Comparison of open reduction and internal fixation versus closed reduction and percutaneous fixation of medial malleolus fractures: a comparative study

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Background

Medial malleolus fractures (MM) are the most common intra-articular fractures of a weight-bearing joint. Surgical treatment is frequent and is reported to improve patient functional outcome, quality of life and also avoid complications. This treatment consists of open reduction and internal fixation (ORIF) or closed reduction and percutaneous fixation (CRPF).

Aim

To compare ORIF versus CRPF of MM fractures for the assessment of union, functional outcome, and complications.

Patients and methods

A prospective randomized controlled clinical research has been performed at Ain Shams University Hospitals and Egyptian Railway Medical Center recruiting 50 patients with MM fracture mainly transverse types (25 cases undergoing ORIF, and 25 cases undergoing CRPF) starting from September 2023 to March 2024. We excluded skeletally immature patients, Charcot disease, comminuted fracture, correlated neurovascular injury and crush injury of foot and ankle, and avulsion of tip of MM (Type A).

Results

Regarding operative time, CRPF was statistically significant with mean±SD (35±3.82) minutes when compared with ORIF (64±8.16) min. The American Orthopedic Foot and Ankle Society scoring (AOFAS) scoring, which is an indicator of functional outcome, weight-bearing (weeks), and range of motion were statistically significant in CRPF rather than ORIF. Regarding postoperative complications, A statistically significant variance was observed among ORIF and CRPF with a P=0.017.

Conclusion

CRPF appeared to be superior concerning AOFAS as an indicator of functional outcome, weight-bearing, range of motion, and duration of operation. Insignificant variances among CRPF and ORIF in general complications involving infection of the wound, osteoarthritis, osteomyelitis and failure of fixation, Sudeck's atrophy, and nonunion.

Keywords:
medial malleolus, open reduction, percutaneous fixation

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Introduction

The prevalence of medial malleolus (MM) fractures has increased as a result of assaults, road traffic accidents, falls from height, and twisting injuries to the ankle [1].

MM fractures represent about 50% of ankle fractures and can present as isolated MM fractures or compared with pilon fractures, bimalleolar fractures, and trimalleolar fractures [2].

MM fractures are categorized into four types according to the site of the fracture, utilizing the Herscovici classification. Avulsions of the tip of the malleolus are categorized as type A. Fractures that happen among the tip and the level of the plafond are classified as type B. Type C fractures occur at the level of the plafond, which is the bony structure at the bottom of the tibia. On the other hand, type D fractures are vertical fractures. Fractures classified as Type B and C can be effectively treated by using screws for fixation [3].

MM fractures can be treated using several methods based on the specific pattern of the fracture. Conservative treatment, involving the insertion of a cast below the knee, is typically sufficient for treating the majority of isolated and undisplaced MM fractures. Bi- or tri-malleolar ankle injuries, are usually treated by surgically fixing them [4].

Various methods have been documented for fixing fractures of the MM, involving the use of bicortical fully threaded screws, unicortical partially threaded compression screws, tension band fixation, and buttress or neutralization plating [5,6].

Fracture geometry and the extent of comminution are critical factors to consider when identifying a specific fixation technique. Typically, these fixation techniques include a traditional open approach to fracture fixation and reduction [7,8].

Comminuted fracture patterns are more challenging to decrease and are more likely to necessitate open reduction and internal fixation (ORIF) for direct visualization and fracture reduction [9].

The open reduction technique involves exposing the fracture site, directly visualizing the fracture fragment, and then reducing, fixing the fragment, and reducing periosteal entrapment. However, there is a possibility of wound complications and damage to the soft tissues [10,11].

A percutaneous technique has the potential benefit of reduced operative morbidity, reduced pain following surgery, and reduced risk of wound complications, without direct visualization of the fracture or debridement of the fracture site [12–14].

Several investigations have demonstrated that percutaneous screw fixation is an effective procedure even for unstable MM fractures [10,11].

Periosteum entrapment is a possible complication of medial malleolar fractures. It can occur in about 20–70%. This is because the lining of the bone, called the periosteum, will fold into the fracture site at the time of injury, which would not be seen on an radiography. If this membrane is not removed from between the bone fragments, the fracture may not heal, and a nonunion fracture could develop [15].

Aim

This research aims to compare ORIF versus closed reduction and percutaneous fixation (CRPF) of MM fractures for the assessment of:

(a) Union.
(b) Complications.
(c) Functional outcome.

Patients and methods

A prospective randomized controlled clinical research has been performed on Ain Shams University Hospitals and Egyptian Railway Medical Center recruiting 50 patients of MM fracture mainly transverse types (25 cases undergoing ORIF, and 25 cases undergoing CRPF) starting from September 2023 to March 2024.

Even numbers have been submitted for open reduction and internal fixation. Odd numbers were submitted for CRPF.

We excluded skeletally immature patients, Charcot disease, comminuted fracture, correlated crush injury, and neurovascular injury of the foot and ankle.

Inclusion criteria

(a) Types B, C mainly, and D of MM fractures according to (Herscovici classification).
(b) Both sex groups.
(c) Skeletally mature.

Exclusion criteria

(a) Avulsions of the tip of the malleolus (type A).
(b) Charcot disease.
(c) Comminuted fracture.
(d) Correlated injury of neurovascular.
(e) Crush injury of foot and ankle.

Preoperative workup

(i) Clinical evaluation of edema, soft tissue condition, and neurovascular assessment.
(ii) Soft tissue condition is assessed by Tscherne and Oestern categorization of soft tissue injury in closed fractures [16].
(iii) Plain x-rays of the ankle for evaluation of fracture classification.
(iv) Laboratory investigations:
    (a) Complete blood countBC and routine preoperative investigations.
    (b) Routine use of low molecular weight heparin to reduce the incidence of venous thromboembolism [17].
    (c) Antibiotics were given to prevent postoperative infections.

Operative technique

Preparation

(i) Anesthesia (regional vs. general).
(ii) C-arm, to verify the reduction of fractures.
(iii) Position:
    (a) Supine position, the foot at the edge of the table in a slight external rotation to facilitate visualization of the MM.

(iv) Tourniquet.

Mid-thigh tourniquet was applied [18].

Approach

Open reduction and internal fixation

(a) Incision

Ten centimeters longitudinal, curved incision on the medial aspect of the ankle was made [19].

(b) Superficial dissection

Mobilization of flaps of the skin, identification, and protection of nerve just anterior to the MM and long saphenous vein.

(c) Deep dissection

The fibers of the deltoid ligament should be carefully splitted.

(d) Procedure

The fracture is reduced and curetted, and a bone clamp is positioned to the tibia proximal to the fracture and at the tip of the MM. Two parallel K-wires are placed across the fracture fragments using a cannulated system, followed by the insertion of two 4.0 cannulated screws. Tension banding is an effective choice. It involves the insertion of two parallel K-wires into the MM, similar to the positioning of 4.0 cannulated screws. A 4.0 completely threaded cancellous 'bone screw' is inserted into the concave aspect of the tibia, 2–3 cm above the site of the fracture. The tension wire is then positioned across K-wire and the screw in a figure-of-eight pattern, and the bone screw is subsequently tightened. The K-wires are cut medially, bent, and flush with the MM. Antiglide plate fixation techniques have been documented for vertical shear fractures (type D) of the MM. Subsequently, the incision is closed without the use of a drain [20].

Closed reduction and percutaneous fixation

In CRPF, the site of fracture was not visible, in contrast, the fracture was reduced through placing a bone clamp across the tip of the MM and the tibia, just above the fracture site. The skin is penetrated by two parallel K-wires, which are then placed across the fracture fragments, confirmation of reduction was done under image following radiological criteria of reduction, and a small skin incision 1 cm diameter was performed around K-wires insertion's sites, drilling through the cannulated system, with insertion of two 4.0-mm cannulated screws. Closure of the wound, no drain is applied [20,21]. In type D fracture, transverse screws are applied perpendicular to the fracture plane [22], Figs 1 and 2.

Radiological criteria of reduction

An ankle fracture should be detected by a radiographic analysis. Ramsey and Hamilton found that one millimeter of talar shift can lead to a reduction of 42% in the contact among the tibia and talus. The tibiofibular overlap on the antero-posterior view of the ankle should be less than ten millimeters, extending from the medial fibula to the lateral border of the anterior tibia. It's observed by the (1) talocrural angle. A line is drawn perpendicular to the first line and parallel to the articular surface of the distal tibia. The second line is drawn linking the malleoli's most distal aspects. The talocrural angle is the superior medial angle. The talocrural angle must be 83 +/– 4°. (2) The line of Shenton. The contour of the subchondral bone of the tibial subchondral and the tibial plafond bone of the fibula must be a curved, unbroken line is less than two millimeters. (3) The dime sign is characterized by an unbroken curve that connects the recess in the distal tip of the fibula to the lateral process of the talus. (4) Talar tilt can be determined by drawing lines along the dome of the talus and tibial plafond. It is possible to measure the degree of lateral opening. These lines must be parallel or within 3° of parallel distance from one another. On the lateral view, the tibia's central line should intersect with the lateral process of the talus. If not observed, this suggests either posterior or anterior movement of the tibia [20], Fig. 3

Postoperative management

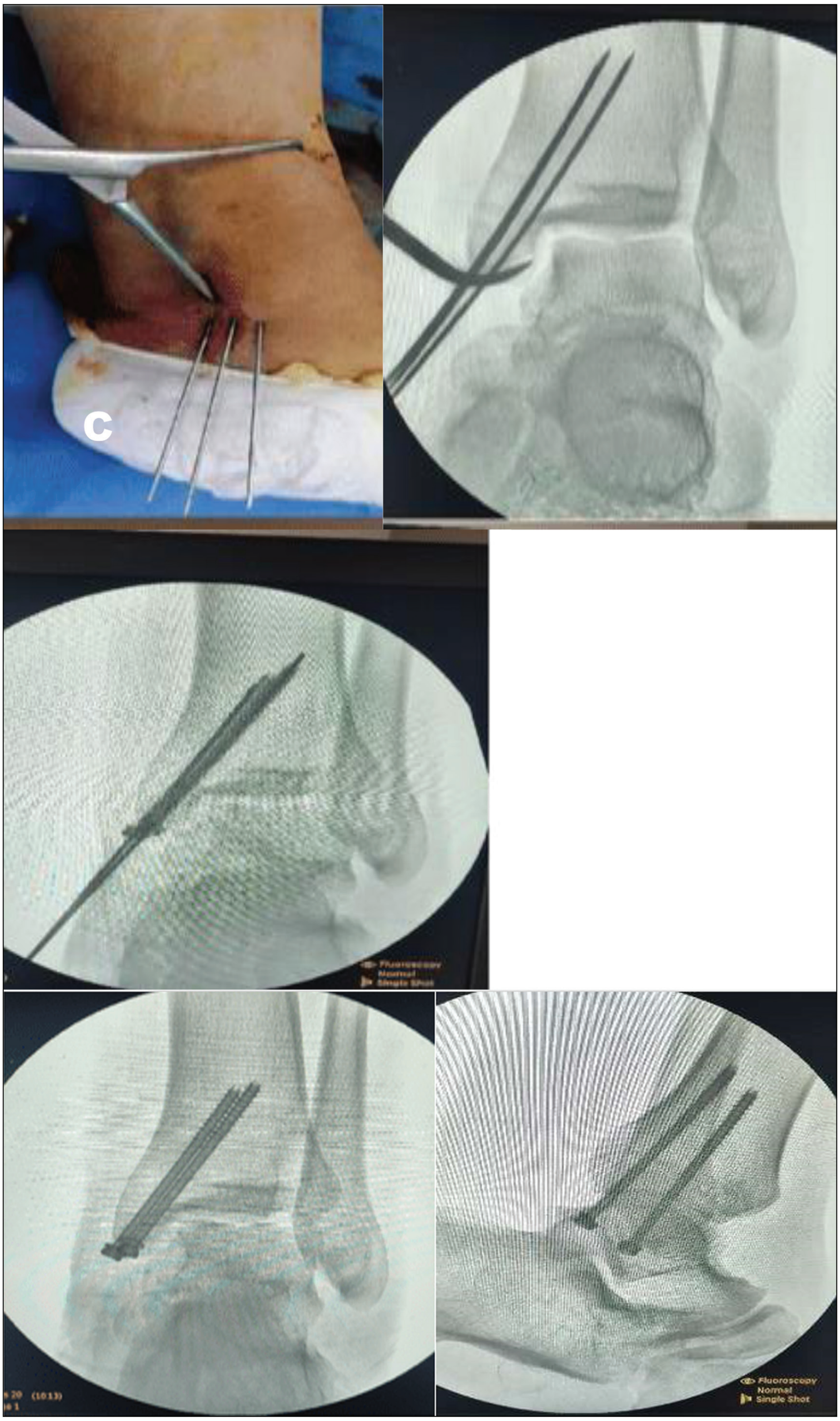
Mobilization of patients occurs with the aid of two crutches without weight bearing. Plain radiography were done at 2, 6 weeks, and 3 months. Following the surgery, a soft bandage was used for 14 days. There were no casts used [24]. At 2 weeks, sutures were removed and will remain in a nonweight-bearing position for a further four weeks. At 6 weeks, if there were indications of healing, patients can start bearing on their feet as tolerated while wearing a controlled ankle motion boot. In cases where fracture union was delayed or any other complications, the period of nonweight-bearing was prolonged by an additional 2–6 weeks, and AOFAS scoring is used to assess the function and walking ability [21,25].

Clinical and functional assessment

American orthopedic foot and ankle society scoring (AOFAS) [26]

Has been used to evaluate walking ability and function.

Figure 1

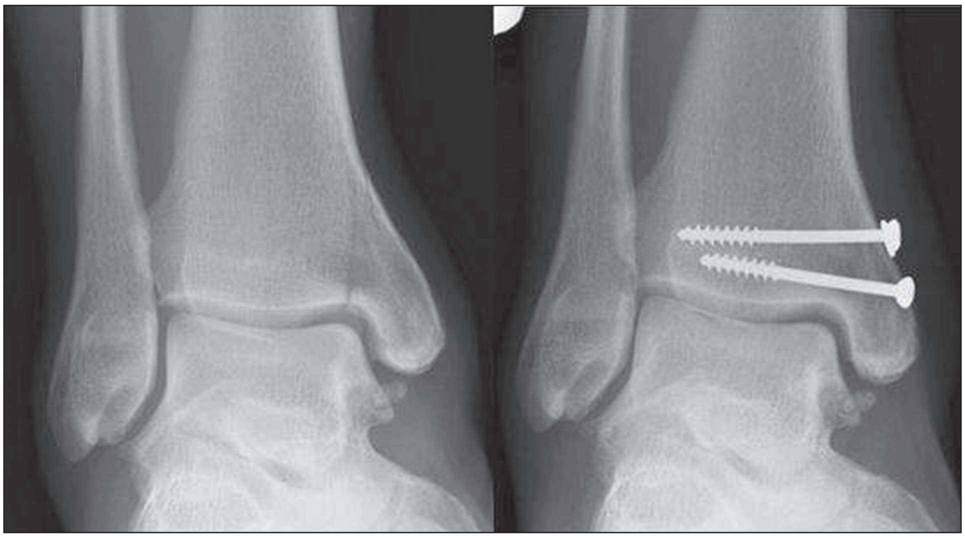


Male patient. 46 year medically free post twisted ankle. (a) Clinical photo of intraoperative showing reduction by clamps and insertion of k-wires. (b) Confirmation of reduction under the image. (c) Insertion of cannulated screws. (d) Antero-posterior and a lateral view show adequate fracture reduction.

Statistical analysis

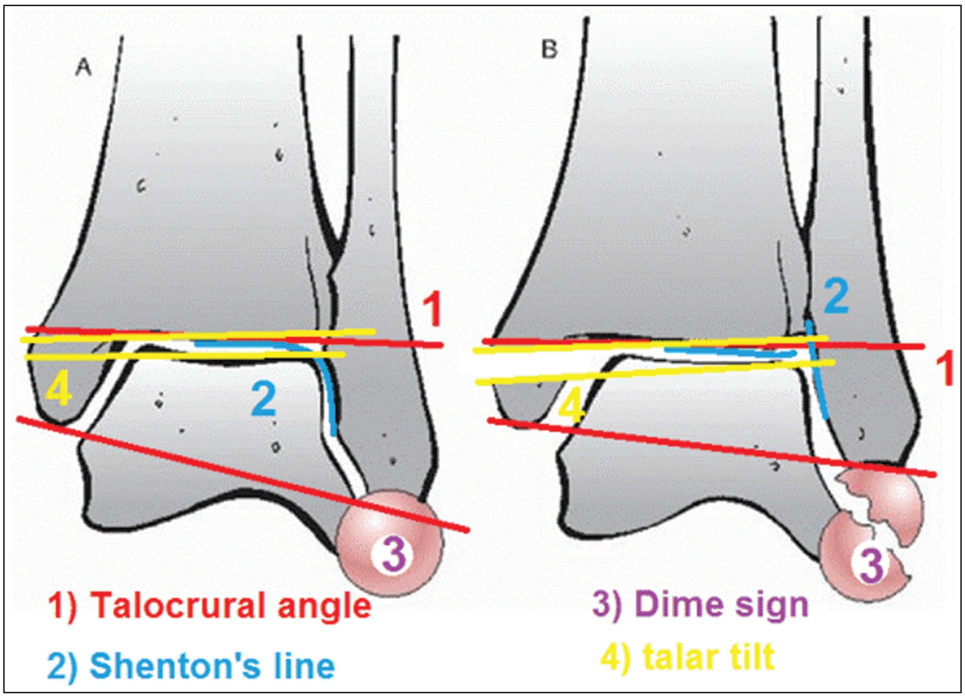
Data have been coded, revised, entered, and collected into the Statistical Package for Social Science (IBM SPSS, Chicago, USA) versus 27. The quantitative data have been described by standard deviations, mean and ranges when parametric and median, and inter-quartile range (IQR)

Figure 2



Plain radiography antero-posterior view for male patient 50 year medically free postroad traffic accident showing type D fracture MM, fixed by percutaneous transverse screws applied perpendicular to the fracture plane.

Figure 3



Radiological criteria of reduction [23]

when data has been observed non-parametric. Similarly, qualitative variables have been described by percentages and numbers. The *P* value has been defined as significant as the following: If the *P* value is greater than 0.05, it is considered nonsignificant (NS). If the *P* value is less than 0.01, it is considered highly significant (HS). If the *P* value is less than 0.05, it is considered significant (S).

Results

Tables 1–5

Case 1

35-year-old male patient medically free, smoking presenting by twisted right ankle with mild edema and intact soft tissue treated by CRPF.

Pre and postoperative imaging (Fig. 4 and Fig. 5).

Case 2

A 60-year-old male patient diabetic and nonsmoker. Postoperative MM fracture complicated by a wound infection after ORIF (Fig. 6).

Table 1 Comparison among open reduction and internal fixation and closed reduction and percutaneous fixation groups regarding general characteristics and characteristics of the examined cases

	ORIF group	CRPF group	Test value	*P* value	Significance
	N=25	*N*=25			
Age					
Mean±SD	44.4 ± 9.54	44.12 ± 8.67	0.109•	0.914	NS
Range	26–60	29–65			
Sex, *n* (%)					
Female	4 (16)	4 (16)	0.000*	1.000	NS
Male	21 (84)	21 (84)			

P value less than 0.05: Significant; *P*-value less than 0.01: Highly significant; *P* value greater than 0.05: Nonsignificant
•: Independent *t*-test.
*: Chi-square test.

Table 2 Comparison among open reduction and internal fixation and closed reduction and percutaneous fixation groups as regard mode of trauma, fracture classification, and soft tissue condition among the examined cases

	ORIF group	CRPF group	Test value	*P* value	Significance
	Number = 25	Number = 25			
Mode of trauma, *n* (%)					
RTA	12 (48)	7 (28)			
Twisted ankle	13 (52)	16 (64)	3.626*	0.163	NS
Isolated trauma	0	2 (8)			
Fracture class *n* (%)					
Type B	6 (24)	9 (36			
Type C	11 (44)	11 (44)	1.292*	0.524	NS
Type D	8 (32)	5 (20)			
Soft tissue condition, *n* (%)					
Grade 0	16 (64)	16 (64)			
Grade 1	8 (32)	9 (36)	1.059*	0.589	NS
Grade 2	1 (4)	0			

Table 3 Comparison among open reduction and internal fixation and closed reduction and percutaneous fixation groups as regard operation period from trauma, smoking, BMI, past medical history, and duration of operation among the examined cases

	ORIF group	CRPF group	Test value	*P* value	Significance
	Number = 25	Number = 25			
Duration from trauma to surgical intervention					
Median (IQR)	2 (1–2)	1 (1–2)	–1.620≠	0.105	NS
Range	1–7	1–3			
Smoking, *n* (%)					
No	13 (52)	14 (56)	0.081*	0.777	NS
Yes	12 (48)	11 (44)			
BMI					
Mean±SD	27.6 ± 1.47	27.24 ± 1.54	0.846•	0.402	NS
Range	24–30	25–30			
Past med. history, *n* (%)					
Free	19 (76)	20 (80)			
DM	2 (8)	3 (12)			
HTN	2 (8)	2 (8)	2.226*	0.694	NS
BA	1 (4)	0			
DM, HTN	1 (4)	0			
Duration of operation (min)					
Mean±SD	64 ± 8.16	35 ± 3.82	16.086•	0.000	HS
Range	50–75	25–40			

DM, diabetes mellitus; HTN, hypertension
*: Chi-square test.
•: Independent *t*-test.
≠: Mann–Whitney test.

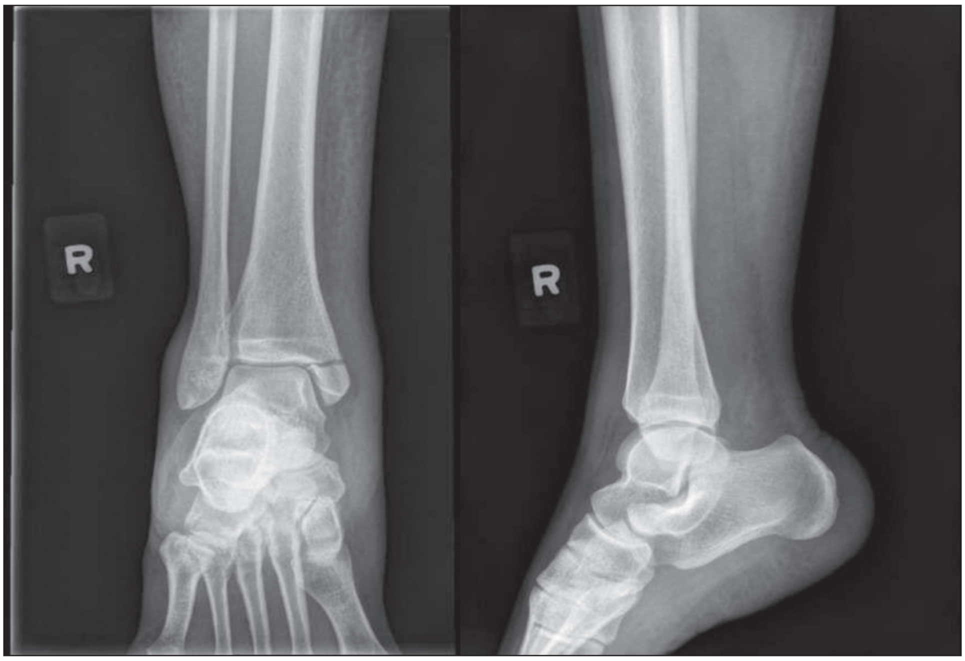
Table 4 Comparison among open reduction and internal fixation and closed reduction and percutaneous fixation groups as regard postoperative data of the studied cases

	ORIF group	CRPF group	Test value	*P* value	Significance
	Number = 25	Number = 25			
Union and Weight-bearing (weeks)					
Mean±SD	8.04 ± 0.89	6.04 ± 0.68	8.956•	<0.001	HS
Range	7–10	5–7			
Range of motion, n (%)					
Full	15 (60)	24 (96)	9.441*	0.002	HS
Limited	10 (40)	1 (4)			
AOFAS Scoring					
Mean±SD	70.68 ± 14.12	90 ± 7.09	–6.114•	0.000	HS
Range	38–87	68–99			

Table 5 Comparison among open reduction and internal fixation and closed reduction and percutaneous fixation groups as regard complications among the examined cases

Complication	ORIF group	CRPF group	Test value	*P* value	Significance
	Number = 25	Number = 25			
Uncomplicated, *n* (%)	16 (64.0)	23 (92.0)	5.711*	0.017	S
Complicated, *n* (%)	9 (36.0)	2 (8.0)			
Wound infection, *n* (%)	3 (33.3)	0	0.917*	0.338	NS
Osteoarthritis, *n* (%)	3 (33.3)	0	0.917*	0.338	NS
Fracture related infection, *n* (%)	1 (11.1)	0	0.244*	0.621	NS
Failure of hardware, *n* (%)	0	1 (50.0)	4.950*	0.026	S
Malunion, *n* (%)	0	1 (50.0)	4.950*	0.026	S
Sudeck atrophy, *n* (%)	1 (11.1)	0	0.244*	0.621	NS
Nonunion, *n* (%)	1 (11.1)	0	0.244*	0.621	NS

Figure 4

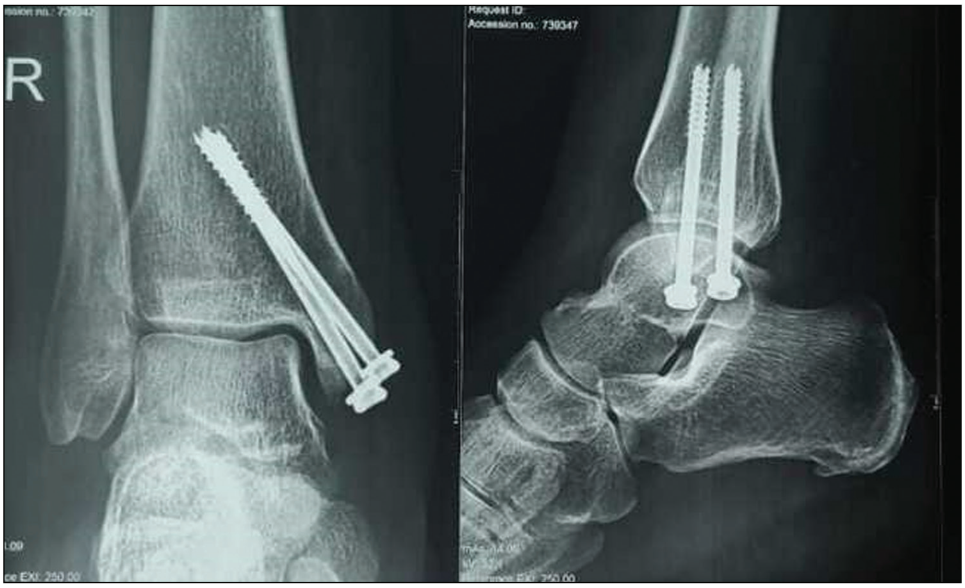


Preoperative medial malleolus fracture antero-posterior and lateral view.

Discussion

Ankle fractures are becoming increasingly a healthcare burden in aging populations, and there is an ongoing argument about the best way to manage them. Restoring the anatomical congruency of the ankle joint after an injury is believed to be crucial for enhancing function and decreasing post-traumatic complications. Operative techniques are used to facilitate the healing of the joint in this manner [27].

Figure 5



6 weeks after closed reduction and percutaneous fixation antero-posterior and lateral view.

So, this study was carried out between CRPF and ORIF to compare the functional outcome to reach the optimum management.

As regards the preoperative data (age, sex, mode of trauma, fracture classification, soft tissue condition, duration from trauma to surgical intervention, smoking, BMI, and past medical history), Statistically insignificant variance was observed among CRPF and ORIF.

As regards duration of operation, CRPF was statistically significant with mean±SD (35 ± 3.82) min when compared with ORIF (64 ± 8.16) min. This coincides with (El-Deen Esmat E. and colleagues) which revealed that the operative time was (36.33 ± 5.16) min. in CRPF and (54.00 ± 12.28) min. in ORIF.

In the postoperative data, we found that the AOFAS scoring, which is an indicator of functional outcome, union, weight-bearing (weeks), and range of motion were statistically significant in CRPF rather than ORIF.

Similarly, a study done at Benha University (El-Deen Esmat *et al.*) disclosed that the percutaneous technique for fixation of closed fractures of the MM is adequate and provide a satisfactory outcome [28].

As regard postoperative complications, ORIF showed nine (36%) complicated cases when compared with CRPF which revealed two (8%) complicated cases.

The statistically significant variance was observed regarding wound infection, osteoarthritis, fracture-related infection, Sudeck's atrophy, or nonunion among the two groups. However a statistically significant variance was observed regarding failure of hardware and mal-union in CRPF than ORIF. Unlike the observations made by Matson *et al.* and El-Deen Esmat *et al.* a statistically insignificant variance was observed among the ORIF and CRPF groups as regard results involving mal-union, time to union, nonunion, wound complications and rate of hardware removal [21,28].

Limitations

The current research was mainly limited by a short follow-up time and a small sample size. For proper data about complications after surgery, it is necessary to prolong the duration of observation.

Conclusion

CRPF appeared to be superior concerning AOFAS as an indicator of functional outcome, weight-bearing, range of motion and duration of operation. There were no significant differences between CRPF and ORIF in general complications such as wound infection, osteoarthritis, osteomyelitis, failure of fixation, Sudeck's atrophy and non-union.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Figure 6

(a) Postoperative open reduction and internal fixation antero-posterior and lateral view. (b) Infected wound after 25 days from fixation.

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