

MINIMALLY INVASIVE TREATMENT OF INTRA-ARTICULAR CALCANEAL FRACTURES

By

**Ahmed Mohamed Ahmed Selim, Mohamed Ibrahim Abulsoud and
Mahmoud Seddik Hassan**

Orthopedic Department, Faculty of Medicine, Al-Azhar University, Egypt

Corresponding author: Ahmed Mohamed Ahmed Selim

E-mail: drshahmedselim@gmail.com

ABSTRACT

Background: Calcaneal fractures have considerable debate of the appropriate methods of management and how to lessen potential complications.

Objective: Evaluation of intra-articular calcaneal fractures that treated by minimally invasive methods.

Patients and Methods: A prospective study has been conducted on twenty patients having intra-articular calcaneal fractures and were managed by minimally invasive methods of fixation at Al Azhar university hospitals, Cairo, Egypt, after that they have been followed up for 6 months.

Results: According to the American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hind foot Score. There was: excellent (5 feet (25%)), good (11 feet (55%)), fair (2 feet (10%)) and poor (2 feet (10%)). The average score was 83 with a range of 68 to 95. No patient in this series experienced any failure of hard-ware, or developed deep infections. Complications included: superficial pin tract infection, varus heel deformity, flexion deformity of the big toe, reflex sympathetic dystrophy, subtalar arthritis and painful heel.

Conclusion: Management of calcaneal, intra-articular, fractures by minimally invasive techniques is a viable surgical alternate as it provides shorter time of surgery, nominal invasiveness, less serious wound problems, and no residual hardware (in case of pinning). Their drawbacks include technical issues and inadequate reduction fracture fragment.

Keywords: Intra-articular calcaneal fractures, minimally invasive techniques, sinus tarsi approach, K. wires, cannulated screws.

INTRODUCTION

Calcaneal fractures constitute around 60 % of all fractures of the tarsal bones and about 1% - 2% of all fractures. Most of these fractures occur in males of working age group. If improperly treated, it can lead to long-lasting pain and

disability (*Kumar et al., 2012*). Displaced intra-articular calcaneal fractures relating the posterior articular facet, account for the bulk of these fractures. These fractures are caused mainly by axial loading like a fall from the height (*Meraj et al., 2012*).

Considerable debate has been held on appropriate treatment and how to minimize potential complications. Untreated calcaneal fractures with altered bone morphology and articular surface result in significant biomechanical alterations (*Wei et al., 2017*). Consequently, open reduction and internal fixation (ORIF) was used to provide appropriate bone morphology and correct the subtalar joint mechanics (*Luo et al., 2016*). However, ORIF is not without complications, the most common of which are wound dehiscence and infection. Persistent subtalar joint stiffness and arthritis also has been one of the main disadvantages. Even in an anatomically repaired subtalar joint (*Spierings et al., 2019*).

The principles of minimally invasive techniques were applied to calcaneus fractures in an effort to minimize the invasive element of ORIF, as well as to provide rigid fixation (*Zhang et al., 2018*).

After a pre-operative CT-scan, the distraction technique for indirect reduction and internal fixation with closed or percutaneous reduction will achieve reduction and stable fixation of most intraarticular calcaneal fractures. The results described in the most recent studies are better than those observed in the past, and are now comparable to treatment by ORIF (*Prod'homme et al., 2018*).

The present work aimed to evaluate the radiographic and clinical results of minimally invasive fixation of intra-articular calcaneal fractures according to American Foot and Ankle Score, and assessment of the postoperative range of motion.

PATIENTS AND METHODS

This prospective study was permitted by ethical committee of Al-Azhar university included 20 patients having intra-articular calcaneal fractures managed with minimally invasive methods of fixation. This included the usage of K. wires, cannulated screws and sinus tarsi approach, at the Orthopedic Department, Al Azhar university hospitals, Cairo, Egypt. Then, they have been followed up for 6 months, the fractures were classified using Sanders' classification and closed Sanders type II, III were considered in this study. Open fractures, neurologic, metabolic-diseased patients, osteoarthritic and/or stiff ankle ones are excluded.

All patients in this study were clinically assisted. Radiographic examinations including plain X-ray of the heel, X-ray for any suspected associated injuries and CT scan of the heel were done to determine the fracture type. Prophylactic preoperative I.V antibiotic (3rd generation cephalosporin) was used, 30 minutes before surgery.

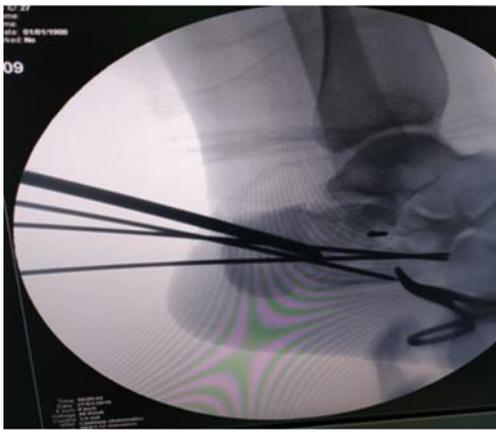
The aim of our method was to restore calcaneal anatomy (length, height, width and angles) as possible to achieve restoration of function as possible and hence reduce complications.

The articular surface was fixed with a cannulated short threaded screw, and then the height and width of the calcaneus were preserved using two positional screws. *Gomaa et al. (2014)* have modified the procedure to minimize the complications, and fix the articular surface under direct vision using a slight lateral incision.

In the calcaneal tuberosity, a 5 mm Steinmann pin was inserted. Then, the pin

was mounted on a traction stirrup. In an attempt to release the impaction of the fracture by pushing the calcaneal tuberosity downwards, a heavy pressure was then applied on the stirrup. Traction was maintained until Bohler's angle, calcaneal length were restored, and varus deformity was corrected.

Figure (1): (a, b) Lateral and axial view of os calcis fixed temporally by k-wires, respectively



(a)

The guide wire for the first positional screw was started at the plantar lateral aspect of the tuberosity and directed superiorly and medial ending below the sustentacular fragment. The guide wire for the second positional screw was then applied from the upper medial part of the calcaneal tuberosity, directly below the compression screw into the anterior calcaneal process. Closure in layers (in case of mini-open), and a below knee cast was done.

Post-operatively, I.V antibiotic, monitoring the neurovascular status, analgesia, heparin (low molecular weight) and radiographs were obtained.

After six weeks, removal of the cast was done and partial weight bearing in

Under image intensifier control. A small strong elevator was pushed under the posterior facet and used to lift the impacted fragments. The articular surface was visualized and was fixed primarily with K-wires and the reduction was checked in lateral and axial views (**Figure 1**).

another walking cast was allowed for



(b)

another two weeks, then after 8 weeks removal of cast and partial weight bearing for another four weeks without cast, full weight bearing started after the confirmation of union.

Check X-rays were obtained every month till the end of the monitoring time, i.e. (6 months) (**Figures 2 and 3**).

At the close of follow up time, patients were assessed according to (AOFAS) score (*Chen et al., 2017* and *Dong et al., 2017*).

Ankle exercises started as soon as possible. Physiotherapy was encouraged and weight bearing was restricted until radiological signs of union.

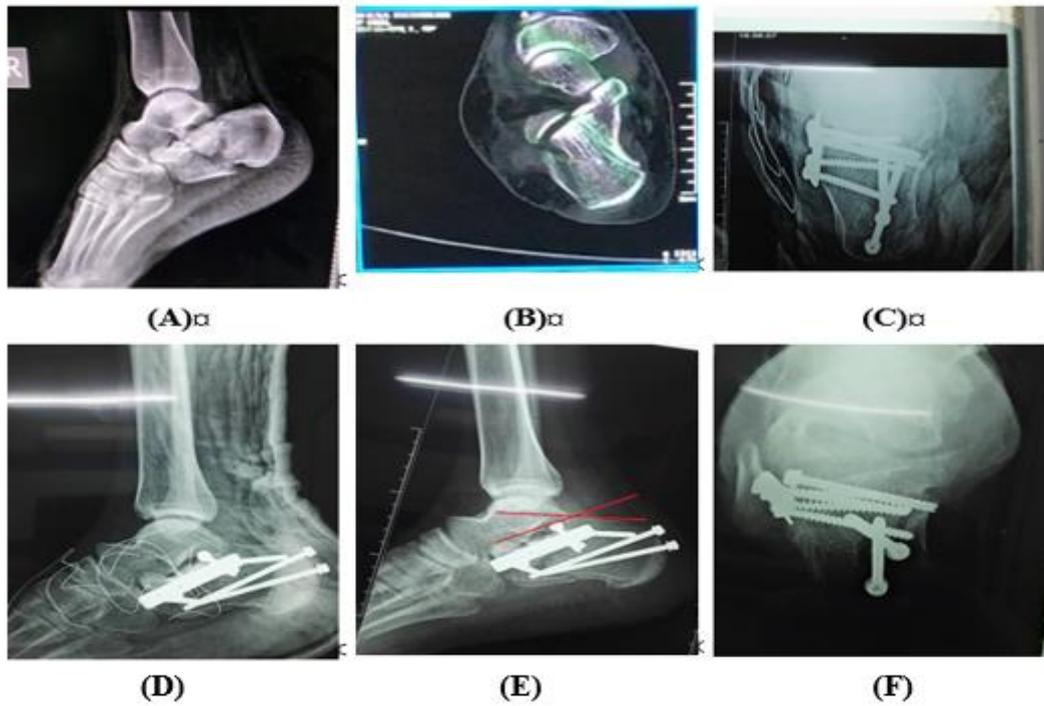


Figure (2): Case I: (A) pre-operative X-ray, (B) pre-operative CT (C, D) immediate post-operative X-ray, (E, F) follow up X-ray after six months, (Sinus tarsi approach have been used).

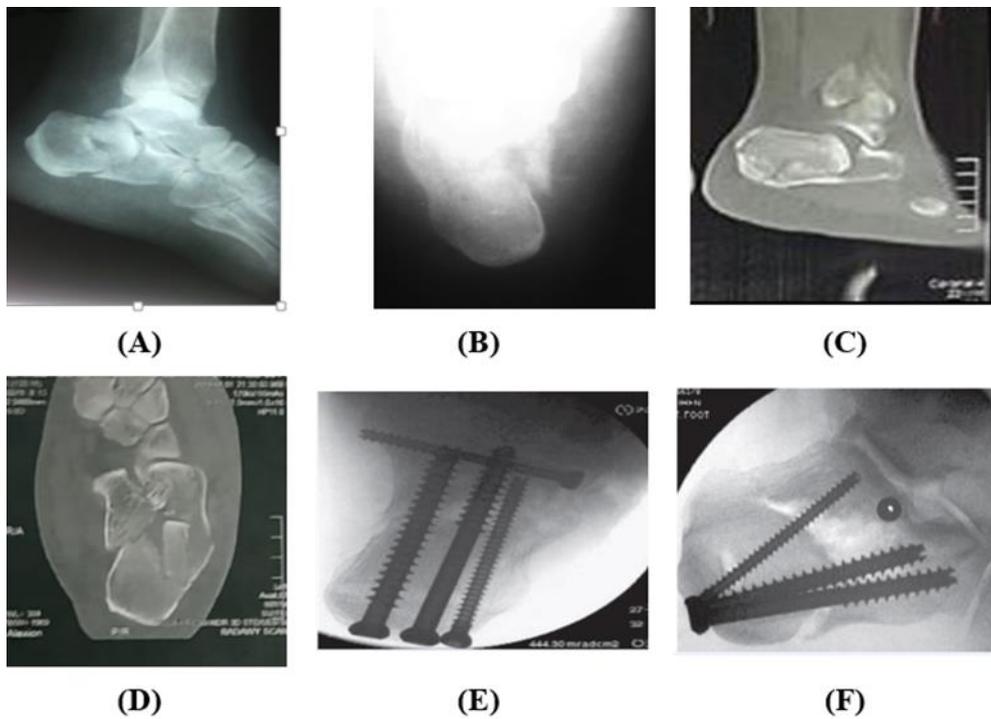


Figure (3): Case II: (A, B) pre-operative X-ray, (C, D) pre-operative CT (E, F) immediate post-operative X-ray, (Cannulated screws have been used).

Statistical methods:

Data were expressed as Mean ± SD for quantitative parametric measures in addition to both number and percentage for categorized data.

The following tests were done:

1. Comparison between two independent mean groups for parametric data using Student "t" test or Mann-Whitney U test.

The degree of change due to follow-up study (delta change or DC) reflect the actual difference changed through the follow-up study and can be calculated for each patient, from which, the mean delta change can

compared with other group or correlate with other variables. It is defined as follow: Delta change (DC) = (Post-Pre)/Pre.

2. Pearson correlation test was to study the possible association between each two variables among each group for parametric data.
3. Chi-square (χ^2) test was to study the association between each 2 variables or comparison between 2 independent groups as regards the categorized data.

The probability of error at 0.05 was considered significant.

RESULTS

Twenty cases of calcaneal fractures have been managed by percutaneous reduction with or without minimal surgical intervention. According to the AOFAS, Ankle-Hind foot score, there was excellent [5 feet (25%)], good [(11 feet (55%)), fair [(2 feet (10%))] and poor [(2 feet (10%))] cases .The average score was 83 with a range of 68 to 95. No patient in this series experienced any failure of hardware, or developed deep infections. None of the patients has required further surgical intervention.

Subtalar range of motion was more than 50% in 16 feet (80%) while in the

remaining 4 feet (20%) was less than 50%.

In our series, 9 feet (45.0%) had early arthritic changes in the subtalar joint: 6 of 9 (66.7%) were type III fracture and 3 of 9 (33.3 %) were type II fracture. No arthritic changes have been noted in the ankle joint at last follow-up.

In our series, type II fractures gave more satisfactory results than type III. This difference was found to be statistically significant ($\chi^2 =1.250$, p =0.582) (**Table 1**).

Table (1): Relation between the results and type of fracture

AOFAS scoring	Satisfactory (n = 16)		Unsatisfactory (n = 4)		p
	No.	%	No.	%	
Type of fracture					
II (n = 10)	9	90.0	1	10.0	0.582
III (n = 10)	7	70.0	3	30.0	

Radiologically: The Bohler's angle of the calcaneus was measured preoperatively and at the last follow-up, Bohler's angle was restored to normal (20°-40°) in 16 feet (80.0%) while 4 feet (20.0%) was less

than normal. The mean Bohler's angle was changed from $-5.42^{\circ} \pm 12.68$ SD preoperatively to $27.13^{\circ} \pm 6.1$ SD postoperatively (**Table 2**).

Table (2): Relation between the results and preoperative and postoperative Böhler's angle

AOFAS Scoring Bohler angle	Satisfactory (n = 16)	Unsatisfactory (n = 4)	U	P
Pre-operative			16.0	0.148
Min. -Max.	-30.0 -16.0	-19.0 - -9.0		
Mean ±SD.	-2.81 ± 13.59	13.25 ± 4.35		
Median	1.0	-12.50		
Post-operative			24.0	0.448
Min. -Max.	19.0 -38.0	19.0 -34.0		
Mean ±SD.	26.8 ± 5.26	29.25 ± 6.90		
Median	26.0	32.0		

U: Mann Whitney test.

P: P value for comparing between satisfactory and unsatisfactory.

Complications: Pin track infection: Superficial pin track infection has been seen in five cases. Varus heel deformity: was noticed in 2 cases. Flexion deformity of the hallux: one case complained from that. Reflex sympathetic dystrophy: One

case complained from intolerable pain, cold, clammy skin, could not tolerate anyone touching the foot, Subtalar arthritis. 9 patients (45%) had early subtalar arthritis.

DISCUSSION

Difficulty in achieving an adequate reduction using conservative approaches, and difficulty of reduction and fixation, even with an open surgical approach, management of calcaneal intraarticular fractures remains contested (*Gusic et al., 2015*).

From meta-analysis, Randle et al. reported a trend for surgically treated patients to get better results. A major concern for most surgeons is the complication rate associated with these procedures (*Li et al., 2016*).

Kundle et al. reported superficial wound complications in 7% of their patients, deep infections in 7%, and the total complication rate was 30% in the group of open reduction and plate fixation (*Su et al., 2013*).

Over the last decade, minimally invasive osteosynthesis was achieved greater popularity in treating of comminuted intra-articular calcaneal fractures (*Abd EL Reheem et al., 2018*).

Twenty patients with fractures of the calcaneus (Sanders types II, and III) were treated using minimally invasive techniques. A limited percutaneous

plantar skin incision was used in some cases to improve posterior facet reduction. The age of the patients varied between 16 and 58 years. Falling from height was the causative trauma in most cases (18 patients). Fractures were evaluated by preoperative CT scans and classified according to Sanders classification. Image intensifier was used to assess the accuracy of reduction in lateral, AP and axial calcaneal views.

In our study, patients were evaluated by physical examination as well as by the AOFAS hindfoot score questionnaire. After follow up of 6 months our study showed excellent results in (25.0%), good results in (55.0 %), fair results in (10.0%) and poor results in (10.0%). The average AOFAS score for 20 patients was 83 (68 to 95). The mean Bohler's angle was changed from 10.50 ± 2.08 SD preoperatively to 30.87 ± 4.41 SD postoperatively. Complications included superficial pin track infections, heel varus deformity, flexion deformity of the hallux and reflex sympathetic dystrophy.

On comparison with the series presented by *Gomaa et al. (2014)* treated twenty-one patients with 26 closed, intraarticular fractures of Calcaneus using a minimally invasive technique that they developed by modifying the procedure of Forgon The results were good in 17 (81%) patients, fair in two (9.5%) patients, and poor in two (9.5%) patients.

Rammelt et al. (2010) used aided arthroscopic reduction and percutaneous fixation for 33 patients with sander's type II Displaced Calcaneal Intraarticular Fractures and minimum follow up of 24 months, the average American Orthopedic

Foot & Ankle Society (AOFAS) score was 92.1 (range,80-100).

El Khalifa et al. (2011) limited open reduction and percutaneous screw fixation with intra-articular calcaneal displaced fractures were evaluated for an average 2.5 years, 79% had quiet good raising to excellent result with excellent results in 27%, good in 52%, fair in 15% and poor in 6% of fractures.

Regarding the factors that may impact on the end result; this study included 10 patients (50.0%) having sander's type II fracture; 10 (50.0 %) type III fracture. Type II fractures had (90%) satisfactory results; type III had (70.0%) satisfactory results, this probably because of the more comminution and displacement in type. Our results revealed no statistically significant relationship between the patients' sex, mechanism of trauma, body mass index, and the final outcome.

CONCLUSION

Closed reduction and fixation by minimally invasive procedures is a suitable surgical option for these fractures, specially comminuted fractures in which soft tissue is compromised, as it include shorter time of surgery, minimal invasiveness, few serious wound problems, and no residual hardware (in case of pinning), though it has its technical problems. However, treatment of choice for calcaneal fracture should be individually tailored and compartmentalized according to type of fracture, patient and surgeon.

Conflict of interest:

The writers report no conflicts of interest.

Authorship contributions:

Authors contributed equally in the study.

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العلاج محدود التدخل لكسور داخل المفصل بعظمة الكعب

أحمد محمداحمد سليم، محمد إبراهيم أبو السعود، محمود صديق حسن

قسم جراحة العظام، كلية الطب، جامعة الأزهر

خلفية البحث: يثير علاج الكسور المفصالية المترحزة بعظمة الكعب تناقضات وتساؤلات عديدة، نتيجةً لاختلاف الباحثين حول العلاج الأمثل لهذا النوع من الكسور وكذلك اختلافهم حول تقييم نتائج ومشاكل العلاج الجراحي أو التحفظي.

الهدف من البحث: تقييم نتائج علاج كسور العقب بواسطة التدخل الجراحي المحدود.

المرضي وطرق البحث: اشتملت مادة البحث على 20 حالة كانوا قد أصيبوا بكسور مفصالية بعظمة الكعب، وقد تم علاجهم بالتنظير الجراحي محدود التدخل بمستشفيات جامعة الأزهر الجامعية خلال الفترة من يوليو 2019 حتى فبراير 2020. وقد تراوحت أعمارهم ما بين 16 وحتى 58 عاماً بمتوسط 35.3 عاماً، وقد اوضحت الدراسة أن السقوط من أعلى كان السبب الرئيسي في 18 حالة (90.0%) وتم متابعتهم لمدة ستة أشهر.

نتائج البحث: كل الكسور تم التئامها في خلال $5,86 \pm 1,74$ أسبوعاً، ووفقاً لمقياس الجمعية الأمريكية لجراحات القدم والكاحل كان متوسط النتيجة 83% (تراوح بين 68 الي 95%).

كانت النتائج مُرضية في 16 حالة (80.0%) (خمسة حالات ممتازة، وإحدي عشرة حالة جيدة، وحالتان بدرجة مقبول، وحالتان بدرجة سيئ).

9 حالات (45%) حدثت لهم خشونة مبكرة في المفصل تحت القنزعي.

وقد نوقشت وقورنت النتائج التي حصلنا عليها مع نتائج من سبق من الباحثين ووجد أنها متشابهة مع كثير منهم.

كما تلاحظ أن النتائج الإكلينيكية لهذا البحث لها علاقة مشتركة ذات قيمة إحصائية معنوية مع كل من عمر المصاب ونوع الكسر حسب تقسيم ساندرز

ودرجة إزاحة واسترجاع زاويتي بوهلر وجيسان، ووقت ما قبل الجراحة وكذلك درجة إزاحة عرض وارتفاع العظمة، كما تلاحظ أيضاً أن هذه النتائج الإكلينيكية لها علاقة مشتركة ولكن ليست ذات قيمة إحصائية معنوية مع كل من نوع المصاب ذكر أم أنثى، وطبيعة عمله، كما وجد أن نوع الكسر حسب تصنيف ساندرز له علاقة مشتركة ذات قيمة إحصائية معنوية بنتائج البحث حيث أن كسور النوع الثاني قد أعطت نتائج أفضل من النوع الثالث وهذا يعني كلما زادت درجة التفتت كلما كانت النتائج أسوأ.

الاستنتاج: العلاج الناجع لكسور عظام الكعب المفصالية لازال محلاً للتساؤلات والنقد.

يعد التثبيت الجراحي محدود التدخل خياراً جراحياً مناسباً لهذه الكسور وخاصة النوع المفتت منها - حيث الأنسجة الرخوة تكون متضررة -، وذلك لما تحققه هذه الطرق الجراحية من قصر وقت الجراحة و محدودية التداخل وعدم وجود بواقى معدنية بالجسم (كما في حالة استخدام الأسلاك المعدنية) وبالتالي معدل مشاكل ما بعد الجراحة أقل، وإن كانت هذه الطرق تتطلب درجة من المهارة ينبغي أن تتوفر في الجراح.

وعلي كل، فإن العلاج الأمثل لكسور عظمة العقب المفصالية ينبغي أن يُصمَّم ويُفصَّلَ بشكل فردي على حسب طبيعة الكسر والمريض وكذلك الجراح.