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Original Article

Treatment of Calcaneal Fracture by Calcaneal Plate

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ABSTRACT

Background: Calcaneal fractures are not uncommon, accounting for 2% and 60.0% of all adult and tarsal fractures, respectively. Its treatment is still controversial.

Aim of the work: To assess results and complications of calcaneal fractures treatment by fixation with calcaneal plate on clinical and radiological basis.

Patients and Methods: A convenient sample of 20 patients, with calcaneal fractures and treated by calcaneal plate fixation were included. They were assessed in preoperative period in a systematic manner. Then, treated with a locking plate. Postoperatively, immediate X-rays, examination of the neurovascular status had been done. Anti-edematous, pain therapy, intravenous antibiotics and anticoagulation medication were administered. All patients had been followed up at 8, 16 weeks after operation and assessed for functional and anatomical state.

RESULTS: According to the American Orthopedic Foot Ankle Society [AOFAS] Ankle-Hindfoot Score, the outcome was excellent [30.0%], good [40.0%], fair [20.0%] and poor [10.0%]. At the last follow-up, Bohler's angle was restored to normal [20°-40°] in 17 feet [85 %] while 3 feet [15 %] was less than normal. Wound infection was seen in [10%], each of varus heel deformity and flexion deformity of big toe was found in one patient [5.0%] and two case had reflex sympathetic dystrophy. Finally, there was no association between fracture type and subtalar arthritis. However, patients with subtalar arthritis had significantly lower AOFAS score when compared to patients with no subtalar arthritis [76.22±6.24 vs 87.0±6.05 respectively, $p < 0.001$].

Conclusion: Displaced calcaneal fractures treated surgically are associated with a relatively better functional outcome, provided that, Bohler's angle was restored to its normal or near normal values.

Keywords: Calcaneal; Plate; Fracture; Bohler's; Intra-articular.

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* Main subject and any subcategories have been classified according to the research topic.

INTRODUCTION

Calcaneal fractures account for 2% and more than of 60.0% of all adult and tarsal fractures, respectively. Extra-articular fractures represent about 30%, while fractures of the anterior process represent 15% and tuberosity avulsion fractures were about 10%. Intra-articular fractures represent about 70% of all adult calcaneal fractures [1].

Displaced fractures of the posterior articular facet [i.e., the subtalar joint] represent the majority of intra-articular fractures. Displaced intra-articular fractures are regularly caused by an axial load mechanism [e.g., a fall from height or a motor car accident] and may be associated with other axial-load fractures [e.g., pelvic, tibial plateau and lumbar fractures] [2].

Despite recent advance in orthopedic traumatology, management of calcaneal fractures is still debatable and outcomes are often unsatisfactory, due to the complex anatomical outline of the calcaneus, its cancellous structure, and its exposure to constant weight load. Thus, this injury is associated with major socioeconomic and functional impairment [3].

Non-operative management usually associated with delayed reconstruction, leaving a painful and stiff foot, which may delay or permanently prevent return to work or former activities. Surgical management had better functional results and less pain than conservative management. However, it had a higher risk of postoperative complications, such as infection and delayed healing [4].

With improvement of imaging modalities, a better understanding of the mechanisms of trauma, and development of the principles of anatomical reduction and complete stability for joint fractures, it is now possible to improve the clinical outcome for calcaneal fracture. Several plates are available [e.g., flat, fusion, reconstruction, Sanders, modified Sander's and 4mm simple cancellous screws for fixation after attainment of an acceptable reduction] [5].

Results are better in less comminuted than more comminuted fractures. Preservation of Bohler's angle is also mandatory for satisfactory outcome along with preservation of articular congruence of posterior calcaneal facet and crucial angle of Gissane [6].

The calcaneal fracture complications include subtalar pain, arthritis, tendinitis, calcaneocuboid arthritis, damage of heel pad, tarsal tunnel syndrome, stiff forefoot and toes, weakness of gastrosoleus complex, a fixed flatfoot and regional pain syndromes. The trend toward open reduction and internal fixation [ORIF] is a trial to avoid these complications [7].

Although ORIF is considered the standard treatment choice for displaced intraarticular calcaneal fractures, uncertainty about the final results of surgical and conservative options still exist, as it was reported that, neither offers satisfactory results without the risk of early or delayed complications [8].

AIM OF WORK

The present study aimed to assess the open reduction and internal fixation on clinical and radiological basis and to document complications of calcaneal fracture fixation by calcaneal plate.

PATIENTS AND METHODS

The present prospective study included 20 patients with DIACFs, who were treated operatively at our trauma center [Al-Azhar University Hospital, Damietta Branch]. Informed consent had been obtained from each patient. The study had been carried out in accordance with ethics code of Helsinki declaration. The study protocol had been approved by the institutional review board of Damietta Faculty of Medicine, Al-Azhar University [IRB number: 00012367-18-09-003].

The inclusion criteria were patient age above 18 years, displaced intra-articular fractures [Types III & IV according to Sanders's classification], closed fractures, good soft tissue condition, and recent fracture within 3 weeks.

On the other side, **exclusion criteria** were extra-articular fractures, fractures not fixed more than 3 weeks, skeletally immature patients, patients with open fractures or bad skin condition, pathological fractures, and patients associated with general condition that affects bone mineralization [renal, malnutrition and parathyroid disturbances].

The preoperative evaluations included full history

taking, clinical examinations, general and local examinations [type of fracture, skin condition, deformity, and associated trauma, vascular and neurological state], plain radiographs and computed tomography [CT] scans.

In addition, laboratory investigations had been performed [Complete blood count [CBC], coagulation profile, liver enzymes, random blood sugar [RBS], urea, and creatinine]. All patients were managed and internal fixation completed by a locking plate. All surgeries were completed at the Department of Orthopedics [Al-Azhar university hospitals, Damietta] and Mansoura New General Hospital. The preoperative management included appropriate pain relief by systemic analgesics and temporary splint.

Operative procedures:

Under spinal anesthesia, the patients were positioned in lateral decubitus on a translucent table with elevation of the affected extremity above the contralateral limb using sterile diapers and surgery was done under tourniquet [Figure 1].



Figure [1]: Positioning

Open access to the lateral wall of calcaneus was attained by the standard L-shaped lateral method, with the posterior arm positioned midway between the fibula and Achilles' tendon; while the horizontal arm was sited in line with the fifth metatarsal base. Particular care

was exerted to do a full-thickness skin flap to minimize any alteration of the vascular supply of soft tissues. The incision was extended to bone, with elevation of a subperiosteal and periosteal flaps along its entire extent. At the site of the peroneal tendon sheath attachment, the tendons were retracted anteriorly and the dissection was sustained on the deep layer. Then the retinaculum was divided, and fibulocalcaneal and talocalcaneal ligaments are separated from the bone to reach the fracture site. Once the lateral side of the calcaneus was entirely exposed, two Kirschner wires were driven into the talus to exert retraction of the flap [Figure 2].



Figure [2]: Incision for the extensile lateral approach, the lateral flap has been elevated, The K- wires in the talus retract soft tissues and assist exposure

After the lateral approach was completed, hematoma was removed and the fracture lines were recognized. Next, a Schanz screw was introduced to the posterior fragment, passed from lateral to medial, through both cortices. It worked as a joystick to help in the reduction. The next step was the reduction of the tuberosity fragment to the "constant" medial sustentacular fragment. It was fixed in position with two K-wires, inserted in an anteroposterior superior path from the posterior inferior aspect of the tuberosity. They were directed superiorly and anteriorly into the "constant" medial fragment. The posterior facet was

raised and the joint was reduced. Fragments of the fracture were reduced and momentarily fixed with K-wires, with a special attention to the articular surface [Figure 3].

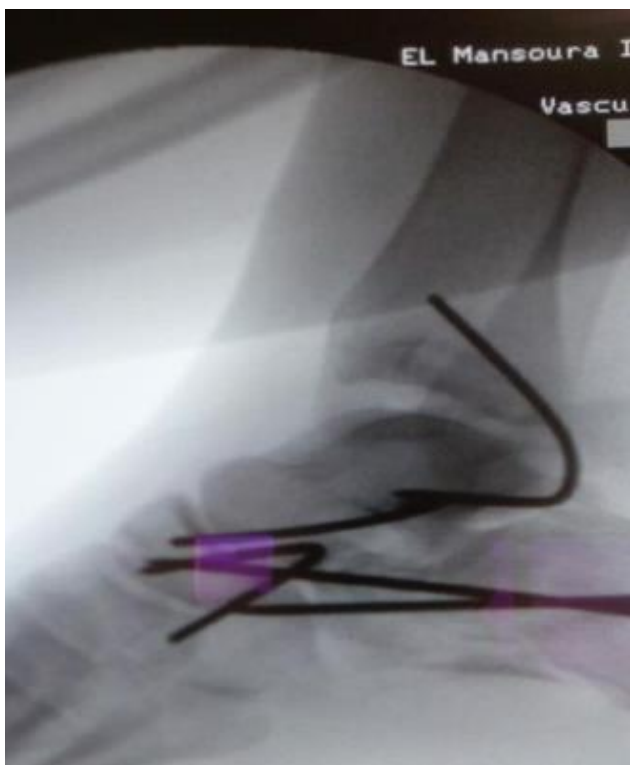


Figure [3]: Reduction and temporary fixation by K-wires.

When acceptable reduction was attained, final fixation was completed by a low-profile plate and screws. Six screws were inserted into the calcaneus: Two from the subthalamic area into the sustentaculum, two into the tuberosity fragment far dorsally, and two screws into the anterior process fragment close to the calcaneo-cuboidal joint

In some cases, graft was introduced to fill the bony defect below the articular surface. Then k-wires were eliminated and a radiographic final reduction confirmation was obtained [Figure 4].

The skin was closed in layers and no wound drainage was used. An absorbable stitch was used for approximation of subcutaneous tissue, Soft-tissue closure was carefully performed to ensure flap advancement, no excessive tension on the distal corner of the incision. An interrupted stitch was used to close the skin [Figure 5].



Figure [4]: Reduction and fixation with the interlocking plate



Figure [5]: Skin closure

Postoperative care: Immediate postoperative X-rays [AP, lateral and Axial views], examination of the neurovascular status, anti-edematous and pain therapy, intravenous broad-spectrum antibiotics for three days then a turn to oral broad-spectrum antibiotics had been done. In addition, oral anti-coagulant had been administered every 24 hours postoperative to high-risk patients. Patients had been

discharged from the hospital on the third postoperative day.

All patients had been followed up at 8, 16 weeks after operation. Physical assessment was performed to assess function. All patients exposed to the same postoperative rehabilitation program and early ankle joint exercises were encouraged. Data regarding operation time, time of starting partial weight bearing exercise, and postoperative complications were collected and documented. All patients were classified according to the scheme of Sanders, there were 7 [35%] type III and 13 [65%] type IV.

The primary outcome was the function according to the functional score [AOFAS, table 1]. The maximum score is 100 points. A value >90 points considered an excellent, 80 to 89 good, 70 to 79 fair, and < 70 considered poor [9]. Other variables represented the secondary outcomes.

Statistical methods: IBM SPSS [statistical package for social science] statistics [V. 24.0, IBM Corp., USA] was used for data analysis. Data were summarized as Mean±SD for quantitative variables or relative frequency and percentages for categorized parameters. The student t test used for comparison between two independent means. The degree of change due to follow-up study [delta change or dC] reflect the actual difference changed through the follow-up study and was calculated and mean delta change compared with the other group. Pearson correlation test examined the possible association between two parametric variables. Chi-square test was used to assess the association between two categorized parameters. The probability of error at 0.05 was considered significant.

RESULTS

In the current work, there were 18 males and 2 women, with average age of 34.15 years, range 18-52 years. The most frequent etiology was fall from height [19 patients; 95.0%]. The youngest patient was 18 years old and the oldest 58 years, with an average of [34.15±10.58 years]. 90.0% of patients were males. The mechanism of injury was mainly fall from height [95.0%]. Four patients had associated orthopedic injuries [3 patients had fracture spine, two of them were

at the level of L3 vertebra, one at the level of L1 vertebra and shoulder dislocation], One patient had ipsilateral fracture distal radius. One patient had fracture left superior & inferior pubic rami. Comorbidities were in the form of smoking in 20% and diabetes mellitus in 15.0%. The fracture type was closed in all patients. Fracture was of Sanders type III in 35% and of type IV in 65.0%. The time of operation after injury was one week in 75%, second week in 20.0% and third week in 5.0% [Table 1]. Pre-operative Bohler's angle ranged from [-30°] to [16°]. The mean Bohler's angle was [-5.42°].

In this study 20 cases with intraarticular calcaneal fractures were treated by calcaneal plate. The results of this study were evaluated on the basis of restoration of anatomy and function. The detailed results of functional outcome presented in Table [2].

According to the American Orthopedic Foot Ankle Society [AOFAS] Ankle-Hindfoot Score, the outcome was excellent [30.0%], good [40.0%], fair [20.0%] and poor [10.0%].

Excellent outcome was achieved in 6 patients [30%]; 4 were Sanders type IV and 2 were type III. All of them were operated within one week of injury. These patients had mild subtalar pain with movement that was tolerable and reduced over time. Clinical examination unable to duplicate the pain. None of those patients had lateral or plantar heel pain. All were able to walk a distance more than four blocks before a rest was required. In these patients, subtalar range of motion was > 50%, when compared to the contralateral foot. Good outcome was achieved in eight patients [40%]; 6 were Sander's type IV and two were type III. Five of them were operated within 1 week and the other 5 were operated after one week of injury. Those patients had a somewhat more persistent, diffuse pain in the rear foot during waking that did not reduced over time. The pain was tolerable and did not affect daily activities. Clinically, lateral rear-foot pain was reproducible with subtalar eversion in 4 of 10 feet. In these patients, subtalar joint range of motion was more than 50% with respect to the opposite side. Fair outcome was achieved in four patients [20%]; two were Sanders's type IV and two were type III. Four of them were operated within 1 week and two were operated after one week of injury. These patients had chronic

pain in subtalar joint and the lateral rear foot during walking and on clinical examination. Two patients had pain in the plantar heel. They had subtalar joint range of motion less than 50%. Poor outcome achieved in two patients [10%]; both were Sanders's type IV. One operated within one week and the other after one week. They had persistent subtalar and lateral rear foot pain. They had subtalar joint range of motion less than 50%.

The average score was 83 with a range of 68 to 95. No patient had any failure of hardware, or intolerance of the fixator. Deep infection had not been reported. In addition, none has required further surgery.

Range of motion of the subtalar joint revealed that, active inversion and eversion were roughly assessed in supine position then passive inversion and eversion were done in prone position measuring the extent of motion by estimating the angle between a line bisecting the heel and another line bisecting the posterior leg. Range of motion of the subtalar joint was assessed in comparison to the normal side. Subtalar range of motion was more than 50% in 13 [65%] feet [figure 6], while in the remaining 7 [35%] feet, it was less than 50% [Figure 7]. Full or almost full range of motion in the ankle joint was achieved in almost all cases.

Radiological Assessment

At the last follow-up, radiological measurements of the fractured feet were compared with normal measurements of non-injured feet in unilateral cases [16 cases]. The length, height, and Bohler's angle of the calcaneus [Figure 8] as well as the width [Figure 9] were measured preoperatively and at the last follow-up recorded visit. Bohler's angle was measured using the highest points of the calcaneal tuberosity, subtalar joint, and anterior process. The angle lies at the intersection of two lines: the first connecting the highest point of calcaneal tuberosity to the highest point of subtalar joint and the second connecting the highest point of subtalar joint to the highest point of anterior calcaneal process. In our series; Bohler's angle was restored to normal [20°-40°] in 17 feet [85 %] while 3 feet [15 %] was less than normal. The mean Bohler's angle was changed from $-5.42^{\circ} \pm 12.68$ preoperatively to $27.13^{\circ} \pm 6.1$ postoperatively. 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. In our series; 16 feet [80%] were restored to nearly equal length [± 10 %] as compared to the opposite side. The length of the remaining 4 feet [20%] was more than 110% as compared to the opposite side. The mean calcaneal length was restored to 103% as compared to the opposite side. 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. In our series; 17 feet [85%] were restored to nearly equal height [± 10 %] as compared to the opposite side. The height of the remaining 3 feet [15%] was less than 90% as compared to the opposite side. The mean calcaneal height was restored to 94% as compared to the opposite side. 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. In our series; 14 feet [70%] were restored to nearly equal width [± 10 %] as compared to the opposite side. The width of the remaining 6 feet [30%] was more than 110% as compared to the opposite side. The mean calcaneal width was restored to 109% as compared to the opposite side in unilateral cases.

Complications: Wound infection was seen in two cases [10%] and treated conservatively with local wound care and systemic antibiotic therapy. We had no deep infection. In addition, each of varus heel deformity and flexion deformity of big toe was found in one patient [5.0%]. Finally, two case complained from intolerable pain, cold, clammy skin, an inability to tolerate anyone touching the foot, in the period of follow-up, diagnosed as reflex sympathetic dystrophy. The symptoms reversed with use of intensive physiotherapy [massage, motion and manipulation], medical treatment and weight-bearing after the fracture has healed [Table 3].

Preoperatively, there was significant increase of Bohler's angle in fracture type III when compared to

fracture type IV. However, no significant difference had been reported after treatment. In addition, AOFAS score was not significant [Table 4].

In the current work, there was no association between fracture type and subtalar arthritis. For

example, of fracture type III, there was 42.9% of subtalar arthritis, compared to 38.5% of type VI. Patients with subtalar arthritis had significantly lower AOFAS score when compared to patients with no subtalar arthritis [76.22±6.24 vs 87.0±6.05 respectively, p < 0.001]

Table [1]: Patient and fracture characteristics and

Variable		Statistics
Age [years]		34.15±10.58 [18-58]
Sex	Male	18 [90.0%]
	Female	2 [10.0%]
Mechanism of injury	Motor care accident	1[5.0%]
	Fall from height	19[95.0%]
Fracture side	Right	7[35.0%]
	Left	13[65.0%]
Associated injury	Yes	4 [20.0%]
	Isolated	16[80.0%]
Comorbidities	Smoking	4 [20.0%]
	Diabetes mellitus	3[15.0%]
Fracture type	Closed	20 [100.0%]
Fracture classification	Sanders type III	7[35.0%]
	Sanders type IV	13[65.0%]
Time of operation after injury	First week	15[75.0%]
	Second week	4[20.0%]
	Third week	1[5.0%]

Table [2]: Functional outcome among studied populations

		n.	%
Pain	No pain	13	65.0
	Mild/moderate	5	25.0
	Severe	2	10.0
Return to job	To the same job	18	90.0
	Change job	2	10.0
Walking	No limit	16	80.0
	Walking short distance	2	10.0
	Indoors only	2	10.0
Limping	None	15	75.0
	Slight when fatigued	2	10.0
	Slight constant	1	5.0
	Moderate limp	1	5.0
	Marked limp	1	5.0
Running	Not affected	15	75.0
	Partially limited	3	15.0
	Totally limited	2	10.0
Recreational activities	Limited	2	10.0
	Not limited	18	90.0
Swelling	No swelling	5	25.0
	Swelling only in evening	5	25.0
	Mild persistent swelling	10	50.0
Subtalar arthritis	Present	7	35.0

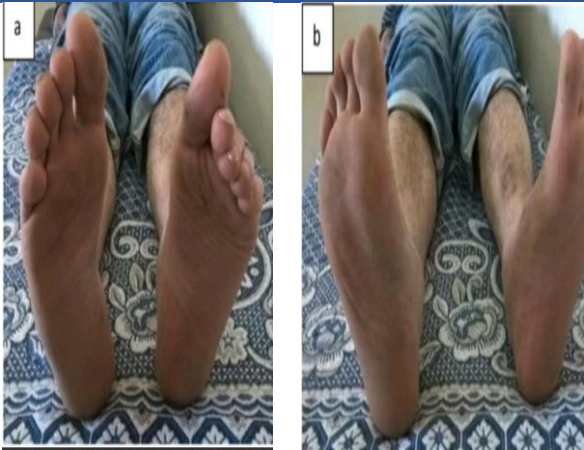


Figure [6 a & b]: Range of motion of subtalar joint more than 50 % [Rt. side is affected].



Figure [7 a & b]: Range of motion of subtalar joint less than 50 % [Rt. side is affected].



Figure [8]: Lateral X-ray showing radiographic measurement of. B: Bohler's angle, H: Height of calcaneus, L: Length of calcaneus



Figure [9]: Axial view of the calcaneus Showing W: Width of calcaneus

Table [3]: Complications among studied populations

	n.	%
Wound infection	2	10.0
Varus heel deformity	1	5.0
Flexion deformity of the big toe	1	5.0
Reflex sympathetic dystrophy	2	10.0

Table [4]: Comparison between fractures type III and IV according to Bohler's angle in pre and post-operative periods

	Fracture Type	n.	Mean	SD	t	P
Bohler's angle Pre-treatment	III	7	4.71	12.473	2.18	0.04*
	IV	13	-9.06	14.584		
Bohler's angle Post-treatment	III	7	29.86	5.46	1.09	0.28
	IV	13	26.59	7.027		
Bohler's angle difference	III	7	225%	140%	1.31	0.20
	IV	13	413%	361%		
AOFAS score	III	7	82.71	8.558	-0.09	0.92
	IV	13	83.06	8.05		

DISCUSSION

In this prospective study, the majority of fractures occurred between the ages of 19 to 58 years with the mean age of 34.15 years. This is attributed to active engagement in different activities and exposure to variable outdoor life events and road traffic accidents.

These findings are in line with previous studies regarding intraarticular calcaneal fracture for example, Xia *et al.* [10] study, on 75 cases with intraarticular calcaneal fracture patients age ranged from 19 to 67 years and the mean age of was [37] years. Hyer *et al.* [11] had done prospective study on 17 cases of displaced intraarticular calcaneal fractures repaired with locked plate fixation. There were 12 male patients [70.6%; in current study, males represented 90.0%]. Fractures were much commoner in males because that males are usually subjected to outdoor activities and hence more included in fall from height and motor car accidents.

Results of the current work are consistent with Bohl *et al.* [12], who reported that, the annual incidence of calcaneal fractures was highest in males under the age of 60 years, with a peak in the 20-30 years. Fractures in males were less common after the age of 60 years. In addition, fractures were much less common in females, rare before the age of 50 years, although there was a slow increase in the incidence with increasing age thereafter.

In comparison to the current study, Cao *et al.* [13] had done prospective study on 33 cases and reported that of the 33 patients, 78.79% were due to a fall from height [95.0% in the current work], 18.18% resulted from a traffic accident [5% in the current study], and 3.03% resulted from sports-related trauma. In addition, they reported fracture we on the right side in 54.5% [35% in the current study] and on left side in 45.5% [65.0% in the current work].

According to Sander classification, Wu *et al.* [14] reported that there were 78 displaced intra-articular calcaneal fractures managed by ORIF and fixed by calcaneal plate. 61 fractures [78.2%] were Sander type III and 17 fractures [21.8%] were Sander type IV. This is different than the current work, which included 7 fractures [35%] of Sander type III and 13 fractures [65%] of Sander type IV.

Timing of surgery was determined by skin condition; because of subcutaneous location of the calcaneus, gross swelling, skin injury and blisters are common after calcaneal fractures. Splinting for immobilization, icepacks and delayed surgery help in prevention of further soft tissue destruction and subsequently better soft tissue conditions in the preoperative period. Surgery was performed after resolution of the swelling, with positive wrinkle sign. Dorsiflexion of the ankle is performed with concomitant observation of the anterior aspect of the ankle for skin creases; the absence of a skin crease or wrinkle suggests severe swelling.

Vicenti *et al.* [15] reported that out of 62 patients [63 fractures] managed by the lateral access with plate and screws, surgery was completed at a mean of four days after trauma [range 7–17 days]. In this study, mean time from injury to operation was 5.75 days [range 1–17 days]. Seven cases were operated after five days due to poor skin condition. There was no difference in union rates and complications in those who were operated before or after 5 days.

The assessment of functional outcome was done using by AOFAS Score. Wu *et al.* [14] reported that there were 78 displaced intraarticular calcaneal fractures from them 18 of 78 [23.07%] of feet with excellent results, 37 of 78 [47.43%] with good results, 16 of 78 [20.51%] with fair results, and 5 of 78 [6.41%] with poor results The mean AOFAS score is 85.59. In the current study, AOFAS Score there were 6 of 20 [30%] of feet with excellent results, 8 of 20 [40%] with good results, 4 of 20 [20%] with fair results, and 2 of 20 [10%] with poor results.

Different previous studies concluded that the Bohler's angle restoration was associated with an excellent outcome and that induce osteosynthesis, and should be considered for intra-articular calcaneal fractures in order to reestablish the shape of the hindfoot and Bohler's angle. This reflected the good functional outcome with the restoration of Bohler's angle [16-18].

Kulkarni *et al.* [19] study, reported that the mean Bohler's angle was changed from 11° preoperatively to 23.66° postoperatively with significant difference [$p < 0.05$]. In the current study, Bohler's angle was restored to normal [20°-40°] in 17 feet [85 %] while 3

feet [15 %] was less than normal. The mean Bohler's angle was changed from $-5.42^{\circ} \pm 12.68$ preoperatively to $27.13^{\circ} \pm 6.1$ postoperatively. Cao *et al.* [13] reported that, the mean Bohler's angle was changed from $9^{\circ} \pm 2.7$ preoperatively to $31 \pm 3.6^{\circ}$ postoperatively with significant difference.

Regarding calcaneal height, width and length, Jain *et al.* [20] study of 40 patients with intraarticular calcaneal fracture reported that the calcaneal height, width and length were restored to 82, 95 and 90 % of normal, respectively. Results of the current work are comparable to the results of this study. In line with the current study, Ding *et al.* [21] reported that the patient-related factors, which could affect outcome of surgical intervention include smoking history, diabetes mellitus [either type 1 or type 2], and Sanders type and these factors were also associated with a surgical wound complication. An overall wound postoperative wound complications following open reduction and internal fixation of closed calcaneus fractures was 17.8% [compared to 10% of superficial wound infection in the current trial with no deep infection].

Li Y *et al.* [22], on the other side, reported that, factors associated with surgical outcome in patients underwent open reduction and internal fixation of calcaneal fractures were: skill of the surgeon, duration of surgery, duration of antibiotics, hospital stay and tourniquet use.

Kline *et al.* [23] summarized in a retrospective study, the data of 79 displaced intra-articular fractures of the calcaneus, that were managed by the extensile lateral approach. Complications in the extensile group included flexion deformity of big toe, sural nerve injury and complex regional pain syndrome in 11.5, 7.69%, and 15.4%, successively. In comparison to the current trial, there were 3 cases [15%] included flexion deformity of big toe and complex regional pain syndrome in 2 of 20 [10%].

Pain was the most common reported complication in 176 fractures, where 14 [7.96%] developed pain [arthritis pain [3 fractures], heel pad pain [5 fractures] and diffuse pain [6 fractures]] [24]. In the current study, five cases [25%] had slight or occasional pain after long walks or sports. The remaining two cases [10%] had a severe pain after walks or long standing. Wu *et al.* [14]

reported on a retrospective study of 148 patients [170 feet with displaced intra-articular calcaneus fractures] treated by ORIF. Radiological evidence of post-traumatic subtalar arthritis was reported in and 22 cases [12.9% compared to 35% in the current work]. Also, Basile [25] reported that subtalar arthritis was [11.11%]

In this study, mean time to achieve union was 9.65 [range 8 to 12] weeks. Cao *et al.* [13] reported that, in a total of 33 patients [33 feet] with closed, dislocated, intraarticular calcaneal fractures, the radiological evidence of solid union was attained in all patients at a mean period of 8.2 ± 1.1 [range 7 to 11] weeks.

The current study had a few limitations, the sample number of patients, which prevent generalization of our results and any concrete recommendations are difficult. besides, the one year follow up in average is relatively short. Hence long-term complications of subtalar arthritis not considered. However, we conclude that displaced intra-articular calcaneal fractures treated by ORIF have a relatively better functional outcome, provided that, Bohler's angle was restored. Thus, we recommend the restoration of Bohler's angle as a standard for the treatment success. Future studies are required to address the best [optimal] surgical technique.

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