Clinical Outcome Of Fixation Of Posterior Malleolus Fragment In Trimalleolar Ankle Fracture

Dr. Sharif Md. Musa[1*], Dr. Sazzad Hossain[2], Dr. Md. Saiful Islam[3]

[1]Medical officer, Department of Orthopedic Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh
[2]Medical officer, Department of Orthopedic Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh
[3]Medical officer, Department of Laboratory Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh
**Corresponding Author: Dr. Sharif Md. Musa, Medical officer, Department of Orthopedic Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, Email: sharifmdmusa99@gmail.com*

KEYWORDS
Trimalleolar fracture, posterior malleolus fixation, AOFAS score, surgical outcomes, ankle stability

ABSTRACT:
Background: Trimalleolar ankle fractures, involving the lateral, medial, and posterior malleoli, are complex injuries that significantly impact joint stability and long-term function. Fixation of the posterior malleolus fragment has emerged as an important consideration in optimizing surgical outcomes. **Aim of the study:** To evaluate the clinical and functional outcomes of posterior malleolus fixation in patients with trimalleolar ankle fractures. **Methods:** This retrospective observational study included 85 patients with radiographically confirmed trimalleolar fractures who underwent posterior malleolus fixation using either posterior-to-anterior screws or plate fixation. Functional recovery was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score at preoperative and postoperative intervals (6 weeks, 3 months, 6 months, and 12 months). Complications were also documented. **Result:** The mean age of the study population was 43.2 ± 11.5 years, with 60% males. Posterior-to-anterior screw fixation was used in 70% of cases, and plate fixation in 30%. At 12 months, the mean AOFAS score improved from 42.6 ± 8.3 preoperatively to 85.2 ± 7.4 ($p < 0.001$). Complication rates were low, with infection (9.4%) and joint stiffness (8.2%) being the most common. Radiographic assessment revealed satisfactory alignment in the majority of cases, particularly with combined fixation techniques. **Conclusion:** Fixation of the posterior malleolus fragment in trimalleolar ankle fractures results in significant functional improvement and high rates of satisfactory alignment, with low complication rates. These findings support the importance of posterior fragment fixation in restoring joint stability and improving clinical outcomes.

INTRODUCTION

Trimalleolar ankle fractures, defined as fractures involving the lateral malleolus, medial malleolus, and posterior malleolus of the distal tibia, represent one of the most severe and unstable forms of ankle injuries [1]. These injuries pose considerable challenges due to their complex anatomical involvement, potential for articular surface disruption, and the high risk of long-term complications if inadequately managed [2]. Globally, ankle fractures are the third most common type of fracture, accounting for approximately 15 to 20 million of all fractures, and trimalleolar fractures constitute about 1756 of these cases, particularly affecting the elderly and individuals with osteoporotic bone [3,4]. In Bangladesh, a recent tertiary hospital-based retrospective analysis found that trimalleolar fractures comprise nearly 23% of surgically treated ankle injuries, with a rising trend observed in road traffic accidents and fall-

related trauma [5]. The posterior malleolus, or the posterolateral tibial plafond, is biomechanically significant as it contributes to the stability of the tibiotalar joint, particularly by supporting the posterior inferior tibiofibular ligament (PITFL) and maintaining syndesmotic integrity [6]. Fractures of the posterior malleolus were often underappreciated or managed conservatively, especially when involving a small portion of the articular surface [7]. However, evolving evidence suggests that even smaller posterior malleolar fragments can substantially affect joint congruity and stability, and their neglect may lead to malreduction, syndesmotic diastasis, altered biomechanics, and early-onset post-traumatic osteoarthritis [8]. Recent biomechanical studies and clinical reviews have demonstrated that anatomical reduction and internal fixation of the posterior malleolus, regardless of fragment size, may enhance syndesmotic stability, reduce the need for trans-syndesmotic fixation, and improve overall clinical outcomes [9]. Direct approaches as posterolateral or posteromedial incisions permit visualization of the fragment and allow for more precise reduction and rigid fixation [10]. Indirect anterior-to-posterior screw techniques may fail to achieve optimal reduction and are associated with suboptimal biomechanical results [11]. Despite these advancements, consensus is still lacking regarding specific indications for fixation, fragment size thresholds, optimal surgical approach, and their impact on long-term functional recovery [12]. Furthermore, numerous studies have evaluated the radiological and clinical outcomes of posterior malleolus fixation in trimalleolar fractures using different scoring systems, such as the Olerud-Molander Ankle Score (OMAS), American Orthopaedic Foot and Ankle Society (AOFAS) scores, and visual analogue scale (VAS) for pain [13]. While several studies suggest improved functional scores and reduced arthritis progression with fixation, others report minimal differences, highlighting the need for more population-based clinical investigations that consider surgical timing, patient-specific factors (e.g., age, comorbidities), and variations in fracture morphology [14]. Given the limited yet evolving body of literature, especially in resource-limited settings like Bangladesh, a comprehensive evaluation of the clinical outcomes of posterior malleolus fixation in trimalleolar ankle fractures is warranted to guide evidence-based practice [15]. Therefore, the aim of this study is to evaluate the clinical and functional outcomes associated with posterior malleolus fixation in surgically treated trimalleolar ankle fractures.

METHODOLOGY & MATERIALS

This retrospective observational study was conducted at Department of Orthopedic Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, over a period of one year, from July 2021 to June 2022. This was a retrospective analysis of prospectively maintained clinical data from patients with trimalleolar ankle fractures who underwent surgical fixation of the posterior malleolus fragment.

Inclusion Criteria

- Patients aged 18 years and above.
- Radiographically confirmed trimalleolar ankle fractures.
- Patients treated operatively with fixation of the posterior malleolus fragment using either posterior plating or screw fixation.
- Minimum follow-up duration of 12 months with complete clinical and radiographic records.

Exclusion Criteria

- Pathological fractures.
- Open fractures classified as Gustilo-Anderson Type II or III.
- History of previous ankle surgery or deformity.
- Patients with incomplete follow-up or missing outcome data.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee prior to the initiation of the study. Informed written consent was obtained from all patients at the time of treatment, allowing the use of their clinical data for academic and research purposes.

Surgical Procedure

All patients underwent fixation of the posterior malleolus under spinal anesthesia using a posterolateral surgical approach. The fixation technique included either posterior-to-anterior screw fixation or posterior plating, depending on the size and configuration of the fracture fragment. Additional fixation for the medial and lateral malleoli, and syndesmotic stabilization when required, were performed according to standard operative protocols.

Biomechanical Considerations

The surgical planning and fixation approach incorporated basic biomechanical principles to optimize outcomes:

- The force equilibrium equation was used to ensure proper load transmission across the fracture site.
- The torque balance equation helped maintain rotational stability during healing.
- The stress-strain relationship (Hooke's Law) guided the choice of implant material and configuration to reduce the risk of hardware failure.
- A fracture healing rate model was used to estimate recovery timelines and guide rehabilitation planning.

Postoperative Care and Rehabilitation

Postoperatively, patients were immobilized in a below-knee splint or cast for 2–3 weeks, followed by gradual mobilization. Partial weight-bearing was initiated by 6 weeks post-op based on radiographic signs of healing, with progression to full weight-bearing as tolerated. All patients underwent supervised physiotherapy to restore range of motion and function.

Data Collection

Data were collected retrospectively from the medical records and surgical databases. Demographic details, comorbidities (e.g., diabetes, hypertension, smoking status), laterality, fixation method, surgical approach, and duration of surgery were collected from the hospital database. Postoperative complications such as infection, joint stiffness, hardware failure, and non-union were recorded. Functional outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score at five time points: preoperatively, 6 weeks, 3 months, 6 months, and 12 months postoperatively.

Data Analysis

Statistical analysis was conducted using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD). Paired t-tests were used to compare preoperative and postoperative AOFAS scores across different time points. A p-value of <0.05 was considered statistically significant.

RESULT

A total of 85 patients were included in the study. The baseline characteristics of the study population are illustrated in Table 1. The average age of the participants was 43.2±11.5 years, indicating that most patients were middle-aged. Out of the total, 51 (60.00%) were male and 34 (40.00%) were female, showing a male predominance. The right ankle was more frequently involved, observed in 47 (55.29%) patients, while the left ankle was affected in 38 (44.71%) cases. Several comorbid conditions were also noted. Among them, 24 (28.24%) patients had diabetes mellitus, 17 (20.00%) had a history of hypertension, and 12 (14.12%) reported being current or former smokers. All 85 (100%) patients underwent fixation of the posterior malleolar fragment. Regarding the fixation method used, 60 (70%) patients received posterior-to-anterior screw fixation, while 25 (30%) were managed using plate fixation. Concerning the surgical approach, the posterolateral approach was employed in 54 (63.3%) cases, whereas a medial or combined approach was used in 31 (36.7%) patients. In addition, 20 (23.3%) patients underwent additional syndesmosis fixation. The mean duration of the operative procedure was 95±18 minutes, indicating moderate surgical time (Table 2). Radiographic alignment outcomes based on the type of fixation method are illustrated in Figure 1. Satisfactory alignment was observed in 80% of the patients treated with screw fixation. Similarly, 75% of patients managed with plate fixation and

85% of those treated with a combination technique demonstrated good alignment. In contrast, only 50% of patients treated conservatively achieved satisfactory alignment. Among the 85 patients, 64 (75.29%) had no complications during the follow-up period. However, 8 (9.41%) patients developed infection, 7 (8.24%) experienced joint stiffness, 4 (4.71%) had hardware failure, and 2 (2.35%) showed signs of non-union (Table 3). The functional recovery, assessed using the AOFAS score, is demonstrated in Table 4. The mean preoperative score was 42.6±8.3. Postoperatively, there was steady improvement: 58.4±9.7 at 6 weeks, 68.9±8.6 at 3 months, 77.1±7.5 at 6 months, and 85.2±7.4 at 12 months. Each postoperative score was significantly higher than the baseline, with p-values <0.001.

Table 1: Baseline characteristics of the study population (n=85)

Parameters	Frequency (n)	Percentage (%)
Age (years), (Mean±SD)	43.2±11.5	
Gender		
Male	51	60.00
Female	34	40.00
Affected side		
Right ankle	47	55.29
Left ankle	38	44.71
Comorbidities		
Diabetes	24	28.24
Hypertension	17	20.00
Smoking history	12	14.12

Table 2: Surgical and fixation details of the study population (n=85)

Parameter	Frequency (n)	Percentage (%)
Posterior fragment fixation performed	85	100
Fixation method		
Posterior-to-anterior screw	60	70
Plate fixation	25	30
Approach used		
Posterolateral	54	63.3
Medial or combined	31	36.7
Additional syndesmosis fixation	20	23.3
Duration of surgery (minutes), (Mean ± SD)	95 ± 18	

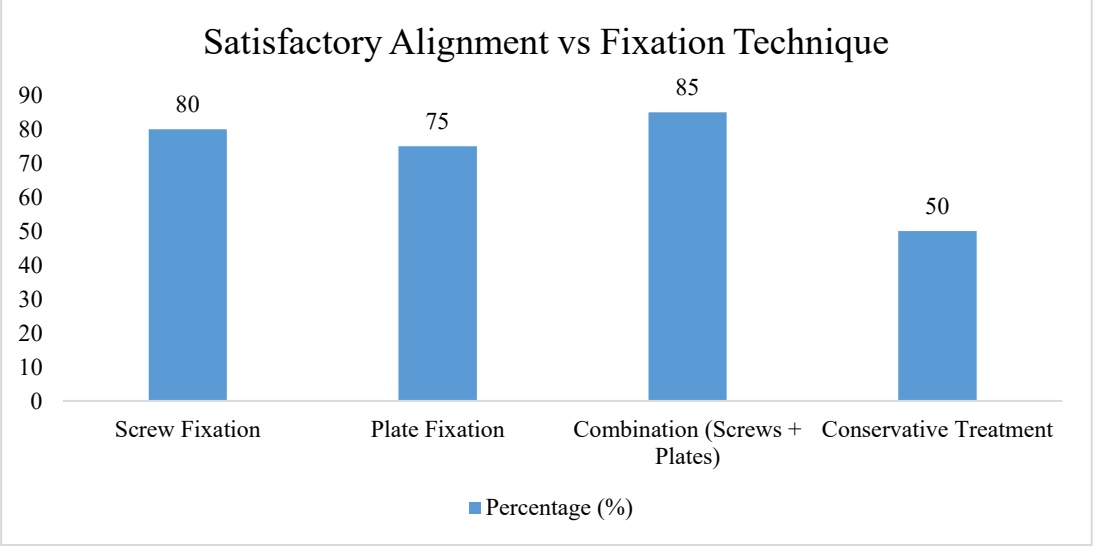

Figure 1: Bar chart showing radiography: good alignment

Table 3: Complication among patients (n=85)

Complication Type	Frequency (n)	Percentage (%)
No Complication	64	75.29
Infection	8	9.41
Joint Stiffness	7	8.24
Hardware Failure	4	4.71
Non-union	2	2.35

Table 4: Functional outcome table (AOFAS Score Improvement)

Time Point	Mean AOFAS Score ± SD	Mean Change from Pre-op	p-value
Pre-op	42.6 ± 8.3	–	–
6 weeks post-operative	58.4 ± 9.7	+15.8	<0.001
3 months post-operative	68.9 ± 8.6	+26.3	<0.001
6 months post-operative	77.1 ± 7.5	+34.5	<0.001
12 months post-operative	85.2 ± 7.4	+42.6	<0.001

DISCUSSION

Trimalleolar ankle fractures involve the lateral, medial, and posterior malleoli, often resulting in joint instability and poor functional outcomes if inadequately treated. Fixation of the posterior malleolus fragment has gained increasing attention for its role in restoring ankle stability, congruity, and long-term function. This study evaluated the clinical and functional outcomes of posterior malleolus fixation in trimalleolar fractures using the American Orthopaedic Foot and Ankle Society (AOFAS) score. In this study, the mean age of patients was 43.2±11.5 years, indicating that these injuries predominantly affected middle-aged adults. A study reported that the peak incidence of trimalleolar fractures is in the age from 60 to 69 years [1]. Gender distribution in our study showed a male predominance (60%), which may reflect occupational or activity-related risk differences. Elsoe et al found that the incidence shows a peak incidence among adolescents in both genders with a male predominance [16]. The laterality of injury showed a slightly higher involvement of the right ankle (55.3%) compared to the left (44.7%) in this study. We observed diabetes in 28% and hypertension in 20% of patients, with smoking in 14%. Diabetes is a known predictor of poorer outcomes, including wound complications and stiffness

[17]. Smoking has similarly been identified as a risk factor for infection and delayed healing in ankle fracture surgery [18]. In our series, all cases underwent fixation of the posterior malleolus fragment. The majority were fixed using posterior-to-anterior screws (70%), while plate fixation was utilized in 30%. The posterolateral approach was favored in roughly two-thirds of cases (63%), with medial or combined approaches in 37%. Syndesmotic fixation was added for 23% of patients when instability persisted, and mean surgery time was 95 ± 18 minutes. While locking plates have become increasingly prevalent, screw fixation alone is still widely used and not entirely supplanted by locking plates. The choice between the two depends on various factors, including fracture type, bone quality, and surgical approach. The findings from surgical features in our study are comparable with the results of Pilskog et al [19]. According to our study, satisfactory alignment rates by fixation method: Screw fixation: 80%, Plate fixation: 75%, Combination (Screw + Plate): 85%, and Conservative treatment: 50%. In other words, direct surgical methods consistently outperform conservative care, with combination treatment yielding the highest alignment success. These results align with the findings of Pina et al, who reported a mean AOFAS score of 82.5 in patients treated with posterior malleolus fixation [20]. These outcomes indicate that surgical fixation promotes better weight-bearing capacity, pain reduction, and joint stability, ultimately contributing to enhanced functional performance. Regarding complications, 75.3% of our patients had no post-operative complications. The most common complication was superficial infection (9.4%), followed by joint stiffness (8.2%) and hardware failure (4.7%). These rates are relatively low. Behery et al reported that posterior plating offers greater stability and a lower incidence of malunion compared to screw fixation alone [21]. Furthermore, Park et al emphasized that fixation is especially advantageous when the posterior malleolar fragment involves more than 25% of the articular surface, reinforcing our findings [22]. Our cohort demonstrated a robust and progressive improvement in AOFAS scores—from a mean of 42.6 ± 8.3 preoperatively to 85.2 ± 7.4 at 12 months post-op, representing a 42.6-point increase ($p < 0.001$). Significant gains were observed as early as 6 weeks (+15.8 points) and continued steadily through 3 months (+26.3) and 6 months (+34.5). Our results confirm that fixation of the posterior malleolus fragment in trimalleolar ankle fractures produces significant, time-dependent functional improvements—achieving a mean AOFAS score in the good range (~85) by 12 months. While slightly lower than pooled ORIF outcomes (~90–92), our data reinforce the benefit of addressing the posterior fragment.

Limitations of the study:

- The absence of a non-fixation or conservatively managed control group prevents direct comparison of outcomes.
- Only AOFAS scoring was used; additional patient-reported outcome measures (e.g., OMAS, VAS) could provide a more comprehensive evaluation.

CONCLUSION

Fixation of the posterior malleolus fragment in trimalleolar ankle fractures leads to significant functional improvement, as evidenced by progressive increases in AOFAS scores, and achieves satisfactory radiographic alignment in most cases. The use of direct surgical approaches, combined with appropriate fixation techniques, contributes to enhanced ankle stability and reduced complication rates. Despite the favorable short-term outcomes, further multicenter prospective studies with larger sample sizes and extended follow-up are recommended to assess long-term functional recovery, incidence of post-traumatic osteoarthritis, and comparative efficacy of different fixation methods.

Funding: No funding sources
Conflict of interest: None declared

REFERENCES

1. Pflüger P, Braun KF, Mair O, Kirchhoff C, Biberthaler P, Crönlein M. Current management of trimalleolar ankle fractures. EFORT open reviews. 2021 Aug 10;6(8):692-703.
2. Mehta SS, Rees K, Cutler L, Mangwani J. Understanding risks and complications in the management of ankle fractures. Indian Journal of Orthopaedics. 2014 Oct;48(5):445-52.

3. Kannus P, Parkkari J, Niemi S, Palvanen M. Epidemiology of osteoporotic ankle fractures in elderly persons in Finland. Annals of internal medicine. 1996 Dec 15;125(12):975-8.
4. Juto H, Nilsson H, Morberg P. Epidemiology of adult ankle fractures: 1756 cases identified in Norrbotten County during 2009–2013 and classified according to AO/OTA. BMC musculoskeletal disorders. 2018 Dec 13;19(1):441.
5. Haque A. Surgical outcome of closed bi-malleolar fracture in adult, Bangladesh perspective. Sch J Med Case Rep. 2021 Aug;8:773-82.
6. Miller AN, Carroll EA, Parker RJ, Helfet DL, Lorich DG. Posterior malleolar stabilization of syndesmotic injuries is equivalent to screw fixation. Clinical Orthopaedics and Related Research®. 2010 Apr;468(4):1129-35.
7. Odak S, Ahluwalia R, Unnikrishnan P, Hennessy M, Platt S. Management of posterior malleolar fractures: a systematic review. The Journal of foot and ankle surgery. 2016 Jan 1;55(1):140-5.
8. Drijfhout van Hooff CC, Verhage SM, Hoogendoorn JM. Influence of fragment size and postoperative joint congruency on long-term outcome of posterior malleolar fractures. Foot & Ankle International. 2015 Jun;36(6):673-8.
9. Van den Bekerom MP, Haverkamp D, Kloen P. Biomechanical and clinical evaluation of posterior malleolar fractures. A systematic review of the literature. Journal of Trauma and Acute Care Surgery. 2009 Jan 1;66(1):279-84.
10. Talbot M, Steenblock TR, Cole PA. Surgical technique: posterolateral approach for open reduction and internal fixation of trimalleolar ankle fractures. Canadian journal of surgery. 2005 Dec;48(6):487.
11. Kyriakopoulos G, Panagopoulos A, Pasiou E, Kourkoulis SK, Diamantakos I, Anastopoulos G, Tserpes K, Tatani I, Lakoumentas J, Megas P. Optimizing fixation methods for stable and unstable intertrochanteric hip fractures treated with sliding hip screw or cephalomedullary nailing: A comparative biomechanical and finite element analysis study. Injury. 2022 Dec 1;53(12):4072-85.
12. Metsemakers WJ, Morgenstern M, Senneville E, Borens O, Govaert GA, Onsea J, Depypere M, Richards RG, Trampuz A, Verhofstad MH, Kates SL. General treatment principles for fracture-related infection: recommendations from an international expert group. Archives of orthopaedic and trauma surgery. 2020 Aug;140(8):1013-27.
13. Martin KD, Tripp CT, Huh J. Outcomes of posterior arthroscopic reduction and internal fixation (PARIF) for the posterior malleolar fragment in trimalleolar ankle fractures. Foot & Ankle International. 2021 Feb;42(2):157-65.
14. Karaca S, Enercan M, Ozdemir G, Kahraman S, Çobanoğlu M, Küçükkaya M. Importance of fixation of posterior malleolus fracture in trimalleolar fractures: a retrospective study. Turkish Journal of Trauma and Emergency Surgery. 2016 Nov 1;22(6):553-8.
15. Dlamini NK. A descriptive study of the prevalence of Acute Foot and Ankle complaints/injuries of adults attending a public sector secondary hospital orthopaedic clinic in South Africa over a 12-week period.
16. Elsoe R, Ostgaard SE, Larsen P. Population-based epidemiology of 9767 ankle fractures. Foot and Ankle Surgery. 2018 Feb 1;24(1):34-9.
17. Dasari N, Jiang A, Skochdopole A, Chung J, Reece EM, Vorstenbosch J, Winocour S. Updates in diabetic wound healing, inflammation, and scarring. InSeminars in plastic surgery 2021 Aug (Vol. 35, No. 03, pp. 153-158). Thieme Medical Publishers, Inc..
18. Mehta SS, Rees K, Cutler L, Mangwani J. Understanding risks and complications in the management of ankle fractures. Indian Journal of Orthopaedics. 2014 Oct;48(5):445-52.
19. Pilskog K, Gote TB, Odland HE, Fjeldsgaard KA, Dale H, Inderhaug E, Fevang JM. Traditional approach vs posterior approach for ankle fractures involving the posterior malleolus. Foot & Ankle International. 2021 Apr;42(4):389-99.
20. Pina G, Fonseca F, Vaz A, Carvalho A, Borralho N. Unstable malleolar ankle fractures: evaluation of prognostic factors and sports return. Archives of Orthopaedic and Trauma Surgery. 2021 Jan;141(1):99-104.
21. Behery OA, Narayanan R, Konda SR, Tejwani NC, Egol KA. Posterior malleolar fixation reduces the incidence of trans-syndesmotic fixation in rotational ankle fracture repair. The Iowa Orthopaedic Journal. 2021;41(1):121.

22. Park JS, Porter DA, Sferra JJ, Cooper MT. Postoperative Weight Bearing and Rehabilitation After Foot and Ankle Surgery. Foot & Ankle Specialist. 2020 Aug;13(4):330-4.