ankle Society (AOFAS) scores for evaluation of functional results. The range of motion of the subtalar joint was measured by placing the patient prone, and then passive inversion and eversion of the heel was done while measuring the extent of motion with a goniometer following the movement of the calcaneal tuberosity relative to the axis of the leg. At the last follow-up, radiological measurements of the fractured feet (48 feet) were compared with normal measurements of noninjured feet (32 feet) in unilateral cases.

Results

In this study among 30 fractures, there were 12 (40%) excellent, 9(30%) good, 5(16.66 %) fair and 4(13.33%) poor (Table 2) according to the clinical rating system of the American Orthopaedic Foot and Ankle Society (AOFAS) scores. We achieved good alignment in all cases except 4 (13.33%) feet and had varus deformity at the last follow-up. Superficial pin tract infection occurred in 5 (16.66%) fractures which were controlled with local antibiotics and frequent pin care. We had no deep infection in this study. In this study, radiological follow-up showed subtalar joint arthritic changes in 7 (23.33%) of cases, 2 cases (6.66%) showed both calcaneocuboid and subtalar arthritis. No arthritic changes were noted in the ankle joint at last follow-up. 1 (3.33 %) patient developed reflex sympathetic dystrophy, treated with physiotherapy and oral medications showed an improvement, later on. The range of movement of the subtalar joint was $>25^\circ$ in 23 (76.66%) patients. In 7 (23.33%),

the range of movement of the subtalar joint was $<25^\circ$. All patients returned to work. Ankle joint in all cases showed no signs of restriction of movement.

Table 2: Results according to the American Orthopaedic Foot and Ankle Society (AOFAS) scores

Parameters	No. of patients	Percentage
Excellent	12	40
Good	9	30
Fair	5	16.66
Poor	4	13.33

Discussion

High energy fractures of the calcaneum challenge the orthopaedic surgeon due to the difficulties in restoring the complex bony architecture and the tenuous nature of the soft tissues. Cotton and Wilson in 1916 wrote that the man who breaks his heel bone is done^[30]. The management of displaced, calcaneal fractures continues to elicit debate. Open reduction has not consistently improved outcome when compared with non-operative treatment and in some cases has resulted in worse outcome^[31]. Various techniques of surgical and non-surgical treatment have been advocated by different researchers across the decades with more and more variable outcomes. The consensus however is that the treatment should attempt to improve the natural history of the injury.

In our study, we tried to analyze the results of our principle of short segment capsulo-ligamentotaxis applying it to specific joints like subtalar or calcaneocuboid, while leaving the adjacent joints free allowing early return to function, with minimal disturbance of soft tissues or devascularization of bone. To improve the functional outcome we used Ilizarov frame to achieve restoration of the calcaneal shape and consequently the foot and ankle kinematics. We used distraction technique through the mechanical axis of the leg and through the foot axis to restore the height, width, and length of the calcaneus to restore depressed subtalar fragments instead of open reduction through minimal skin incisions.

In this study we have used the AOFAS score as a functional outcome measure that provided the best comparison tool between different studies^[32-34].

Many recent studies which compared operative and non-operative or minimally invasive modalities of treatment for calcaneal fractures indicated comparable functional results with a lesser rate of infections in non-operative/minimally invasive treatment procedures^[35-37]. In our study there was no instance of deep infection, all the reported ones were superficial and healed with local treatment. However open reduction and internal fixation of calcaneum may be associated with a high rate of infection up to 25%,^[38] Zwipp *et al.* in 7.9% cases^[39].

Distraction and dynamization along with ankle motion lead to fewer incidences of contracture, stiffness of ankle and subtalar joint. Distraction also helps in healing of cartilaginous surface at involved joint hence fewer chances of developing subtalar arthritis^[40], Subtalar arthritis may result from cartilage damage at time of injury due to irreversible high energy impact as depicted by Boreli *et al.*^[41]. Zwipp *et al.* reported subtalar arthritis in $>50\%$ cases and calcaneocuboid joint arthritis in $>25\%$ cases. In this study, radiological follow-up showed subtalar joint arthritic changes in 7 (23.33%) of cases and 2 cases (6.66%) showed both calcaneocuboid and subtalar arthritis.

In our study 1 (3.33%) patient developed reflex sympathetic dystrophy. The Ilizarov external fixator permits partial to full

early weight bearing in all patients. This may be helpful in desensitization of the heel fat pad and thus prevent chronic heel pad pain and dystrophy^[31, 42].

The normal motion in the subtalar joint was reported to have great variations from a minimum of 20° to a maximum of 60° of motion^[43]. With our surgical technique, full or almost full range of movement of the ankle joint was achieved in all cases. The range of movement of the subtalar joint was more than 25° in 23 (76.66%) fractures. Similar mobility in the ankle and subtalar joints has been reported in literature after open reduction and osteosynthesis with a plate^[15, 23, 44]. However, Buch reported a worse range of motion in the ankle and subtalar joints after performing a percutaneous wire osteosynthesis in 100 calcaneal fractures with a varus or valgus deviation of the hind foot occurring in half of the cases. In our study, we achieved good alignment in all cases except 4 (14.29%) feet and ended up with varus deformity at the last follow-up.

However, the study has certain limitations like small sample size, difficulty in assessing the reduction intra-operatively, no control group and limited follow-up. We believe that patients should be evaluated at 10 years for valid conclusions to be drawn.

Conclusion

Based on these observations, we can say that this subtalar joint spanning Ilizarov frame is a useful device in treating intra-articular calcaneal fractures helping patients in gaining an early range of motion at foot and ankle joints, early weight-bearing with reduced incidence of subtalar arthritis. It provides a good functional foot outcome with a low risk of postoperative complications.

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