

## Comparative study between Percutaneous screw Fixation and Open reduction and internal fixation in minimally displaced Medial Malleolar Fractures

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### Abstract

**Background:** Medial malleolar fractures are common ankle injuries that can be managed using different surgical techniques. This research purposed to evaluate the short-term effects of percutaneous cancellous screw fixation against open reduction and internal fixation in the treatment of minimally displaced medial malleolar fractures. **Methods:** This study included a random sample of 20 patients who have minimally displaced medial malleolar fracture, fulfilled the inclusion criteria and completed 6 months follow up period at the Orthopedic Department of Benha University Hospitals and Mahalla General Hospital. Patients were split into 2 equal groups: Group I (Percutaneous group): included 10 patients who were treated with Closed Percutaneous cancellous screw Fixation. Group II (open group): comprised of 10 patients treated with open reduction and internal fixation. **Results:** A substantially critical change was present between both groups according to Operative Time which was  $36.33 \pm 5.16$  min. in Percutaneous group and  $54.00 \pm 12.28$  min. According to Operative outcomes in both groups, Follow-up time was about 6 months in both groups with no critical change between both groups. Union time was  $9.7 \pm 1.54$  week in Percutaneous group and  $9.1 \pm 3.83$  in Open group with no substantial change between both groups. Complete union was happened in 7 (70%) patients in Percutaneous group and 8 (80%) patients in Open group while delayed union has happened in 3 patients from percutaneous group and 2 patients from open group with no substantial change between both groups. **Conclusions:** The percutaneous technique for fixation of closed fractures of the medial malleolus is adequate and provided satisfactory final outcome but the open reduction and internal fixation allows removal of the trapped periosteal flap, direct inspection of the joint and the fracture so, it is better to use open reduction technique in all cases but in cases with bad soft tissue condition percutaneous technique could be used with acceptable results.

**Keywords:** Medial Malleolar Fractures; Percutaneous Screw Fixation; Open Reduction; Internal Fixation; Functional Outcome; Complications.

### 1. Introduction

Medial malleolar fractures are a common type of ankle injury, accounting for a significant proportion of lower extremity fractures. These fractures typically occur as a result of indirect mechanisms, such as rotational forces applied to the ankle joint. When the fracture is minimally displaced, treatment options include percutaneous screw fixation and open reduction and internal fixation (ORIF) [1].

The optimal management strategy for minimally displaced medial malleolar fractures remains a subject of debate among orthopedic surgeons. Both percutaneous screw fixation and ORIF have been widely utilized, each with its own set of advantages and potential complications [2]. Therefore, it is essential to compare these two treatment modalities to determine the most effective approach in achieving satisfactory outcomes for patients with minimally displaced fractures of the medial malleolus [3].

Under fluoroscopic supervision, percutaneous screw fixation includes the insertion of screws across the fracture site in order to achieve anatomic reduction and secure fixation. This minimally invasive technique offers several potential advantages, including reduced soft tissue trauma, shorter operative time, and faster recovery [4]. Additionally, percutaneous screw fixation may be associated with lower rates of infection and wound-related complications when compared to ORIF [5].

In contrast, ORIF requires open exposure of the fracture site, precise reduction of the fragments, and

screw or plate fixation. This approach enables direct fracture viewing, allowing for accurate reduction and reliable fixation [6]. Although ORIF is generally considered the gold standard for displaced medial malleolar fractures, it requires a larger incision, leading to increased soft tissue trauma, higher risk of wound complications, and longer hospital stays [7].

To date, limited research has directly compared the outcomes of percutaneous screw fixation and ORIF for minimally displaced medial malleolar fractures [8].

Therefore, this research aimed to evaluate the short-term effects of percutaneous cancellous screw fixation against open reduction and internal fixation in the treatment of minimally displaced medial malleolar fractures.

### 2. Methods

This prospective study aims to compare the outcomes of percutaneous screw fixation and ORIF in the management of minimally displaced medial malleolar fractures. A random sample of 20 patients who fulfilled the inclusion criteria and completed a 6-month follow-up period was included in the study. The patients were treated at the Orthopedic Department of Benha University Hospitals and the Orthopedics Department at Mahalla General Hospital between November 2021 and September 2022. The study cohort comprised 13 males and 7 females, with ages ranging from 22 to 59 years. Thirteen patients had right-sided fractures, whereas seven patients had left-sided fractures.

All patients provided their informed permission in writing, and their privacy and data confidentiality were strictly protected. The research was conducted in accordance with The Declaration of Helsinki and the standards of good clinical practise.

Two groups of patients were randomised by chance: the first group included 10 patients with odd numbers who underwent closed percutaneous cancellous screw fixation, while the second group included 10 patients with even numbers who underwent ORIF.

The inclusion criteria for this study were as follows: recent trauma, patients aged between 18 and 60 years old, simple fractures, and no associated fractures. Patients with medical comorbidities, associated fractures, old fractures, or open fractures were excluded from the study.

All patients underwent a comprehensive evaluation, including a detailed medical history, physical examination (both general and local), and preoperative radiological investigations, which consisted of anteroposterior, lateral, and mortise view ankle X-rays. The first group of patients received closed percutaneous cancellous screw fixation, while the second group underwent open reduction and internal fixation.

Data collection included personal information, special medical habits, comorbidities, mechanism of injury, affected side, physical examination findings, laboratory investigations, and radiological findings. Follow-up visits were scheduled at regular intervals, including one week, two weeks, and monthly visits for a period of three months. The patients were assessed using the American Orthopedic Foot and Ankle Society (AOFAS) scale for ankle joint function at the three-month mark.

Radiological assessments were conducted to evaluate the maintenance of reduction, fixation failure, and evidence of fracture healing. Functional outcomes and pain were assessed using the AOFAS scale, with

scores categorized as excellent (100-85), good (84-75), fair (74-60), or poor (<60).

#### Statistical analysis:

The data collected was revised, coded, and entered into IBM SPSS (Statistical Package for Social Sciences) version 23. For quantitative data, the mean, standard deviation, and range were used to describe parametric data, while the median and interquartile range (IQR) were used for non-parametric data. Qualitative variables were presented as frequencies and percentages. To compare qualitative data between groups, the Chi-square test was employed. In cases where the expected count in any cell was less than 5, the Fisher exact test was used. For comparing quantitative data between two groups with parametric distribution, the independent t-test was utilized. When the data had a non-parametric distribution, the Mann-Whitney test was employed. The confidence interval was set at 95%, and a margin of error of 5% was accepted. A two-tailed P-value of less than 0.05 was considered statistically significant.

### 3. Results

Of the 20 patients enrolled in the study, the youngest patient was 22 years of age at the time of surgery and the eldest was 59 years of age with a mean of 40 years. The group of patients included 13 males and 7 females. 6 males and 4 females for group (A) and 7 males and 3 females for group (B). Of the 20 patients enrolled in the study; 5 patients are smokers; 15 patients are nonsmoker. In Group (A) 2 patients were smokers and 8 patients were nonsmoker while in Group (B) 3 patients were smokers and 7 patients were nonsmoker. Of the 20 patients enrolled in the study, 13 patients had right side fracture; 7 patients had a left side fracture. Twisting is found to be the commonest trauma to produce fracture as in 13 patients (65%), 3 patients presented post falling from height (FFH) (15%) and 4 patients presented after traffic accident (20%). **Table 1**

**Table (1)** Demographic results between two groups

		Percutaneous group	open group
		No. = 10	No. = 10
Age	Mean $\pm$ SD	38.20 $\pm$ 10.43	43.60 $\pm$ 16.60
	Range	23 – 54	22 – 59
Sex	Female	4 (40.0%)	3 (30%)
	Male	6 (60.0%)	7 (70%)
Occupation	Active	8 (80%)	7 (70.0%)
	Sedentary	2 (20%)	3 (30.0%)
Smoking	Yes	2(20.0%)	3 (30%)
	No	8(80%)	7 (70%)
HTN	Yes	1 (10%)	0 (0%)
	No	9 (90%)	8 (80%)
Previous operation	Yes	1 (13.3%)	2 (20%)
	No	10 (100.0%)	9 (90.0%)
Side	Yes	0 (0.0%)	1 (10.0%)
	Right	6 (60%)	7 (70%)
	Left	4 (40%)	3 (30%)

<b>Mode of trauma</b>	Twisting	7 (70%)	6 (60%)
	Fall	1 (10%)	2 (20%)
	Motorcycle accident	2 (20%)	2 (20%)

The analysis revealed a statistically significant difference between the two groups according to Operative Time which was  $36.33 \pm 5.16$  min. in Percutaneous group and  $54.00 \pm 12.28$  min. **Table 2**

**Table (2)** Comparison of mean Operative time between two groups

Operative Time (min.)	Mean $\pm$ SD Range	Percutaneous group	Open group	Test value	P-value
		No. = 10 $36.33 \pm 5.16$ 30 – 45	No. = 10 $54.00 \pm 12.28$ 45 – 75		
				5.137	<0.001

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant

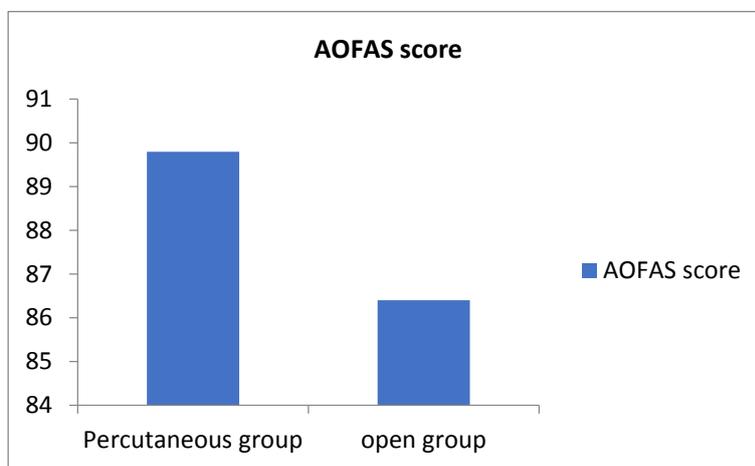
According to Operative outcomes in both groups, Follow-up time was about 6 months in both groups with no substantial change between both groups. Union time was  $9.7 \pm 1.54$  week in Percutaneous group and  $9.1 \pm 3.83$  in Open group with no substantial change between both groups. Complete union was happened in 7 (70%) patients in Percutaneous group and 8 (80%) patients in Open group while delayed union has happened in 3 patients from percutaneous group and 2 patients from open group with no substantial change between both groups. **Table 3**

**Table (3)** Comparison of Operative outcomes in both groups

Follow-up, wk Time to bone union, wk Final outcome	Mean $\pm$ SD	Percutaneous group	Open group	T /X2/Fisher	P
		No. = 10 $11.4 \pm 1.24$	No. = 10 $11.9 \pm 0.91$		
				1.28	0.71
		$9.7 \pm 1.54$	$9.1 \pm 3.83$	2.74	0.11
	Complete union	7 (80%)	8 (70%)	0.267	0.606
	Delayed union	3 (20%)	2 (30%)		

According to AOFAS score, there was no significant difference between both groups, the mean AOFAS score was  $89.8 \pm 12.74$  in Percutaneous group ranged from 69 to 100 and was  $86.4 \pm 15.69$  in Open group ranged from 72 to 95.

**Figure 1**



**Fig. (1)** Comparison of mean AOFAS score in both groups

According to AOFAS score criteria, there was no significant difference between both groups. **Figure 2**



Fig. (2) comparison of AOFAS score criteria in both groups

There was non-significant difference between both groups according to complications as open group showed some complication due to presence of surgical wound in contrary to percutaneous group like superficial infection and inflamed surgical wound which was treated by daily dressings and parenteral antibiotics and resolved. **Table 4**

Table (4) Relation output of complications between two groups

	Complications	Percutaneous group	open group	X2/Fisher	P-value
		No. = 10	No. = 10		
Total	Not Complicated	9 (90%)	8(80%)	0.392	0.531
	complicated	1 (10%)	2 (20%)		
	Superficial infection	1 (10%)	2 (20%)	0.392	0.531

**Case No (1):**

A 50-year-old male patient visited with a complaint of an ankle twisting injury. The injury specifically affected the left side. The patient had no prior medical conditions or associated injuries. The surgery was performed one day after the trauma occurred. Postoperatively, the patient was followed up for six months. The functional score, evaluated according to the AOFAS score criteria, was 90 points. This indicates a favourable outcome in terms of functional recovery and suggests a high level of ankle joint function for the patient. **Figure 3**



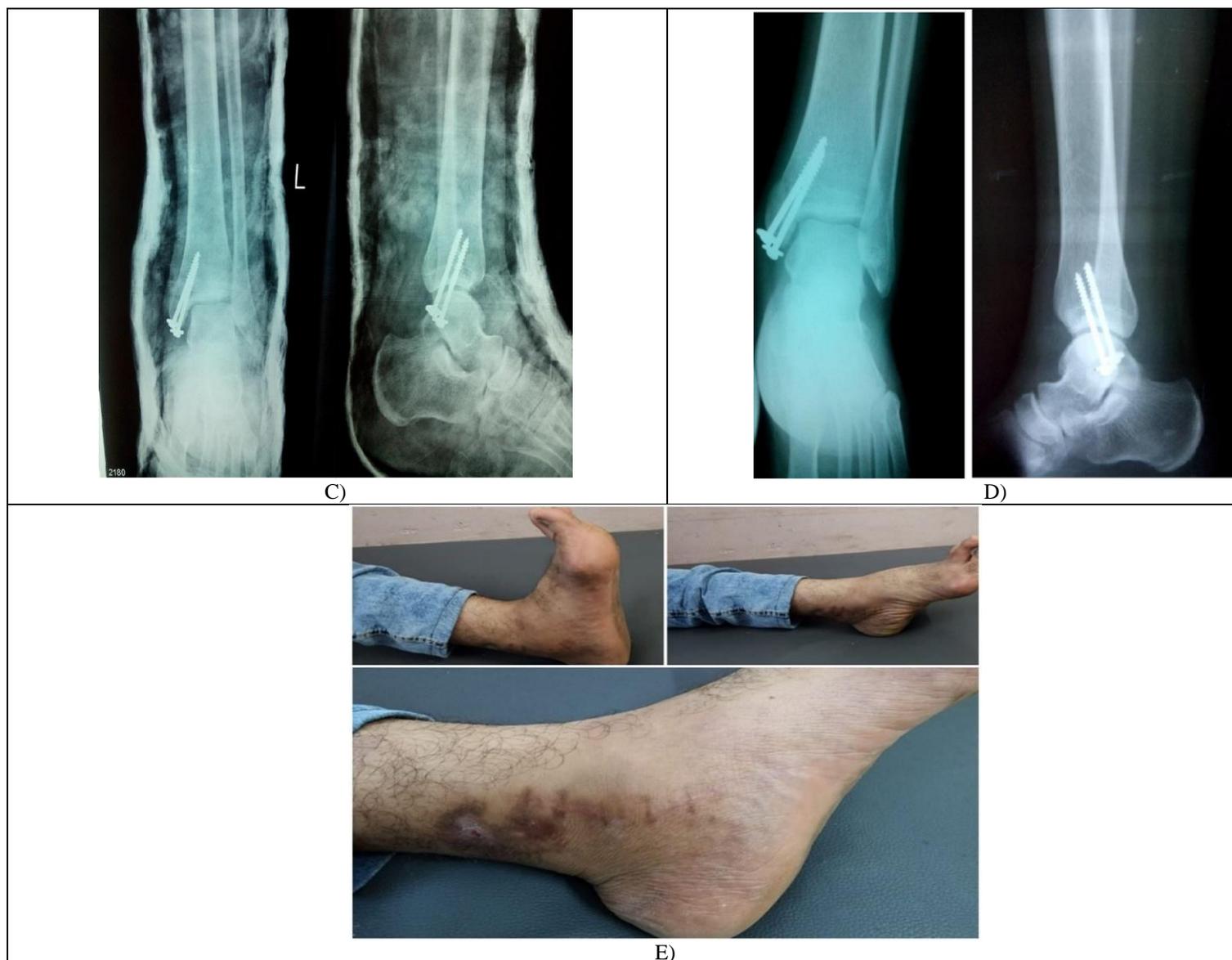


**Fig. 3** (A) The presenting X-ray of case 1, B) 6 weeks postoperative X-ray of case (1), C) month postoperative X-ray of case (1) and D) 6 month clinical outcome of case (1).

**Case No (2):**

A 34-year-old female patient presented with a history of ankle twisting injury. The left side was affected, and there were no concomitant diseases or associated injuries. The time elapsed between the trauma and surgery was 3 days. Postoperatively, the patient was followed up for six months. According to the AOFAS score criteria, the functional score was 70 points. However, at the 2-week follow-up, the patient exhibited signs of superficial infection and an inflamed surgical wound, which were managed through daily dressing and parenteral antibiotic treatment. **Figure 4**





**Figure 4** (A) The presenting X-ray, B) immediate imaging, C) 6 weeks postoperative X-ray, D) 6 months postoperative X-ray, E) clinical outcome

#### 4. Discussion

Regarding patients' demographics, Age, Sex, occupation, smoking, HTN, previous operation, side, dominance, and causes of the fracture were insignificantly different between both studied groups ( $P$ -value  $> 0.05$ ).

In line with our results, **Abd El Ghany et al. (2022)** conducted a comparative study to evaluate the outcomes of two different treatment methods for medial malleolar fracture in adults: percutaneous reduction and ORIF using a lag compression screw. The study included patients with medial malleolar fracture and divided them into two groups: Group A, treated with closed reduction, and Group B, treated with ORIF using a lag compression screw. In terms of demographic data, the mean age of the recruited patients was 33.30 years. Among the patients, 65% were males and 35% were females. The researchers found that these demographic

characteristics did not show any statistically significant differences between the two groups.<sup>[9]</sup>

In the present work, the operative time was considerably lower in Percutaneous group than Open group  $36.33 \pm 5.16$  min vs.  $54.00 \pm 12.28$  ( $P$ -value  $< 0.001$ ).

In research conducted by **Burbano et al. (2021)**, it was determined that closed percutaneous techniques need less time for surgical procedures than open techniques. The ORIF group averaged 124.82 minutes in the operating room compared to 97.6 minutes in the CRPP group.<sup>[10]</sup>

In agreement with our results, **Gamal and Shams (2017)** reported that the surgical time was much shorter with percutaneous fixation than with the conventional ORIF approach<sup>[11]</sup>.

According to operative outcomes in both groups, the follow-up time was about 6 months in both groups with no significant difference. Union time was  $9.7 \pm 1.54$

week in Percutaneous group and  $9.1 \pm 3.83$  in Open group with no significant difference. Complete union has happened in 7 (70%) patients in Percutaneous group and 8 (80%) patients in Open group while delayed union has happened in 3 patients from percutaneous group and 2 patients from open group with no significant difference ( $P$ -value  $> 0.05$ ).

In line with our findings, **Abd El Ghany et al. (2022)** reported that none of the patients experienced loss of reduction in their study. However, they did observe a delayed union in 30% of the patients<sup>[9]</sup>.

Indeed, the findings of **Hu et al. (2018)** support our results. According to their study, the incidence of delayed union and malunion among patients with medial malleolar fracture was 20.3% and 4.4%, respectively. They identified several factors that contributed to delayed union, including high-energy injury, vertical or comminuted fractures, bi- or trimalleolar fractures, fair or poor reduction, and the presence of interposed soft tissue. These factors were found to be associated with an increased risk of delayed healing in medial malleolar fractures<sup>[12]</sup>.

Malunion of the MM generally follows a bi- or trimalleolar ankle fracture. Malalignment of the MM is connected with coronal shift of the talus and concurrent malalignment or shortening of the fibula due to the architecture of the ankle<sup>[13]</sup>.

In addition, without malunion of the MM component, there may be considerable ankle malunion linked to the fibula and talar displacement. Consequently, ankle malunion may not be associated with medial malleolar fixation. As a result, MM malunion is defined radiographically as articular incongruity 2 mm at the location of the MM fracture since this degree of step-off has been linked with aberrant joint kinematic<sup>[8]</sup>.

The findings of **Weinraub et al. (2017)** from their retrospective comparative study support the superiority of open reduction internal fixation (ORIF) over percutaneous fixation for medial malleolar fractures. The study involved the review of electronic medical records and digital radiographs of 845 patients who underwent either ORIF or percutaneous fixation. According to their results, ORIF was deemed superior to percutaneous fixation in terms of outcomes. They concluded that ORIF should be the preferred treatment option for healthy patients without any bone or wound healing risk factors. This suggests that ORIF provides better results and should be considered as the treatment of choice for medial malleolar fractures in appropriate patient populations<sup>[14]</sup>.

According to AOFAS score, there was no substantial change between both groups, the mean AOFAS score was  $89.8 \pm 12.74$  in Percutaneous group ranged from 69 to 100 and was  $86.4 \pm 15.69$  in Open group ranged from 72 to 95. According to AOFAS score criteria, there was no considerable change between both groups.

**Ebraheim et al. (2014)** performed a comparative analysis on 111 patients who had open reduction and

internal fixation for medial malleolar fractures (ORIF). This research assessed the efficacy of several fracture fixing procedures for transverse, oblique, and vertical fractures. Tension band fixation had the greatest union rate for transverse fractures at 79 percent. It also resulted in the highest average AOFAS score of 86, the lowest revision rate of 5%, and the lowest complication rate of 16%. At 71 percent, lag screws had the greatest union rate for oblique fractures. In addition, they obtained the highest average AOFAS score of 80, the lowest revision rate of 19%, and the lowest complication rate of 33% among regularly used fixation procedures. In all but one instance of vertical fractures, buttress plating was used, and union (whether normal or delayed) was accomplished. The average AOFAS score was 84, and there were no reported revisions or complications. These data demonstrate that various fixation procedures have variable outcomes depending on the kind of medial malleolar fracture, with tension band fixation producing the best results for transverse fractures, lag screws for oblique fractures, and buttress plating for vertical fractures<sup>[15]</sup>.

In the current study, there were non-significant difference between both groups according to complications as Open group showed some complication due to presence of surgical wound in contrary to percutaneous group like superficial wound infection and inflamed surgical wound that was treated by parenteral antibiotics and daily dressings in contrary to percutaneous technique with small surgical wound.

Supporting our results, **Abd El Ghany et al. (2022)** reported no substantially considerable change between type of fixation concerning infection incidence ( $P$ -value $>0.05$ )<sup>[9]</sup>.

According to **Matson et al. (2017)**, in the treatment of medial malleolar fractures, there was no statistically significant difference between the ORIF approach and the closed percutaneous method in terms of the incidence of infection<sup>[8]</sup>.

In contrast, **Burbano et al. (2021)** reported that Among fracture fixation, there was an overall complication rate of 8.4 percent, with ORIF accounting for 10.4 percent of problems and CRPP for 5.8 percent. Among fracture mechanisms, the high-energy mechanism of damage had a complication rate of 21,3 percent, while the low-energy mechanism had a complication rate of 4.3 percent. Also, infections were more prevalent in the group treated percutaneously. Reportedly, these pin-tract infections were effectively treated with antibiotics and K-wire removal following consolidation. No other effects have been recorded from these illnesses. 33% of the open-treated patients reported discomfort, compared to 22% of the closed-treatment patients<sup>[10]</sup>.

**Zaghloul et al. (2014)** reported that the higher incidence of infection in the ORIF group, particularly surgical site infection, is more prevalent in older patients with risk factors such diabetes, immunosuppression, and peripheral vascular disease<sup>[16]</sup>.

In addition, **Ovaska et al. (2013)** found that the open reduction approach has a 6.8% incidence of deep infection and that diabetes, alcohol misuse, fracture-dislocation, and soft-tissue damage are major patient-related risk factors for infection<sup>[17]</sup>.

Lastly, medial malleolar fractures may be repaired with ORIF or percutaneous technique. However, both approaches include a substantial number of complications.

In comparison to ORIF, the benefits of the percutaneous technique include a less invasive approach, less soft tissue dissection, and a decreased chance of wound healing issues. Therefore, it is more appropriate for people with comorbidities such diabetes, peripheral vascular disease, and cigarette use.

The benefit of ORIF is that permits direct viewing of the fracture and removal of the trapped periosteal flap, but it is a more dangerous procedure in patients with poor soft tissue condition, peripheral vascular disease, or diabetes.

## 5. Conclusion

The percutaneous technique for fixation of closed fractures of the medial malleolus is adequate and provided satisfactory final outcome but ORIF allows removal of the trapped periosteal flap, direct inspection of the joint and the fracture so, it is better to use open reduction technique in all cases but in cases with bad soft tissue condition percutaneous technique could be used with acceptable results.

## References

- [1] 1. B. Luo, Y. Wang, D. Wang. Effect of buttress plate in Herscovici type D vertical medial malleolar fractures and peripheral fractures: a retrospective comparative cohort study. *J Orthop Surg Res*;18:411. 2023
- [2] 2. R.M. Corey, L.K. Cannada, G. Bledsoe, H. Israel. Biomechanical evaluation of medial malleolus fractures treated with headless compression screws. *J Clin Orthop Trauma*;10:310-4. 2019
- [3] 3. T.H. Carter, W.M. Oliver, C. Graham, A.D. Duckworth, T.O. White. Medial malleolus: Operative Or Non-operative (MOON) trial protocol - a prospective randomised controlled trial of operative versus non-operative management of associated medial malleolus fractures in unstable fractures of the ankle. *Trials*;20:565. 2019
- [4] 4. B. Gao, Z. Xiang, Y. Fang, Q.Q. Kong, F.G. Huang, S.Q. Cen, et al. [Percutaneous screw fixation for pelvic fractures with fluoroscopy-based navigation]. *Zhongguo Gu Shang*;25:70-3. 2012
- [5] 5. K.H. Zhou, C.F. Luo, N. Chen, C.F. Hu, F.G. Pan. Minimally invasive surgery under fluoroscopy for anterior pelvic ring fractures. *Indian J Orthop*;50:250-5. 2016
- [6] 6. J.C. Koshy, E.M. Feldman, C.J. Chike-Obi, J.M. Bullocks. Pearls of mandibular trauma management. *Semin Plast Surg*;24:357-74. 2010
- [7] 7. T.K. Amin, I. Patel, M.J. Patel, M.M. Kazi, K. Kachhad, D.R. Modi. Evaluation of Results of Open Reduction and Internal Fixation (ORIF) of Fracture of Distal End of Femur with Intra-Articular Extension. *Malays Orthop J*;15:78-83. 2021
- [8] 8. A.P. Matson, S.R. Barchick, S.B. Adams. Comparison of Open Reduction and Internal Fixation Versus Closed Reduction and Percutaneous Fixation for Medial Malleolus Fractures. *J Am Acad Orthop Surg Glob Res Rev*;1:e048. 2017
- [9] 9. A.E.G. MA, M. MA, A.-A. ME, F. HE. Comparative study between percutaneous and open reduction with internal fixation of medial malleolar fracture by lag screw in adults. *Benha Journal of Applied Sciences*;7:49-60. 2022
- [10] 10. F.M. Burbano, P. Jones, N. Raghava, F.A. Herrera. Comparative Analysis of Open Reduction Internal Fixation and Closed Reduction Percutaneous Pinning of Hand Fractures: Single Academic Center Retrospective Review. *Ann Plast Surg*;86:S470-s2. 2021
- [11] 11. M. Osama Gamal, A. Shams. Percutaneous fixation of medial malleolar fractures.
- [12] 12. J. Hu, C. Zhang, K. Zhu, L. Zhang, W. Wu, T. Cai, et al. Adverse Radiographic Outcomes Following Operative Treatment of Medial Malleolar Fractures. *Foot Ankle Int*;39:1301-11. 2018
- [13] 13. P. Pflüger, K.F. Braun, O. Mair, C. Kirchhoff, P. Biberthaler, M. Crönlein. Current management of trimalleolar ankle fractures. *EFORT Open Rev*;6:692-703. 2021
- [14] 14. G.M. Weinraub, P. Levine, E. Shi, A. Flowers. Comparison of Medial Malleolar Fracture Healing at 8 Weeks After Open Reduction Internal Fixation Versus Percutaneous Fixation: A Retrospective Cohort Study. *J Foot Ankle Surg*;56:277-81. 2017
- [15] 15. N.A. Ebraheim, T. Ludwig, J.T. Weston, T. Carroll, J. Liu. Comparison of surgical techniques of 111 medial malleolar fractures classified by fracture geometry. *Foot Ankle Int*;35:471-7. 2014
- [16] 16. A. Zaghoul, B. Haddad, R. Barksfield, B. Davis. Early complications of surgery in operative treatment of ankle fractures in those over 60: a review of 186 cases. *Injury*;45:780-3. 2014
- [17] 17. M.T. Ovaska, T.J. Mäkinen, R. Madanat, K. Huotari, T. Vahlberg, E. Hirvensalo, et al. Risk factors for deep surgical site infection following operative treatment of ankle fractures. *J Bone Joint Surg Am*;95:348-53. 2013