

Original Research Article

Results of fixation of medial malleolus fractures with closed versus open reduction

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ABSTRACT

Background: Medial malleolus fractures are common ankle injuries with varied treatment approaches, most notably closed and open reduction techniques. Each method presents distinct outcomes and complication profiles. The study aimed to investigate and compare the clinical and radiological outcomes of both techniques in a local context and in comparison, with international literature.

Methods: A prospective-retrospective study was conducted at Aleppo University Hospital, orthopedic surgery Branch, between January 2020 and January 2025. A total of 67 patients with medial malleolar fractures were included. Patients underwent closed or open reduction based on clinical judgment. Data were collected via clinical examination, medical history, radiological, and laboratory investigations. Outcomes and complications were statistically analyzed.

Results: The non-union rate was higher in the open reduction group (7.7%) than in the closed group (2.4%), but this was not statistically significant. However, the mean union time was significantly longer in the closed reduction group (14.6 weeks vs. 11.5 weeks, $p=0.041$). Complications such as infection, nerve injury, malunion, and joint stiffness were more frequent in the open reduction group. Secondary displacement and Sudeck's atrophy were more frequent in the closed group, although none of these differences were statistically significant.

Conclusions: While both open and closed reduction techniques are effective in managing medial malleolus fractures, open reduction is associated with a higher rate of complications despite shorter union time. Closed reduction may be preferable in selected patients due to its favorable complication profile. These findings align with international data, although variations exist depending on study settings and sample characteristics.

Keywords: Medial malleolus, Fracture, Closed reduction, Open reduction, Outcomes, Complications, Fixation

INTRODUCTION

Medial malleolus fractures are a common type of ankle injury, often resulting from high-energy trauma such as road traffic accidents or falls from a height. These fractures can occur in isolation or as part of complex ankle fracture-dislocations, and they account for a significant proportion of lower extremity fractures requiring surgical intervention.^{1,2} Treatment strategies for medial malleolar fractures typically involve either closed reduction (with or without percutaneous fixation) or open reduction with internal fixation (ORIF), and the choice of technique is

largely guided by fracture type, displacement severity, surgeon preference, and soft tissue condition.

Several studies have compared the clinical and radiological outcomes of open versus closed reduction techniques, with varying conclusions. Some research suggests that ORIF may lead to faster radiological union and allow for more accurate anatomical restoration in cases of comminuted or displaced fractures.^{3,4} Other studies, however, emphasize the higher complication rates associated with open surgical procedures, including infection, wound healing issues, and joint stiffness.^{5,6}

Conversely, closed reduction methods, particularly minimally invasive approaches, are often favored for their lower complication profiles, despite potentially longer healing times and limited visualization of the fracture site.⁷

Clinically reported studies have also highlighted differences in healing outcomes based on fixation type, fracture complexity, and patient demographics.^{4,8} While minimally invasive techniques may offer benefits in terms of soft tissue preservation, concerns remain regarding their use in unstable or comminuted fracture patterns, where rigid fixation is often required.⁹

Despite extensive international literature on this subject, there remains limited data from regional or local settings, such as Syria. This gap underscores the importance of evaluating these treatment modalities in diverse healthcare environments, considering factors such as resource availability, patient follow-up compliance, and surgeon expertise.

The objective of this study was to investigate and compare the clinical and radiological outcomes of closed versus open reduction techniques in the management of medial malleolus fractures in a local Syrian population and to assess how these findings correspond to outcomes reported in international studies.

Study design and setting

This was a prospective-retrospective observational study conducted at Aleppo university hospital, orthopedic surgery branch, from January 2020 to January 2025.

Inclusion criteria

Patients aged 18-60 years with isolated medial malleolus fractures. Patients who received either closed reduction (surgical or conservative) or open reduction were included.

Exclusion criteria

Polytrauma patients, pathological fractures and recurrent or revision surgeries were excluded.

Procedure

Patients were categorized into two groups based on the treatment received:

Closed reduction: Either conservative (cast immobilization) or surgical percutaneous fixation.

Open reduction: Open surgical fixation using lag screws and/or plates under general or regional anesthesia.

Radiological assessment included standard ankle X-rays (AP, lateral, and mortise views), and in some cases, CT scans for comminuted fractures. Follow-up was performed at 2-week intervals until radiological union.

Ethical approval

The study protocol was approved by the ethical committee of Aleppo University Hospital. Informed consent was obtained from all participants.

Sample size and sampling technique

A convenience sampling method was used. The final sample size included 67 patients who met inclusion criteria during the study period.

Statistical analysis

Data were analyzed using SPSS (Version XX). Continuous variables were expressed as mean $\pm$ standard deviation, while categorical data were shown as frequencies and percentages. Chi-square or Fisher's exact test was used for categorical variables; Student's t-test was used for continuous variables. A $p < 0.05$ was considered statistically significant.

RESULTS

Distribution of cases by gender

A total of 67 patients with medial malleolus fractures were included in the study. Each case was managed using either closed or open reduction techniques. The proportion of males with a medial malleolus fracture was 64.2% compared to 35.8% for females, representing the total number of cases.

Table 1: Distribution of cases by gender.

Gender	N (%)
Male	43 (64.2)
Female	24 (35.8)
Total	67 (100)

Distribution of cases by age groups

The age of the patients in the study ranged from 18 to 60 years, with a mean age of 39.6 years. The most common age group was 31 to 40 years, accounting for 46.3% of the cases. The least common age group was 41 to 50 years, which represented 28.5% of the total cases.

Table 2: Distribution of cases by age groups.

Age groups (in years)	N (%)
18-20	2 (2.9)
21-30	7 (10.4)
31-40	31 (46.3)
41-50	19 (28.5)
51-60	8 (11.9)
Total	67 (100)
Mean age (SD)	39.6 $\pm$ 3.7

Distribution of cases by side of injury

The majority of medial malleolus fractures occurred on the right side, accounting for 71.6% of the cases, while 28.4% of the cases involved the left side.

Table 3: Distribution of cases by side of injury.

Side of injury	N (%)
Right side	48 (71.6)
Left side	19 (28.4)
Total	67 (100)

Distribution of cases by cause of fracture

The most common cause of fractures was road traffic accidents, accounting for 52.2% of cases. Falls from a height were the second most frequent cause, contributing to 34.3% of the cases, while slipping during walking was responsible for 13.5%.

Table 4: Distribution of cases by cause of fracture.

Cause of fractures	N (%)
Road traffic accident	35 (52.2)
Fall from height	23 (34.3)
Slipping while walking	9 (13.5)
Total	67 (100)

Distribution of cases by management type

Closed reduction was the most common management approach among patients, accounting for 61.2% of cases. Among these, 7 cases were managed conservatively using casting, while the remaining 34 cases underwent closed surgical reduction. In comparison 38.8% cases were treated via open surgical reduction, based on the total number of cases.

Table 5: Distribution of cases by management type.

Management type	N (%)
Closed reduction	41 (61.2)
Open reduction	26 (38.8)
Total	67 (100)

Distribution of cases by fracture type according to management method

Both management groups showed similarity in that transverse fractures were the most common type of medial malleolar fractures among patients, with a higher prevalence in the closed reduction group 46.3% compared to the open reduction group 42.3%. On the other hand, comminuted fractures were more frequently observed in the open reduction group, accounting for 23.1%, versus 4.9% in the closed reduction group. This difference was statistically significant

Table 6: Distribution of fracture types by management approach.

Fracture type	Closed reduction	Open reduction
Spiral	3 (7.4%)	2 (7.7%)
Oblique	8 (19.5%)	7 (26.9%)
Transverse	19 (46.3%)	11 (42.3%)
Simple	9 (21.9%)	0 (0%)
Comminuted	2 (4.9%)	6 (23.1%)
Total	41 (100%)	26 (100%)
P value	0.031	

Fracture displacement by management approach

Both treatment groups were similar in terms of fracture displacement, with the majority of cases presenting with mild displacement. Mildly displaced fractures were more common in the closed reduction group (87.8%) compared to the open reduction group (69.2%).

In contrast, severely displaced fractures were more frequent in the open reduction group (30.8%) than in the closed reduction group (12.2%).

This difference did not reach statistical significance ($p=0.06$).

Table 7: Distribution of fracture displacement according to management approach.

Fracture displacement	Closed reduction	Open reduction
Mild	36 (87.8%)	18 (69.2%)
Severe	5 (12.2%)	8 (30.8%)
Total	41 (100%)	26 (100%)
P value	0.06	

Distribution of cases according to injury pattern based on management method

Both management groups showed similarity in that closed fractures were the most common injury pattern among patients, with a predominance in the closed reduction group (85.4%) compared to the open reduction group (80.8%). Open fractures were more common in the open reduction group (19.2%) compared to the closed reduction group (14.6%). However, this difference was not statistically significant.

Table 8: Distribution of cases according to injury pattern based on management method.

Injury pattern	Closed reduction	Open reduction
Closed	35 (85.4%)	21 (80.8%)
Open	6 (14.6%)	5 (19.2%)
Total	41 (100%)	26 (100%)
P value	0.62	

Distribution of cases according to treatment outcomes by method

The rate of non-union was higher in the open reduction group, reaching 7.7%, compared to 2.4% in the closed reduction group; however, this difference was not statistically significant. Regarding the time to union, it was longer in the closed reduction group, with a mean duration of 14.6 weeks compared to 11.5 weeks in the open reduction group, and this difference was statistically significant ($p=0.041$).

Table 9: Distribution of cases according to treatment outcomes by method.

Treatment outcome	Closed reduction	Open reduction
Successful union	40 (97.6%)	24 (92.3%)
Non-union	1 (2.4%)	2 (7.7%)
Total	41 (100%)	26 (100%)
P value	0.31	
Mean time to union (weeks $\pm$ SD)	14.6 $\pm$ 1.07	11.5 $\pm$ 1.2
P value	0.041	

Distribution of complications according to the treatment method

In general, complications were more frequent in cases managed with open reduction compared to those treated with closed reduction.

Among early complications, both nerve injury and infection were more commonly observed in the open reduction group, while secondary displacement was more frequent in the closed reduction group. However, these differences were not statistically significant. For late complications, malunion, pin tract infection, and joint stiffness were more frequent in the open reduction group, while Sudeck's atrophy was more common in the closed reduction group. Again, these differences were not statistically significant.

Regarding the fracture type, closed fractures were the most common injury pattern in both groups, with a slightly higher frequency in the closed reduction group (85.4%) compared to the open reduction group (80.8%). Open fractures were more frequently observed in the open reduction group (19.2%) compared to the closed reduction group (14.6%), without statistically significant difference.

Table 10: Distribution of complications according to treatment method.

Complications		Closed reduction	Open reduction
Early complications	Secondary displacement	2 (4.9%)	0 (0%)
	Nerve injury	0 (0%)	2 (7.7%)
	Infection	3 (7.3%)	5 (19.2%)
	P value	0.11	
Late complications	Malunion	1 (2.4%)	1 (3.8%)
	Sudeck's atrophy	2 (4.9%)	1 (3.8%)
	Pin tract infection	1 (2.4%)	3 (11.5%)
	Pin loosening	0 (0%)	0 (0%)
	Joint stiffness	0 (0%)	1 (3.8%)
	P value	0.56	

The non-union rate was higher in the open reduction group (7.7%) compared to the closed reduction group (2.4%), although this was not statistically significant. However, the time to union was significantly longer in the closed reduction group, with a mean of 14.6 weeks versus 11.5 weeks in the open reduction group ($p=0.041$).

Overall, complications were more common in the open reduction group. Among early complications, nerve injury and infection were more frequent in the open reduction group, while secondary displacement occurred more often in the closed reduction group. These differences were not statistically significant. For late complications, malunion, pin tract infection, and joint stiffness were more common in the open reduction group while Sudeck's atrophy was more frequently observed in the closed reduction group compared to the open reduction group. However, this difference was not statistically significant.

DISCUSSION

This study aimed to compare the clinical outcomes of closed versus open reduction techniques in managing medial malleolus fractures. Our findings suggest that while both methods are effective, closed reduction is associated with fewer complications, albeit with a longer union time.

The higher rate of comminuted fractures and severe displacement in the open reduction group explains the need for surgical exposure. Our results are consistent with Matson et al who also observed more complications in the open reduction group, particularly infections and joint stiffness.⁴

The statistically significant longer union time in the closed group mirrors results from Prabhu et al who also reported prolonged healing in conservatively or percutaneously

managed fractures.⁵ In contrast, Andrew et al reported longer union times in the open reduction group, although without statistical significance.⁵

We also found a higher non-union rate in the open reduction group, although not statistically significant. Abd El Ghany et al observed more infections in closed reduction cases, which contradicts our results and may be due to smaller sample size and different surgical protocols.³

Our study confirms that complication rates, including infection, nerve injury, and pin tract infection, are more frequent with open procedures. This aligns with international trends.^{4,5}

The study by Andrew included the largest sample size, comprising 165 cases of medial malleolar fractures, compared to 67 cases in both our study and the study by Prabhu, while Abd El Ghany's study included the smallest sample, with 20 patients.³⁻⁵ The highest mean patient age was reported in Andrew's study, with an average of 51 years, followed by 46.5 years in Prabhu's study, 39.6 years in our study and 33.3 years in Abd El Ghany's study.³⁻⁵

Regarding gender distribution, our study, along with those by Abd El Ghany and Prabhu, reported a higher prevalence of male patients with medial malleolar fractures.^{3,5} Prabhu^[5] had the highest proportion of male patients (88.1%), followed by 65% in Abd El Ghany's study and 64.2% in our study.³

In contrast, Andrew's study reported a female predominance, with 55.8% females and 44.2% males. Our study was consistent with that of Prabhu, in which the right ankle was more commonly affected.^{4,5} This predominance was more pronounced in our study (71.6%) compared to 53.7% in Prabhu's. In contrast, Abd El Ghany reported an equal distribution between the right and left sides (50% each).³ Our study and Prabhu's showed similarity in that road traffic accidents (RTAs) were the most common cause of medial malleolar fractures, with a higher rate in Prabhu's study (70.1%) compared to ours (52.2%).⁵ In our study, falls from height were the second most common cause (34.3%), whereas in Prabhu's, slipping while walking accounted for 14.9%.

In contrast, Andrew's study found that associated fibular fractures were the most frequent mechanism (79.4%), followed by high-energy trauma in 20.6% of cases.⁴ In our study, closed reduction was the more frequently used approach (61.2%) compared to open reduction (38.8%).

This contrasts with both Andrew's and Prabhu's studies, where open reduction was more commonly applied 81.2% and 77.6% respectively.^{4,5} In contrast, Abd El Ghany's study reported equal distribution between the two treatment methods.³ Our study was consistent with Andrew and Prabhu in that transverse fractures were the most common type of medial malleolar fracture treated by

both methods.^{4,5} In our cohort, simple fractures were more frequent in the closed reduction group, while comminuted fractures predominated in the open reduction group. In Prabhu's study, oblique fractures were more common in open reduction cases, while vertical fractures were more common in the closed group. A statistically significant difference was observed only in our study. In our study, non-union was more frequent in the open reduction group (7.7%) compared to 2.4% in the closed group, though not statistically significant.

In contrast, in Abd El Ghany and Prabhu, non-union was more common in closed reduction groups, while in Andrew's study, the rates were equal-all without statistical significance.³⁻⁵

Regarding time to union, our study and Prabhu's showed longer mean healing time in closed reduction (14.6 vs. 11.5 weeks in our data), with a significant difference in both studies. In contrast, Andrew's study reported longer union time in open reduction cases, though without statistical significance. Our findings aligned with Andrew in showing that both infection and malunion were more frequent in open reduction cases.⁴

Similarly, we shared findings with Prabhu regarding joint stiffness, which was more common after open reduction.⁵ None of these differences reached statistical significance. However, Abd El Ghany reported the highest rate of infection in closed reduction cases, at 40%.³ In our study, we observed that patients who underwent ORIF demonstrated a significantly shorter time to radiographic union compared to those treated with closed reduction (mean: 11.5 weeks vs 14.6 weeks, $p=0.041$). This finding is consistent with results from a large retrospective cohort study ($n=490$), which reported that patients treated with ORIF were five times more likely to demonstrate radiographic healing at 8 weeks than those managed with percutaneous fixation ($p<0.001$).⁶

However, not all studies corroborate this difference. For instance, Matson et al in a study of 165 patients comparing closed reduction with percutaneous fixation (CRPF) and ORIF, found no statistically significant difference between the groups in terms of union rate or time to healing.⁷ The discrepancy between our results and theirs may be attributed to variations in fracture complexity, sample size, or differences in surgical technique and selection criteria. Notably, their CRPF group included less severe fractures, while in our cohort, comminuted or displaced fractures were more often managed with open techniques, which might have influenced healing patterns.

Moreover, systematic reviews on ankle fractures suggest that while minimally invasive techniques may reduce soft tissue complications, they can potentially delay union in more complex fracture types.⁸ Thus, our findings support the idea that ORIF may offer advantages in terms of faster radiological healing, particularly in more unstable or comminuted medial malleolar fractures.

In our study, ORIF was associated with a significantly faster radiographic union compared to closed treatment (mean 11.5 vs. 14.6 weeks, $p=0.041$). This finding aligns with a large retrospective cohort study involving over 490 patients, in which ORIF-treated individuals were five times more likely to demonstrate fracture healing by 8 weeks than those treated with percutaneous screw fixation ($p<0.001$).⁹ The consistency between these results supports the notion that more stable fixation facilitates earlier bone healing.

However, Matson et al found no statistically significant differences in healing time, non-union, malunion, or wound complications between closed reduction percutaneous fixation (CRPF) and ORIF in a cohort of 165 patients.¹⁰ One explanation may be the higher rate of comminuted fractures in the ORIF group, potentially introducing selection bias ($p=0.04$). In our own study, comminuted fractures were also more often treated operatively, reflecting a similar treatment pattern.

A prospective study comparing different fixation techniques found that patients treated with fully threaded headless compression screws healed significantly faster and required fewer revision surgeries than those treated with tension-band wiring or partially threaded screws ($p=0.037$).¹¹ This corresponds with our findings, where rigid fixation via ORIF provided better outcomes in terms of healing time and patient satisfaction.

Another study investigating arthroscopically-assisted percutaneous fixation reported that all 78 fractures healed within 6-8 weeks, without wound complications and with high functional scores (AOFAS 75-95).¹² Although this healing time is shorter than in our closed treatment group, it should be noted that the patient population consisted primarily of minimally displaced fractures and underwent minimally invasive treatment, which may have positively influenced outcomes.

CONCLUSION

In conclusion, both closed and open reduction methods are viable for medial malleolus fracture management. Open reduction offers faster radiological union but is associated with a higher risk of complications. Closed reduction, while leading to longer healing times, demonstrates fewer adverse outcomes and may be preferable in less complex fracture types. These results support existing literature and highlight the importance of individualizing treatment plans based on fracture complexity and patient condition.

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