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Functional Assessment of Calcaneal Fructures Fixed Minimally Invasive: Comparing between Screws and Wires Technique

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Abstract

Background: The goal of therapy for calcaneal fractures is the elimination of pain and restoration of normal foot shape and walking ability. The occurrence of wound complications is a serious concern in treating calcaneal fractures.

Aim of Study: The purpose of the present study was to describe and evaluate the functional outcome of a modified minimally invasive technique for the treatment of intra-articular fractures of the calcaneus.

Patients and Methods: A prospective randomized study was conducted on 40 patients who had recent calcaneal fractures. Twenty patients undergo minimally invasive fixation through sinus tarsiby cancellous K wires and twenty patients undergo fixation by cancellous screws. The patients were operated on and followed-up at Cairo University in the screws group and El-Haram Hospital in the K.wire group during the period between March 2014 and April 2016.

Results: In the current study regarding follow-up, the duration of follow-up ranged between 6 months and 18 months. Functional assessment was done in our series using the scoring system of the American Foot and Ankle Society Scale for fractures of the calcaneus. This scoring system was recommended by Kitaoka et al. **[1]**, For Pain (40 points), Activity (10 points), Range of motion (14 points), walking distance (5 points), walking surface (5 points), gait abnormality (8 points), Ankle stability (8 points), and Alignment (10 points). The maximum score was 100 points, the result was rated excellent if the score was 90 points or more, good if it was 80 to 89, fair if it was 65 to 79, and poor if it was 64 or less.

Conclusion: We concluded that this minimally invasive technique permitsre building of the articular surface of the posterior facet resulting in decrease drisk of infection and hared wear failure. It is an excellent option for the treatment of displaced intra-articular calcaneal fractures in selected patients despite the frequent need for screw removal following fracture-healing with the advantage of the threaded screws over smooth wires in the preservation of reduction till union as smooth wires biomechanically not designed to distract a collapsed bone as screw.

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Key Words: *Minimally invasive – Calcaneal fracture – Treatment for fracture calcaneus – Intra-articular calcaneus fracture management.*

Introduction

THE most often fractured tarsal bone is the calcaneus, which accounts for 75% of displaced intra-articular fractures. The treatment of such fractures is still debatable **[2]**. Previous research has demonstrated that when treating these fractures, anatomic restoration of the calcaneal morphology and joint congruity is associated with superior functional scores, a reduced incidence of post-traumatic subtalar arthritis, and a lower rate of subsequent subtalar fusion **[3,4]**. Soft tissue damage with disruption of wound healing and necrosis is a common consequence when undergoing open reduction and internal fixation, particularly over when the lateral calcaneal wall is exposed during surgery **[5,6]**.

The rate of skin necrosis has ranged from 2% to 11%, with the soft tissue infection rate ranging from 1.3% to 7% after an extended lateral approach, with reported wound complications in 25% of patients **[7,8]**. To overcome the soft tissue problems in the treatment of complex calcaneus fractures, some investigators have proposed minimally reduction and fixation **[6,9]**. Compared with open procedures, minimally invasive techniques can guarantee good reduction with fewer complications **[9]**. There are four main types of minimally invasive such; Kirschner wire (K-wire)/Steinmann pin leverage for percutaneous fragments reduction **[10,11]**, external fixators used for distraction **[12]**, and then percutaneous procedures are used to stabilize them **[13]**, Ligamentotaxis followed by percutaneous screw fixation **[14]**, and the sinus tarsi strategy. These maneuvers are technically challenging in terms of achieving anatomic reduction and stable

fixation, and they typically require indirect reduction using ligamentotaxis and a variety of other maneuvers such as pins, periosteal elevators, laminar spreaders, or bone punches to achieve reduction under the guidance of an intraoperative image intensifier **[15-17]**.

The reduction's quality should be validated intraoperatively using image intensifier pictures, particularly Broden's views to evaluate the articular surfaces of the posterior facet, and postoperatively with standard radiographs and computed tomography (CT) scans **[18]**.

We aim to evaluate the functional and radiological outcome of intraarticular calcaneal fractures fixed minimally invasive by either K wires or screws.

Patients and Methods

A prospective randomized study was conducted on 40 patients who had a recent calcaneal fracture. Twenty patients undergo minimally invasive fixation through sinus tarsi by cancellousK wires and twenty patients undergo fixation by cancellous screws. The patients were operated on and followed up at Cairo University in the screws group and El-Haram Hospital in the K.wire group during the period between March 2014 and April 2016.

The youngest patient was 20 years old and the eldest was 50 years, with an average of 35 years. Fig. (1) shows the distribution of patients in the different age groups in correlation with the sex of patients. Out of 40 cases in our series, 24 cases (60%) were males and 16 cases (40%) were females.

Mechanism of injury: The major cause of injury in this series was falls from height in 36 cases (90%) followed by motor vehicle accidents in 4 cases (10%) of cases. 20 patients (50%) had right-sided fractures, while 16 patients (40%) had left-sided fractures. Bilateral fracture calcaneus was seen in 4 patients (10%).

- Case 1: Bilateral, left side was operated.
- Case 4: Bilateral, the right side was operated.
- Case 20: Bilateral, left side was operated.
- Case 21: Bilateral, left side was operated.

Associated injuries: 36 cases (90%) had no associated injuries, while 4 cases (10%) had associated orthopedic injuries. The associated orthopedic injuries included the following: Fracture spine at the level of L1 vertebra, fracture neck right femur, fracture spine at the level of L1 vertebra, and right Colle's fracture.

This study will be done on patients with the following criteria: (1) Age: Adult patients (average age 20-50 years old), (2) Mode of trauma: Falling from height and motor vehicle accidents, and (3) Fracture: Recent (less than 3 weeks), Intra-articular, and Type II & III by Sanders classification. The exclusion criteria are: (1) Patient is unfit for surgery, (2) Old and malunited fractures, and (3) Highly comminuted fractures.

Pre-operative assessment:

For every case, the pre-operative clinical data were recorded. These included the name-age-sex of the patient, the side affected, and the mechanism of injury. The foot has to be examined, and the skin was inspected for possible ecchymosis and abrasions. These patients were initially treated with elevation, compressive bandage to avoid the development of skin blisters which interferes with surgical intervention, waiting for the time of surgery delayed to allow soft-tissue swelling to resolve enough, until swelling adequately dissipated, as indicated by a positive wrinkle test. For every patient, the following were done including (1) Pre-operative X-rays and (2) Pre-operative CT: For Sanders classification.

Operative technique:

Three patients were operated upon under general anesthesia due to associated spine injuries or colle,s fracture which was 3 cases, and mostly under spinal anesthesia. The patient was placed in the lateral decubitus position because it facilitates the lateral approach used in our series (the nonoperative down limb lies with the knee flexed and the operative up limb straight). Protective padding was placed beneath the contralateral limb to protect the peronealnerve, a pillow is placed between the legs. The c-arm monitor was set opposite the operating surgeon. The bony landmark is lateral malleolus and base 4^{th} MTB. The short lateral incision (4-5cm long) was made from the tip of the lateral malleolus to the level of the calcaneocuboid joint in a line strait towards the base of the 4^{th} metatarsal.

Proximally, we expose the interval between the peroneal tendons and the sinus fat pad is entered, carefully persevering the integrity and the dorsal attachments of the fat pad. Distally, the fascia of the extensor brevis muscle is incised longitudinally in the line with the skin incision, and the muscle split in line with its fibers as far as the calcaneocuboid joint if necessary. The resulting window gives access to the posterior facet, the anterior

process, and the calcaneocuboid joint. Then we remove the lateral wall piece with an osteotome and clean the fracture site. In addition, we mobilize the intra-articular piece and reduce the tuberosity and then the posterior facet.

For fixation, we use 4mm cancellous screws to fix the fracture through the subchondral bone. Then we place the screw into the sustentaculumtali. Two parallel screws are directed upwards to end with their tips in the posteromedial and the posterolateral joint fragment about 5mm short of the joint. Two additional parallel screws are directed into the dorsal portion of the anterior process of the calcaneum. Minimal invasive fixation by k.wire.

First, perform preparation & positioning of the patient as described previously. A lateral incision of 2cm was made as an accessible entry point for insertion of the periosteal elevator by which the articular fragment was elevated into anatomic configuration. K wire was inserted from the same direction of the major axis of calcaneus parallel to the reduced posterior facet into the cuboid the same procedure is used to insert the second wire in the same direction and parallel to the first.

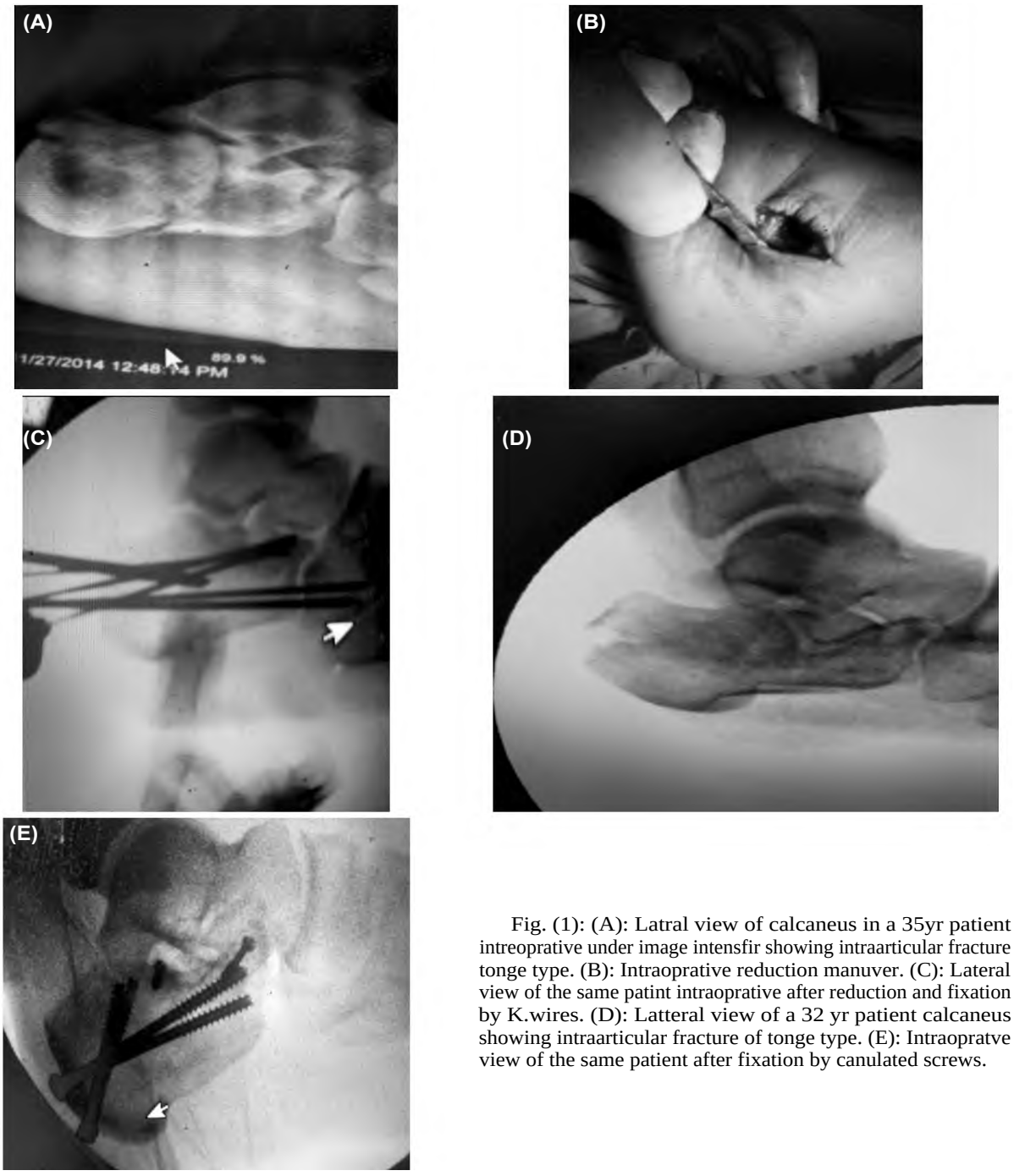

Fig. (1): (A): Latral view of calcaneus in a 35yr patient intreoprative under image intensfir showing intraarticular fracture tonge type. (B): Intraoprative reduction manuver. (C): Lateral view of the same patint intraoprative after reduction and fixation by K.wires. (D): Latteral view of a 32 yr patient calcaneus showing intraarticular fracture of tonge type. (E): Intraopratve view of the same patient after fixation by canulated screws.

Additional elevation of the posterior facet can be done using the 2 wires as an elevator with the cuboid as a fulcrum. The reduction of the posterior facet should be checked in Broden views. Acting on the lateral wall 2 K-wires was introduced until sustentaculumtali which usually not have been dislocated in most calcaneal fractures because of intact ligaments. If there is a depression other fragments can be elevated and fixed by another wire which is preferred to be arranged conically.

During the closure, we remove the temporarily fixing K-wires and the 3 K-wires which are used for exposure. Also, we consider a deep small vacuum drain that exits in a safe internervous zone in the sinus tarsi. The wound is closed by careful reapproximation of the divided fascia and interval.

The whole number of patients was recalled for assessment of the final results of the operation. X-rays were done on the 3rd, 6th, and 12th postoperative months. Standard views (lateral and axial views) were sufficient to follow-up the patients. In the current study regarding follow-up, the duration of follow-up ranged between 3 months and 18 months. Functional assessment was done in our series for 40 cases using the scoring system of the American foot and ankle society scale for fractures of the calcaneus. This scoring system was recommended by Kitaoka et al., **[1]**. The maximum score was 100 points, the result was rated excellent if the score was 90 points or more, good if it was 80 to 89, fair if it was 65 to 79, and poor if it was 64 or less. The duration of follow-up ranged between 6 months and 18 months.

Data analysis:

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 24. Data were summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Comparisons between quantitative variables were done using the non-parametric Mann-Whitney test. For comparison of serial measurements within each patient, the non-parametric Wilcoxon signed-rank test was used (Chan, 2003a). For comparing categorical data, Chi-square (I^2) test was performed. The exact test was used instead when the expected frequency is less than 5 (Chan, 2003b). *p*-values less than 0.05 were considered statistically significant **[19]**.

Results

In the current study regarding follow-up, the duration of follow-up ranged between 6 months and 18 months. Functional assessment was done in our series using the scoring system of the American Foot and Ankle Society Scale for fractures of the calcaneus **[1]**. This scoring system was recommended by Kitaoka et al., **[20]**, For Pain (40 points), Activity (10 points), Range of motion (14 points), walking distance (5 points), walking surface (5 points), gait abnormality (8 points), Ankle stability (8 points), and Alignment (10 points). The maximum score was 100 points, the result was rated excellent if the score was 90 points or more, good if it was 80 to 89, fair if it was 65 to 79, and poor if it was 64 or less.

According to the American Foot and Ankle Society Sale for fractures of the calcaneus **[1]**, the result in Group A was in the first measurement after 6 months: Good in 4 cases (20%), fair in 10 cases (50%), and poor in 6 cases (30%). The second measurement at 12 months was: Excellent in 2 cases (10%), good in 4 cases (20%), fair in 12 cases (60%), and poor in 2 cases (10%). In the third measurement: Excellent in 3 cases (15%), good in 9 cases (45%), fair in 7 cases (35%), and poor in one case (5%). The results of Group B were the first measurement after 6 months good in 2 cases (10%), fair in 14 cases (70%), and poor in 4 cases (20%). After 12 months, results were excellent in one case (5%), good in 9 cases (45%), fair in 9 cases (45%), and poor in one case (5%). After 18 months the results were excellent in 3 cases (15%), good in 15 cases (75%), fair in one case (5%), and poor in one case (5%).

The duration of delay until surgery ranged from 1 day to 16 days with an average of (8.5 days). The time of weight bearing in our study ranged from 12th to 16th postoperative weeks.

In the current study according to statistical studies after about 18 months of follow-up mean of hindfoot pain was 30.50 points in group A and 31.50 points in group B. Mean of activity in group A 8.80 and 9.55 in group B. Mean of walking distance in group A 4.15 and 4.10 in group B. Mean of walking surface in group A 3.80 and 4.10 in group B. Mean of Gait abnormality in group A 8.00 and 8.00 in group B. Mean of motion in group A 11.20 and 12.95 in group B. Mean of stability in group A 8.00 and 7.80 in group B. Mean of alignment in group A 8.30 and 8.30 in group B. There was a statistically significant in group A through follow-up from 6 to 18 months in Gait abnormality, walking surface, walking distance, activity, pain, and results of clinical assessment.

Complications:

There are 2 cases in group A complaining of osteodystrophy, one case complicated with superficial infection, two cases developed mild to moderate subtalar arthritis, and one case has complicated hindfoot flatteningvalgus heel, and persistent pain ended by subtalar arthrodesis.

In group B there are two cases complicated with peroneal tendon impingement and one case complicated with manifest subtalar OA ended by subtalar arthrodesis.

Radiological assessment:

In group A: The average percentage of correction of Bohler's angle was excellent (100%) in 13 cases, good (85%) in 3 cases, and fair (75%) in 4 cases.

In group B: The average percentage of correction of Bohler's angle was excellent (100%) in12 cases, good (85%) in 4 cases, and fair (75%) in 4 cases.

After 6, 12, and 18 months of follow-up the results of both groups were statistically analyzed and tabulated showing statically insignificant differences between the two groups as shown in Tables (1-3). Results of clinical assessment according to American Foot and Ankle Society Scale in our series after three consecutive measurements every 6 months to the last visit were tabulated showing statically insignificant differences between groups as shown in Table (4). By comparison between results after 6 months and after 18 months in group A shows statical significance in gait, walking surface, distance,pain, and activity as shown in Table (5). By comparison between results after 6 months and after 18 months in group B shows statical significance in motion, gait, walking surface and distance,pain activity, andclinical assessment in such group as shown in Table (6). The relation between changes in alignment scores, stability, gait, and walking on the uneven ground of the two groups during follow-up was exhibited in a diagram showing statically insignificant differences as shown in Fig. (2).

The relation between changes in walking distance, activity, clinical assessment, and pain of the two groups during follow-up was exhibited in a diagram showing statically insignificant differences as shown in Fig. (3). The relationship between changes in the motion of the two groups during follow-up was exhibited in a diagram showing statical significant differences in the result of group B patients as shown in Fig. (4,5).

Table (1): Statical comparative study between the two groups after 6 months of follow-up.

	Group A					Group B					*p*-value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
- Alignment (after 6 months)	8.40	.82	8.00	8.00	10.00	8.00	.00	8.00	8.00	8.00	.289
- Stability (after 6 months)	8.00	.00	8.00	8.00	8.00	8.00	.00	8.00	8.00	8.00	1.000
- Motion (after 6 months)	9.45	3.43	7.00	7.00	14.00	7.70	2.15	7.00	7.00	14.00	.183
- Gait abnormality (after 6 months)	5.60	2.01	4.00	4.00	8.00	6.60	1.96	8.00	4.00	8.00	.183
- Walking surface (after 6 months)	3.00	.00	3.00	3.00	3.00	3.00	.00	3.00	3.00	3.00	1.000
- Walking distance (after 6 months)	3.50	.89	4.00	2.00	4.00	3.20	1.01	4.00	2.00	4.00	.429
- Activity (after 6 months)	7.15	1.53	7.00	4.00	10.00	7.30	.92	7.00	7.00	10.00	.841
- Pain (after 6 months)	25.00	5.13	25.00	20.00	30.00	27.50	4.44	30.00	20.00	30.00	.183
- Results of clinical assessement (after 6 months)	70.15	9.21	69.00	56.00	87.00	71.30	6.66	72.00	59.00	82.00	.565

Table (2): Statical comparative study between groups after 12 months.

	Group A					Group B					*p*-value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
- Alignment (after 12 months)	8.20	.62	8.00	8.00	10.00	8.10	.45	8.00	8.00	10.00	.799
- Stability (after 12 months)	8.00	.00	8.00	8.00	8.00	8.00	.00	8.00	8.00	8.00	1.000
- Motion (after 12 months)	9.10	3.29	7.00	7.00	14.00	10.15	3.57	7.00	7.00	14.00	.429
- Gait abnormality (after 12 months)	7.20	1.64	8.00	4.00	8.00	7.80	.89	8.00	4.00	8.00	.429
- Walking surface (after 12 months)	3.40	.82	3.00	3.00	5.00	3.70	.98	3.00	3.00	5.00	.429
- Walking distance (after 12 months)	3.80	.83	4.00	2.00	5.00	3.95	.51	4.00	2.00	5.00	.799
- Activity (after 12 months)	8.20	1.51	7.00	7.00	10.00	8.35	1.53	7.00	7.00	10.00	.799
- Pain (after 12 months)	28.50	3.66	30.00	20.00	30.00	29.50	2.24	30.00	20.00	30.00	.602
- Results of clinical assessement (after 12 months)	76.40	8.34	75.00	61.00	90.00	79.55	6.44	79.00	61.00	90.00	.134

Table (3): Statical comparative study between groups after 18 months.

	Group A					Group B					*p*-value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
- Alignment (after 18 months)	8.30	.73	8.00	8.00	10.00	8.30	.73	8.00	8.00	10.00	1.000
- Stability (after 18 months)	8.00	.00	8.00	8.00	8.00	7.80	.89	8.00	4.00	8.00	.799
- Motion (after 18 months)	11.20	3.52	14.00	7.00	14.00	12.95	2.56	14.00	7.00	14.00	.183
- Gait abnormality (after 18 months)	8.00	.00	8.00	8.00	8.00	8.00	.00	8.00	8.00	8.00	1.000
- Walking surface (after 18 months)	3.80	1.01	3.00	3.00	5.00	4.10	1.02	5.00	3.00	5.00	.429
- Walking distance (after 18 months)	4.15	.67	4.00	2.00	5.00	4.10	.64	4.00	2.00	5.00	.799
- Activity (after 18 months)	8.80	1.51	10.00	7.00	10.00	9.55	1.10	10.00	7.00	10.00	.183
- Pain (after 18 months)	30.50	3.94	30.00	20.00	40.00	31.50	3.66	30.00	30.00	40.00	.620
- Results of clinical assessement (after 18 months)	82.75	8.78	83.50	63.00	100.00	86.00	7.57	87.00	63.00	100.00	.157

Table (4): Statical comparative study in end results of clinical assessment of the two groups.

	Group A		Group B		*p*-value
	Count	%	Count	%	
Results of clinical assessement (after 6 months):					
Poor	6	30.0	4	20.0	0.489
Fair	10	50.0	14	70.0	
Good	4	20.0	2	10.0	
Excellent	0	0.0	0	0.0	
Results of clinical assessement (after 12 months):					
Poor	2	10.0	1	5.0	0.505
Fair	12	60.0	9	45.0	
Good	4	20.0	9	45.0	
Excellent	2	10.0	1	5.0	
Results of clinical assessement (after 18 months):					
Poor	1	5.0	1	5.0	0.071
Fair	7	35.0	1	5.0	
Good	9	45.0	15	75.0	
Excellent	3	15.0	3	15.0	

Table (5): Statical analysis of parameter changes during follow-up in group A.

Group A	After 6 months					After 18 months					*p*-value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
- Alignment	8.40	.82	8.00	8.00	10.00	8.30	.73	8.00	8.00	10.00	0.655
- Stability	8.00	.00	8.00	8.00	8.00	8.00	.00	8.00	8.00	8.00	1
- Motion	9.45	3.43	7.00	7.00	14.00	11.20	3.52	14.00	7.00	14.00	0.059
- Gait abnormality	5.60	2.01	4.00	4.00	8.00	8.00	.00	8.00	8.00	8.00	0.001
- Walking surface	3.00	.00	3.00	3.00	3.00	3.80	1.01	3.00	3.00	5.00	0.005
- Walking distance	3.50	.89	4.00	2.00	4.00	4.15	.67	4.00	2.00	5.00	0.025
- Activity	7.15	1.53	7.00	4.00	10.00	8.80	1.51	10.00	7.00	10.00	0.001
- Pain	25.00	5.13	25.00	20.00	30.00	30.50	3.94	30.00	20.00	40.00	0.001
- Results of clinical assessement	70.15	9.21	69.00	56.00	87.00	82.75	8.78	83.50	63.00	100.00	<0.001

Table (6): Statical comparative study of results during follow-up in group B.

Group B	After 6 months					After 18 months					*p*-value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
- Alignment	8.00	.00	8.00	8.00	8.00	8.30	.73	8.00	8.00	10.00	0.083
- Stability	8.00	.00	8.00	8.00	8.00	7.80	.89	8.00	4.00	8.00	0.317
- Motion	7.70	2.15	7.00	7.00	14.00	12.95	2.56	14.00	7.00	14.00	<0.001
- Gait abnormality	6.60	1.96	8.00	4.00	8.00	8.00	.00	8.00	8.00	8.00	0.008
- Walking surface	3.00	.00	3.00	3.00	3.00	4.10	1.02	5.00	3.00	5.00	0.001
- Walking distance	3.20	1.01	4.00	2.00	4.00	4.10	.64	4.00	2.00	5.00	0.01
- Activity	7.30	.92	7.00	7.00	10.00	9.55	1.10	10.00	7.00	10.00	<0.001
- Pain	27.50	4.44	30.00	20.00	30.00	31.50	3.66	30.00	30.00	40.00	0.005
- Results of clinical assessement	71.30	6.66	72.00	59.00	82.00	86.00	7.57	87.00	63.00	100.00	<0.001

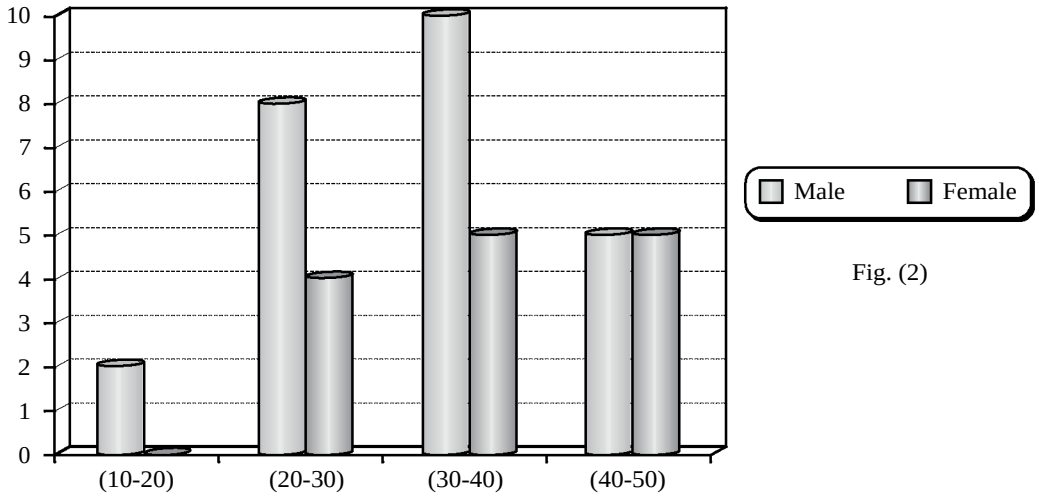

Fig. (2)

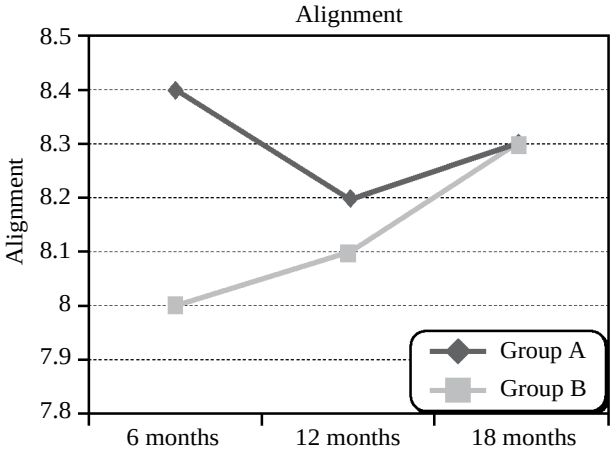

Fig. (3-A): Alignment during the three visits of follow-up in the two groups.

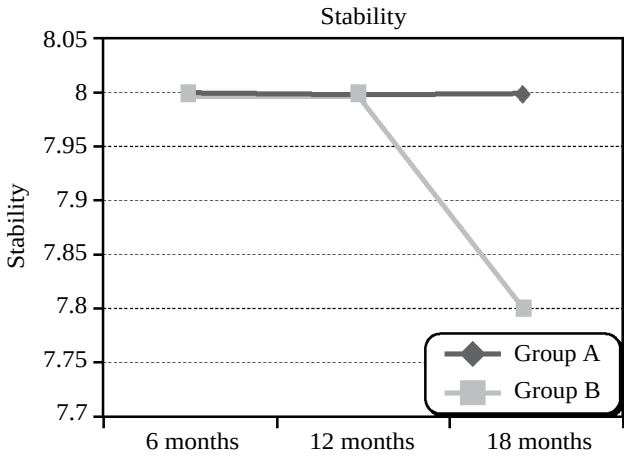

Fig. (3-B): Stability of the two groups during follow-up.

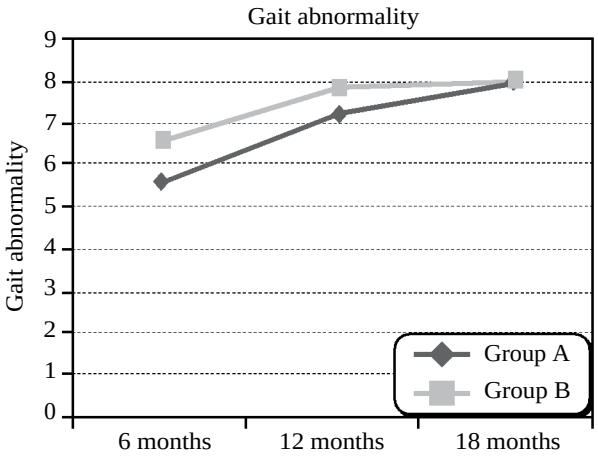

Fig. (3-C): Operative change in gait during the three visits of follow-up.

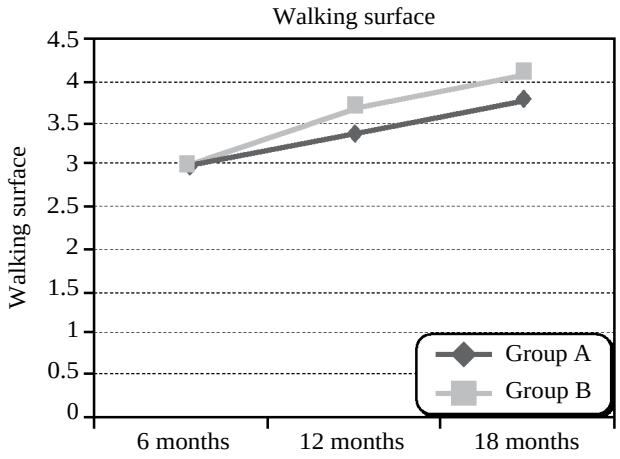

Fig. (3-D): Postoperative ability of walking on uneven ground in our series

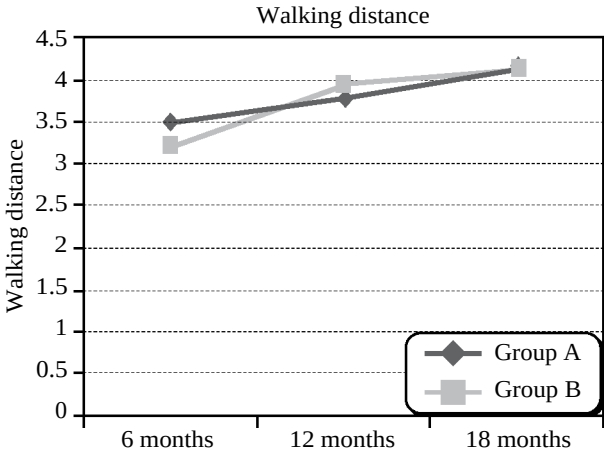

Fig. (4-A): Postoperative distance could be walked by our patients

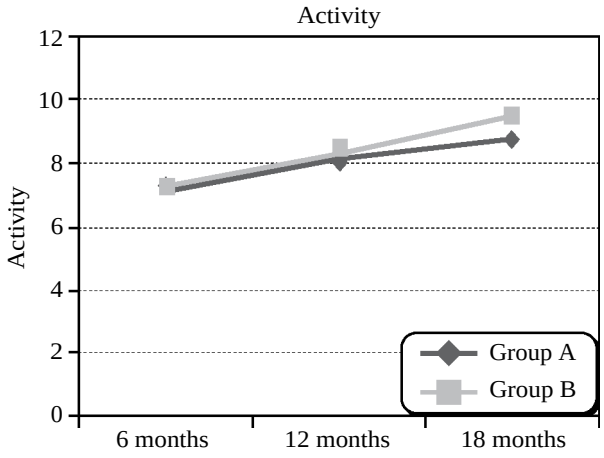

Fig. (4-B): Postoperative return to daily activities in our series during follow.

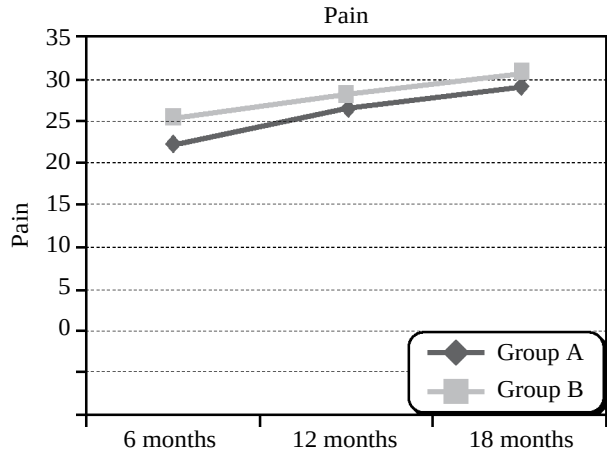

Fig. (4-C): Postoperative pain improvement in our series during follow-up.

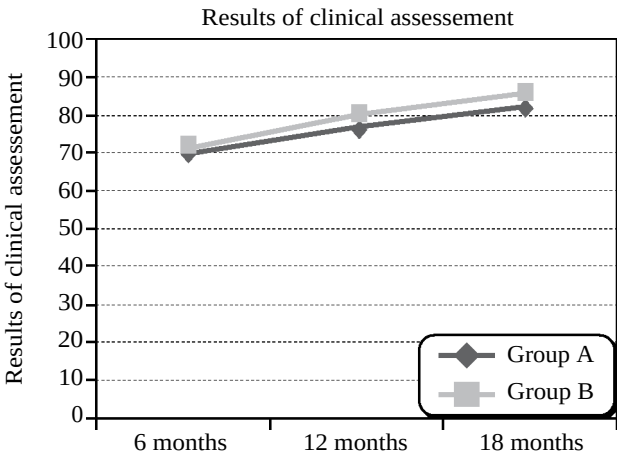

Fig. (4-C): Postoperative pain improvement in our series during follow-up.

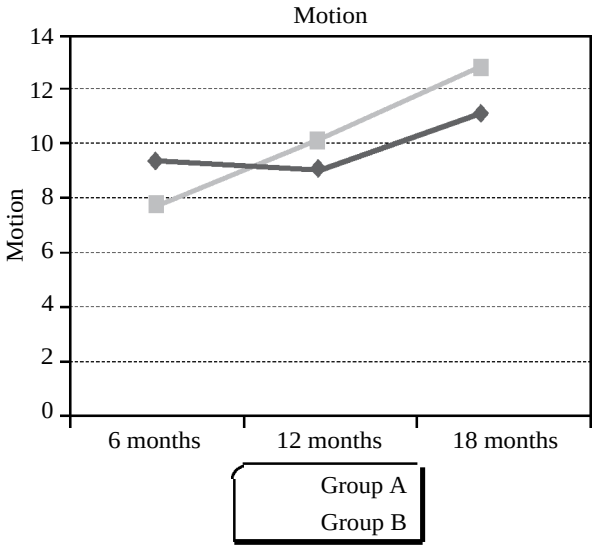

Fig. (5)

Discussion

Surgery for calcaneal fractures aims to restore fractures and articular congruity, offer stable fixation, and restore mobility as soon as possible after surgery **[21-23]**. For the internal fixation of calcaneal fractures, a variety of implants, including plate-screw system (PSS), Kirschner wires (K-wires), cannulated screws (CS), and absorbable screws (AS), have been utilized effectively **[24,25]**. Despite the fact that the stability of the fixation plays a crucial role in preserving the reduction's position, plate selection and implant type were the major topics of prior biomechanical investigations **[26,27]**.

In our study, we presented minimally invasive techniques for the management of intraarticular, dislocated calcaneus fractures and were able to

produce results comparable to open techniques with a lower incidence of complications. We found that after 6, 12, and 18 months of follow up the results of both groups showed statically insignificant variation between both groups. Results of clinical assessment according to American Foot and Ankle Society Scale after three consecutive measurements every 6 months to the last visit showed statically insignificant differences between groups. By comparison between results after 6 months and after 18 months in group A and group B show statical significance in gait, walking surface, distance, pain, and activity. The relation between changes in alignment scores, stability, gait, walking distance, activity, clinical assessment, pain, and walking on the uneven ground of the two groups during follow-up was exhibited in a diagram showing statically insignificant differences. The relationship between changes in the motion of the two groups during follow-up was exhibited in a diagram showing statistically significant differences in the result of group B patients.

A technique similar to ours was done between June 2007 and August 2012 in a previous prospective cohort study by Gomaa et al., **[28]**. They included 52 patients with a total of 61 closed intraarticular calcaneal fractures. Patients were treated with minimally invasive techniques. They used a visual analogue scale (VAS) to evaluate the pain intensity. They finally compared their results to other (ORIF) lateral extensile approach studies and concluded that minimally invasive techniques substantially reduced wound complication rates without compromising the clinical outcome as Böhler s angle and geometry of the calcaneus were returned to the normal anatomical proportions. Furthermore, future screws removal would be performed easily through small incisions without major soft tissue damage and with less surgical procedure time that may be conducted under local anesthesia. Thus it seems that the described minimally invasive technique is a valuable alternative option for the management of intraarticular calcaneal fractures. Differences between their study and our trial were the exclusion of Sanders type VI in our study, range of age which was any adult patient, and mode of trauma which was fall from height in all cases.

Wang et al., **[29]** conducted a systematic review and meta-analysis in the Chinese literature comparing percutaneous poking reduction and ORIF. Their results regarding the percutaneous group showed a statistically significant reduction in postoperative wound complications when compared to ORIF. Furthermore, they found no difference between both groups in the angle of Gissane, Bohler's angle, or functional outcomes. Biz et al., **[2]** conducted consecutive series of 104 calcaneal fractures treated with either percutaneous fixation with screws or Kirschner wires or ORIF. They included 37 (42.5%) Sanders II, 31 (35.7%) Sanders III, and 19 (21.8%) Sanders IV. The overall results favored the ORIF group regarding Bohler's angle, VAS score, Maryl and Foot Scale (MSF), American Orthopaedic Foot and Ankle Society hindfoot scale (AOFAS), and Short-Form 36 (PCF). Concerning the percutaneous group, they found that fixation with screws is superior to fixation with wires.

Shams et al., **[30]** performed a retrospective comparative study that included seventy patients with displaced intraarticular calcaneal fractures. They found that with minimally invasive reduction and fixation techniques, it is possible to treat displaced intraarticular calcaneal fractures with excellent functional and radiographic results and high patient satisfaction. K-wires have the benefit of requiring less time during surgery than cannulated screws.

When the calcaneal fractures were treated with K-wires, cannulated screws, and plate-screw system, the overall stiffness remained constant. The quality of the bone has a significant impact on the stability of the absorbable screws fixation in both the vertical and anterior-posterior planes. Greater strength and pull-out resistance should be incorporated into the design of AS for fracture fixing **[31]**.

Contrary to our study, a retrospective study conducted by Ying et al., **[7]** included a total of 162 patients (176 feet) with calcaneal fractures. The overall complications that occurred in operative fixation of calcaneal fractures were 47 (26.704%). Surgical site infection (SSI) occurred in seven fractures (3.977%), while deep infections and superficial infection occurred in three (1.704%) and four (2.273%) fractures, respectively. Necrosis was noted in all those twelve fractures (6.8%). They reported that the pain was the most commonly faced complication. They reported that malunion was found in five fractures (2.841%), fixation loss in four fractures (2.272%), and nonunion in two fractures (1.136%).

Another retrospective cohort study conducted from January 2014 to June 2017 by Wang et al., **[32]** included 681 patients with calcaneus fractures who were treated by ORIF. The fractures occurred due to different causes including high-energy trauma, vehicle collisions, falls from height, and sports injuries. The overall SSI was found in 66 out of

681 patients (9.7%). The incidence of deep and superficial infections was 2.9% and 6.8%, respectively. Moreover, they demonstrated that intraoperative hypothermia, ASA classification higher than 3, and open fractures were associated with more incidence of wound complications. SSI may occur at any time after the operation from 3 days up to 107 days. The mean time for its occurrence was 5 days. The most commonly found organism was Staphylococcus aureus.

Results in this series are comparable to several recent large studies concerning infection, wound problems, and secondary subtalararthrodeses. Bezes et al., **[33]** reported an infection rate of 2.7% in 257 intra-articular fractures of the calcaneous fixed with third tubular plate and screws. Ten percent had superficial necrosis of the skin. Six patients (2.7%) required secondary arthrodesis of the subtalar joint. In 157 intra-articular fractures treated by Colburn et al., **[34]** the most common complication was wound edge necrosis in (8.3%). Infection occurred in 1.9% and four patients (3.3%) required subtalar arthrodesis.

We concluded that the minimally invasive technique helps in rebuilding the articular surface of the posterior facet causing decreased risk of infection and hared wear failure. It is considered an excellent option for the management of displaced intra-articular calcaneal fractures. But the frequent need for screw removal after the healing of the fracture with the advantage of threaded screws over smooth wires in the preservation of reduction till union as smooth wires biomechanically not designed to distract a collapsed bone as screws.

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نتائج التدخل الجراحى المحدود لكسور عظمة العقب الممتدة داخل المفصل والمقارنة بين التثبيت بالمسامير والأسلاك المعدنية

مازال علاج كسور عظمة العقبال جراحياً أو غير جراحياً محل خلاف. حيث أن هناك عديد من الجراحين من يفضل العلاج التحفظى الغير جراحى بالرغم من وجود العديد من الأبحاث الحديثة التى أوضحت النتائج المرضية لعلاج كسور عظمة العقب برد الكسر على الفتوح مع التثبيت الداخلى للكسر.

مازال العديد من الجراحين يستخدم العلاج التحفظى لعلاج كسور عظمة العقب وذلك لعدم الألفة مع الخطوات الجراحية أو خوفاً من المضاعفات الجراحية إن مشكلات الجلد الناتجة عن الفتح الممتد كإلتهابات الجرح وتفرز الجلد تنعدم تقريباً فى الفتح المحدد لكسور عظمة العقب المفصلية. وفى دراستنا أربعون مريضاً من البالغين (ما بين ٢٠ إلى ٥٠ عاماً) ٢٤ منهم ذكور و ١٦ إناث تم التعامل معهم جراحياً بالتدخل الجراحى المحدود. عشرون مريضاً منهم كانوا يعانون من الإصابة بالجانب الإيمن وستة عشر بالجانب الايسر وأربعة بكلا الطرفين. حضروا إلى المستشفى يعانون من تلك الكسور أما نتيجة السقوط من ارتفاعات متفاوتة فى ٣٦ مريضاً أو حوادث طرق فى أربعة مرضى. تفاوتت إصابتهم ما بين كسور من الدرجة الثانية فى ٢٨ مريضاً أو الدرجة الثالثة فى ١٢ مريضاً بتقسيم العالم ساندر. بالتدخل الجراحى المحدود تم تثبيت هذه الكسور فى عشرين مريضاً منهم بالأسلاك المعدنية. الملساء والآخرون تم تثبيت كسورهم بواسطة مسامير معدنية كاملة الشرشرة.

وبمتابعة هؤلاء المرضى لمدة عام ونصف ومناظرتهم كل ستة أشهر تم فيها تحليل نتائجهم إحصائياً وجدو لتها للوقوف على مزايا وعيوب كل طريقة فى المجمو عتين موضوع البحث و ميزة التدخل الجراحى المحدود بوجه عام على غيرة من الطرق فى تثبيت عظمة العقب وبعد هذه الدراسة خلصنا إلى: ٩٠٪ من المرضى الذين تم تثبيت كسورهم بالمسامير تماثلوا للشفاء بصورة رائعة و ٥٪ منهم كانت نتائجهم مرضية و ٥٪ خضعوا لتدخلات جراحية لاحقة حيث ظلوا يعانون من مضاعفات بعد الجراحة. ٦٠٪ من المرضى الذين تم تثبيت كسورهم بواسطة الاسلاك المعدنية تماثلوا للشفاء بصورة رائعة و ٣٥٪ منهم كانت نتائجهم مرضية و ٥٪ منهم كان لديهم مضاعفات.

وأخيراً استنتجنا من هذه الدراسة أن تثبيت كسور عظمة العقب الممتدة داخل المفصل بالتدخل الجراحى المحدود طريقة مصالية ورائعة حيث يتم من خلالها رد المفصل وتثبيته بعناية وتلافى مضاعفات الجلد والأنسجة الرخوة الناتجة عن الفتح الجراحى الممتد.