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Original Article

OPEN REDUCTION WITH CALCANEAL LOCKING PLATE FIXATION VS PERCUTANEOUS CANNULATED SCREWS FOR THE TREATMENT OF DISPLACED INTRA-ARTICULAR CALCANEAL FRACTURES

Khalaf Fathy Elsayed Ahmed[(*)], Hossam El-Azab, Abdelrahman Hafez Khalefa, Ashraf Rashad Marzouk, Ahmed Abdelaal

Orthopaedics and trauma surgery dept., Faculty of Medicine, Sohag Univ., Sohag, Egypt

[*]E-mail: khalaffathy@med.sohag.edu.eg

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Abstract

Background:-*Minimally invasive surgery in treatment of DIACFs has become popular among the international orthopaedics community to overcome the soft tissue complications associated with the standard ORIF through extensile lateral approach.* ***Objective:-****The current study's objective was evaluation of the functional and radiographic outcomes of closed reduction and percutaneous cannulated screws fixation of DIACFs compared with the standard ORIF by calcaneal locked plate using an extensile lateral approach.* ***Patients and methods:-****35 patients with unilateral DIACFs from June 2019 to May 2022 were retrospectively reviewed. The Percutaneous cannulated screws group included 17 patients, and the ORIF group included 18 patients. Radiographic assessment included calcaneal height, length, and width, Böhler's angle, angle of Gissane, and posterior facet inclination angle. Clinical assessment by the AOFAS ankle-hindfoot score and the visual analog pain score was done.* ***Results:-****No appreciable differences were noticed in the pre-operative and post-operative radiographic parameters measurements, and the final AOFAS ankle-hindfoot scores between the two groups. The pain scores were lowered significantly in the percutaneous cannulated screws group, (P = 0.0364).* ***Conclusion:-****Percutaneous cannulated screws had achieved radiographic and functional outcomes comparable to ORIF in management of DIACFs with lower complication rates.*

Keywords: *Percutaneous cannulated screws, calcaneal locked plate, calcaneal fractures.*

1. Introduction

Calcaneus is an odd-shaped bone with a complex anatomy. It provides a supporting structure for the hind-foot. Fractures of calcaneus represent 1-2% of all fractures, 60% of tarsal fractures, and 75% of calcaneal fractures are intra-articular occurring in young active males [1,2]. The treatment options for DIACFs have varied from conservative to aggressive open reduction and internal fixation (ORIF) [3,4]. ORIF techniques are the gold standard treatment for DIACFs as they provide good exposure and direct reduction of subtalar joint [3]. However, the higher incidence of soft tissue complications including; wound infections, dehiscence, and skin necrosis up to 30% of cases forced many orthopaedics surgeon to stop using these techniques and to seek other alternatives [5-7]. Minimally invasive surgical (MIS) techniques for treatment of DIACFs had minimized the soft tissue complications, but carried the risk of malreduction in comminuted fractures. MIS include; arthroscopic-assisted fixation, Ilizarov fixation [8], interlocking calcaneal nails [9], sinus

tarsi approach [10], percutaneous screws, and K-wires [11]. For more disclosure of the optimum treatment of DIACFs, we conducted the current study aiming at assessment of the functional and radiographic outcomes of closed reduction and percutaneous cannulated screws fixation for DIACFs and comparing them with the standard ORIF by calcaneal locked plate using an extensile lateral approach [4].

2. Patients and Methods

2.1. *Patients*

We retrospectively analyzed patients with DIACFs that had been admitted and treated at the trauma unit of Sohag Univ. hospitals between June 2019 and April 2022. The inclusion criteria were adult patients suffered from unilateral closed DIACFs of Sanders type II or III who had been managed surgically with cannulated screws or calcaneal locked plate system within a period of two weeks from injury. The exclusion criteria were skeletally immature patients, patients with open fractures, Sanders type I or IV fractures, previous calcaneal fracture, and patients with follow-up period less than 6 months post-operatively. Totally, 35 patients were involved in the study after application of our mentioned criteria. There were two groups of patients: Percutaneous cannulated screws group and ORIF group. The Percutaneous cannulated screws group included 17 patients: 5 of them were Sanders type II, and 12 of them were Sanders type III. The ORIF group included 18 patients: 6 of them were Sanders type II, and 12 of them were Sanders type III. General data of the patients in the two groups are displayed in tab. (1). The Sohag Faculty of Medicine's Scientific and Ethical Committee gave its approval to this study.

Table (1) General information for the two groups.

Data	Percutaneous cannulated screws group (n=17)	ORIF group (n=18)
Age (years)	37.5 ± 8 (20-58)	38 ± 7.2 (23-61)
Sex		
▪ Males, no (%)	16 (94.1%)	11(61.1%)
▪ Females, no (%)	1 (5.9%)	7(38.9%)
Side affected		
▪ Right	10 (58.8%)	11 (61%)
▪ Left	7 (41.2%)	7 (39%)
Mechanism of injury		
▪ Falling from height	12 (70.6%)	18 (100%)
▪ Motor car accident	5 (29.4%)	0
Sanders classification		
▪ Type II	5 (29.4%)	6 (33.3%)
▪ Type III	12 (70.6%)	12 (66.7%)
Smoking		
▪ Non-smokers	10 (58.8%)	12 (66.7%)
▪ Smokers	7 (41.2%)	6 (33.3%)
Time from injury to surgery (days)	6 ± 4.54 (1-14)	5.07 ± 4.39 (4-14)
Surgical time (min)	57.06 ± 5.88 (45-65)	87.76 ± 5.61 (75-120)
Hospital stays (days)	1.64 ± 0.50 (1-2)	5.71 ± 0.61 (3-7)
Follow up (months)	12.36 ± 3.69 (8-18)	14.53 ± 3.95(12 - 22)

2.2. *Methods*

Antero-posterior foot, axial and lateral hind-foot views were obtained before and after operative interventions. The calcaneal length, width and height, Böhler's angle, angle of Gissane, and posterior facet inclination angle were recorded before and after operative interventions according to previous studies [12]. The measurements were taken by one senior orthopaedics surgeon. Classifications of fractures were

done according to Sanders CT-scan classification system [13]. The clinical outcomes were assessed by the visual analog pain score (VAS) post-operatively [14], and the AOFAS ankle-hindfoot score at the final follow-up [2]. Complications were recorded in the two groups separately.

2.3. *Operative techniques*

For percutaneous cannulated screws group; the injured side was facing up as the patients were placed in the lateral position. The fractures were reduced by Schanz screw, manipulation of the foot to reduce the fracture fragments and compression of the heel between two hands to reduce widening and to evacuate haematoma. If posterior facet was not reduced in some fractures; a 1-2 cm tiny incision was made at the sinus tarsi laterally, and a curved artery forceps or periosteal elevator was subsequently introduced for elevation of the depressed posterior facet fragments. Fixation of the fractures were done by 4.0 mm cannulated screw that is partially threaded with a washer for the reduced posterior facet fragment directed from lateral to medial at subarticular region of posterior facet, and by 7.3 mm partially threaded cannulated screws (32mm threads) with washers directed from the tuberosity fragment to sustentaculum tali and to anterior process of calcaneus. Confirmation of the final screws lengths and positions was done by hindfoot lateral and axial views, fig. (1). For the ORIF group; the extensile lateral approach was used according to previous studies [15,16], fig. (2)

Figure (1) Percutaneous cannulated screws fixation of Sanders type III DIACFs.

Figure (2) Intra-operative photos of the extensile lateral approach with calcaneal locking plate fixation and after completing stitches of the incision.

2.4. *Statistical analysis*

For continuous data, an independent student t-test was employed for comparison of the two groups. Chi-square and Fischer exact tests were used for comparison of categorical data. Statistical significance was defined as a P-value of <0.05. Every statistical analysis was done using SPSS (SPSS 20.0, SPSS Inc., Chicago, IL, USA).

3. Results

3.1. *Radiographic outcomes*

Union was obtained in all fractures of both groups with no significant difference regarding the time needed for union at both groups, *(P= 0.305)*. Calcaneal height, length and width, Böhler's angle, angle of Gissane, and posterior facet inclination angle of both groups were significantly improved postoperatively, but no appreciable differences were found in the pre-operative and post-operative measurements of these parameters between the two groups, tab. (2) & fig. (3).

Table (2) Radiographic parameters for the two groups.

Parameters	Percutaneous cannulated screws group	ORIF group	P-value
Period for union (weeks)	9.5 ± 2.6 (8-12)	10.8 ± 1.5 (8-14)	0.305
Calcaneal height , (mm)			
▪ Pre-op	42.8 ± 3 (39.5-50)	41.7 ± 2 (41.4-51)	0.654
▪ Post-op	44.7 ± 1 (44.3-53)	43.7 ± 1.5 (42 -54)	0.264
Calcaneal length , (mm)			
▪ Pre-op	79 ± 3.5 (72-82)	77.7 ± 7(70-79)	0.324
▪ Post-op	84.6 ± 4.3 (83- 89)	82.8 ± 5.7 (81-90)	0.051
Calcaneal width , (mm)			
▪ Pre-op	52.6 ± 2 (50 - 59)	51.5 ± 1.7 (48-58)	0.0676
▪ Post-op	44.2 ± 1.5 (45 - 53)	43.3 ± 2.5 (46-55)	0.058
Angle of Gissane, (°)			
▪ Pre-op	132 ± 4.5 (114-147)	135 ± 6.4 (96-139)	
▪ Post-op	126 ± 6.1 (120-136)	124 ± 7.5 (110-132)	0.944
Böhler's angle, (°)			
▪ Pre-op	10.7 ± 5.6 ((-12) - 23.5)	11 ± 7.5 ((-11.5) - 22)	0.853
▪ Post-op	28 ± 3.2 (12 - 35)	29.2 ± 6.7 (15 - 38.8)	0.421

Figure (3) Final radiographic follow up of a case with percutaneous cannulated screws (above) & another case with calcaneal locking plate (below).

3.2. *Functional outcomes*

At the final follow-up, the AOFAS ankle-hindfoot score for the percutaneous cannulated screws group was 85.9 ± 5.3 (range 75-100), and that for the ORIF group score was 87.8 ± 3.7 (range 70-100). However the AOFAS scores were slightly better in the ORIF group, no statistically significant differences were detected between the two groups, *(P= 0.0857)*. The visual analog score in the first few days post-operatively for the percutaneous cannulated screws group was 0.84 ± 0.77 (ranged, 0–3), and that for the ORIF group was 1.51 ± 1.32 (ranged, 0-4). The pain scores were significantly lower in the percutaneous cannulated screws group, *(P = 0.0364)*. The time for full weight-bearing was 12 ± 2.1 (10-14) weeks in the percutaneous cannulated screws group, and 12.4 ± 1.7 (12-16) weeks in the ORIF group, with no significant differences were found between the two groups, *(P = 0.421)*, tab. (3).

Table (3) Functional outcomes for the two groups.

Items	Percutaneous cannulated screws group	ORIF group	P-value
The final AOFAS ankle-hindfoot score	85.9 ± 5.3 (75-100)	87.8 ± 3.7 (70-100)	0.0857 (NS)
Post-operative VAS score for pain	0.84 ± 0.77 (0-3)	1.51 ± 1.32 (0-4)	**0.0364 (S)**
Time for full weight-bearing (weeks)	12 ± 2.1 (10-14)	12.4 ± 1.7 (12-16)	0.421
Complications			
▪ Superficial infections	0	1 (5.55%)	
▪ Deep infections	0	1 (5.55%)	
▪ Subtalar arthritis	1 (5.9%)	2 (11.1%)	
▪ Complication rate (%)	(5.9%)	(22.2%)	**0.0051**

3.3. *Complications*

Post-operative infections had occurred in two cases in the ORIF group; one case had superficial infection, the infection noticed one week post-operatively, IV antibiotics with daily dressing was done and this infection completely cured, and the other case had deep infection involving the plate and needed removal for hardware. Post-traumatic arthritis was developed in one case of percutaneous cannulated screws group and in two cases of ORIF group, however, no cases received subtalar arthrodesis in this study. There is significant increase in the complication rate in the ORIF (22.2%) group compared to percutaneous cannulated screws group (5.9%), *(P = 0.0364)*, tab. (3).

4. Discussion

Our study revealed that the AOFAS ankle-hindfoot scores were slightly higher in the ORIF group 87.8 ± 3.7 (ranged, 70-100) compared to the percutaneous cannulated screws group 85.9 ± 5.3 (ranged 75-100), however no statistically significant differences were found among the two groups, *(P = 0.0857)*. Pain scores were significantly lower in the percutaneous cannulated screws group, (*P = 0.0364*). There were no significant differences found between the two groups regarding time of full weight-bearing, *(P = 0.421)*. The radiographic results of our study revealed that calcaneal length, height, and width, Böhler's angle, posterior facet inclination angle and angle of Gissane in both groups were significantly improved post-operatively compared to pre-operative values. However, ORIF group was significantly inferior to percutaneous cannulated screws regarding the hospital stays, length of surgical time and complication rates. Some studies had compared the results of ORIF with the results of MIS techniques in treatment of DIACFs. Peng et al [17], studied 40 patients (45 feet) suffered from DIACFs for evaluation of the reduction of fractures and clinical outcomes of closed reduction and percutaneous fixation using a traction device method compared with traditional ORIF by calcaneal locking plate and screws using an extended lateral

approach, and found that no significant differences in the criteria for reduction of fractures were detected between the open and closed groups *(P > 0.05)*. AOFAS scores for the two groups were 80.29 ± 6.15 and 83.62 ± 6.95 (open vs closed) *(P = 0.0957)*. VAS scores for open and closed groups were 1.5 ± 1.22 and 0.81 ± 0.87 *(P = 0.0364)*. The durations of hospital stay for open and closed groups were 9.63 ± 2.72 days and 6.71 ± 1.85 days *(P = 0.0002)*. Complication rates for open and closed groups were 20.8% (5/24) and 4.8% (1/21) *(P < 0.0001)*. They concluded that, closed reduction and percutaneous fixation with traction device methods for DIACFs may yield comparable reduction results to ORIF and better results in terms of duration of stay, VAS score, and complication rate. Weber et al [18], published the results of 24 patients with Sanders II or III fractures managed by MIS through sinus tarsi approach and screw fixation and compared them with 26 patients treated by ORIF through an extensile lateral approach and plating. They showed anatomic restoration for all patients in both groups. The surgical time was significantly shorter in MIS group versus ORIF group (108 min vs 160 min; *P < 0.001*). The final AOFAS scores were 82.6 in the ORIF group versus 87.2 in the MIS group (*P* = 0.17). The complications of ORIF group included delayed healing of wounds in 1/26 (3.85%), formation of haematoma in 1/26 (3.85%), sural nerve injuries in 2/26 (7.69%), and complex regional pain syndrome in 4/26 (15.4%). The MIS group had no complications regarding healing of wounds, hematoma formation, or sural nerve injuries. They mentioned that the MIS had become their standard manoeuver for DIACFs, secondary to equal functional outcomes, lower complications and shorter duration of operation. Fan et al [19], conducted a meta-analysis to evaluate the therapeutic efficacy of cannulated screw fixation (CSF) versus plate fixation for DIACFs. There were 707 patients involved. They found that no statistically significant difference between the CSF group and the plate fixation group regarding satisfactory AOFAS scores, improvement of Böhler's angle, improvement of Gissane's angle, or the width of the calcaneus. CSF demonstrated a considerable reduction in surgical time and rate of complications compared to plate fixation *(P ≺0.00001)*. They concluded that CSF and plate fixation have the same fixation efficacy and functional outcomes in the management of DIACFs. CSF is better than plate fixation regarding the shorter duration of surgery and lower rate of complications. In the current study, post-operative infections had occurred in 11.2% of cases in the ORIF group, and no wound complications at the percutaneous cannulated screws group. Harvey et al [20], retrospectively reviewed 218 cases with DIACFs managed by ORIF and reported that the overall wound complication rates were (11%), the majority of them were treated by local dressings. Folk et al [21], reported wound complications with ORIF about 25%, with 21% of these wound complications needed operative management. Limitations to our study were; limited numbers of cases, Sanders type IV fractures were not included, the study is a single center one, and lack of follow up CT scan for cases.

5. Conclusion

Percutaneous reduction and cannulated screws had achieved radiographic and functional outcomes comparable to ORIF in management of DIACFs. Percutaneous reduction and cannulated screws had minimal soft tissues damage, shorter surgical time and lower complication rates than ORIF.

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