

Original Research Article

FUNCTIONAL OUTCOMES OF BIMALLEOLAR ANKLE FRACTURES TREATED WITH OPEN REDUCTION AND INTERNAL FIXATION

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ABSTRACT

Background: Bimalleolar ankle fractures are unstable injuries requiring surgical intervention to restore joint congruity and function. Open reduction and internal fixation is widely used for achieving anatomical reduction and stability. The aim is to study the functional outcome of surgical treatment of bimalleolar ankle fractures and to assess the complications associated with open reduction and internal fixation.

Materials and Methods: A prospective study was conducted on 150 patients treated with open reduction and internal fixation. Functional outcomes were assessed using clinical, radiological, and composite scoring systems. Statistical analysis was performed with significance set at $p < 0.05$.

Results: Majority of patients were in the 21–40 years age group. Diabetes mellitus and smoking were common co-morbidities. Supination external rotation was the most common injury type (45.33%). Good to excellent outcomes were achieved in 72.00% of patients. Stability was restored in 100.00% of cases, with minimal complications.

Conclusion: Open reduction and internal fixation of bimalleolar ankle fractures provides excellent functional outcomes with high stability and low complication rates when performed with proper technique and rehabilitation.

Keywords: Bimalleolar fracture, Ankle, Open reduction internal fixation, Functional outcome.

INTRODUCTION

Bimalleolar ankle fractures are common and clinically important injuries involving both the medial and lateral malleoli, often resulting in loss of ankle stability, disruption of joint congruity, and impairment of weight-bearing function. These fractures may occur due to road traffic accidents, twisting injuries, sports trauma, or falls, and they require careful evaluation because malreduction may lead to chronic pain, stiffness, instability, and post-traumatic arthritis. Open reduction and internal fixation remains an important treatment option for unstable bimalleolar fractures because it helps restore anatomical alignment, ankle mortise congruity, and early functional rehabilitation.^[1]

The ankle joint is a weight-bearing hinge joint in which even minor alteration in articular congruity can significantly affect biomechanics. In bimalleolar fractures, both the medial and lateral stabilizing

columns are disrupted, making the injury mechanically unstable. The main principle of treatment is to achieve anatomical reduction of the malleoli, restore fibular length and rotation, maintain medial stability, and re-establish the normal relationship between the tibia, fibula, and talus. Surgical fixation allows direct visualization of the fracture, stable fixation, and restoration of joint alignment, which are essential for good functional recovery.^[2]

Functional outcome after bimalleolar ankle fracture depends on multiple factors, including patient age, fracture pattern, soft tissue condition, timing of surgery, accuracy of reduction, fixation stability, rehabilitation protocol, and associated complications. Recent clinical studies have shown that patients treated with open reduction and internal fixation commonly achieve good to excellent results when anatomical reduction and stable fixation are obtained.^[3] However, complications such as

superficial infection, delayed wound healing, ankle stiffness, implant irritation, malunion, non-union, and residual pain may affect postoperative recovery and final functional outcome.^[4]

Assessment of functional recovery is commonly performed using validated scoring systems such as the American Orthopaedic Foot and Ankle Society score, Olerud-Molander Ankle Score, Visual Analogue Scale, and range of motion assessment. These tools help quantify pain, walking ability, stability, activity limitation, and return to daily function. Studies evaluating operated ankle fractures have emphasized that restoration of ankle function is not dependent only on radiological union, but also on pain relief, mobility, patient satisfaction, and ability to resume routine activities.^[5]

The role of postoperative rehabilitation is equally important in determining final outcome. Early mobilization and appropriate weight-bearing, when permitted by fixation stability and soft tissue condition, may improve ankle function during recovery. Recent evidence suggests that early weight-bearing after operative fixation can improve short-term ankle function without clearly increasing re-operation risk in appropriately selected patients.^[6] Therefore, surgical fixation and rehabilitation should be considered complementary components of treatment rather than separate stages.

In elderly patients, bimalleolar ankle fractures present additional challenges because of osteoporosis, fragile soft tissue, associated comorbidities, and higher risk of complications. Treatment decisions must balance the need for stable fixation with the patient's general condition and skin viability. Literature emphasizes that the main goal in such patients is early restoration of mobility and prevention of loss of autonomy, while carefully minimizing wound-related complications.^[7]

In high-energy ankle injuries and fracture-dislocations, functional recovery may be comparatively poorer because of greater soft tissue damage, cartilage injury, syndesmotic involvement, and risk of post-traumatic osteoarthritis. A recent systematic review reported that ankle fracture-dislocations are associated with meaningful complication rates, including wound infection, non-union or malunion, and post-traumatic osteoarthritis, highlighting the importance of timely reduction, stable fixation, and careful postoperative monitoring.^[8]

Despite advances in implants, surgical technique, and rehabilitation, outcomes after bimalleolar ankle fractures remain variable. Some patients regain excellent function, while others continue to experience pain, stiffness, swelling, difficulty in squatting or stair climbing, and reduced walking tolerance. Therefore, continuous evaluation of clinical and functional outcomes following open reduction and internal fixation is necessary to understand the effectiveness of treatment in different clinical settings.^[9]

The present study, titled "Study on Functional Outcome of Bimalleolar Ankle Fractures Treated by Open Reduction and Internal Fixation," was undertaken to evaluate the functional outcome of surgical treatment of bimalleolar ankle fractures and to assess the complications associated with open reduction and internal fixation. By analyzing postoperative recovery and complications, this study aims to contribute meaningful clinical evidence regarding the effectiveness of operative management in restoring ankle stability and function.^[10]

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics at a tertiary care hospital to evaluate the functional outcome of bimalleolar ankle fractures treated by open reduction and internal fixation. A total of 150 patients diagnosed with bimalleolar ankle fractures and fulfilling the inclusion criteria were enrolled during the study period. Patients aged between 18 and 60 years presenting with closed bimalleolar ankle fractures were included in the study. Patients with open fractures, pathological fractures, polytrauma, previous ankle surgery, associated neurovascular injuries, or severe comorbid conditions affecting mobility were excluded.

All patients underwent a detailed clinical assessment including history of injury, mechanism of trauma, and physical examination. Radiological evaluation was performed using standard anteroposterior, lateral, and mortise views of the ankle joint to confirm the diagnosis and classify the fracture. Preoperative assessment included evaluation of swelling, skin condition, and timing of surgery was planned accordingly to minimize soft tissue complications. Functional status prior to surgery was assessed using standardized scoring systems such as the Olerud-Molander Ankle Score and Visual Analogue Scale for pain.



Figure 1: X-ray of bimalleolar fracture

All patients were treated with open reduction and internal fixation under appropriate anesthesia. Surgical technique involved anatomical reduction of the fracture fragments with fixation of the lateral malleolus using plate and screws and fixation of the medial malleolus using cancellous screws or tension band wiring, depending on fracture configuration. Intraoperative fluoroscopy was used to confirm adequate reduction and implant placement. Syndesmotic stability was assessed intraoperatively and fixation was performed when required. Postoperatively, the limb was immobilized initially, followed by gradual mobilization as per a standardized rehabilitation protocol. Weight-bearing was allowed progressively based on fracture stability and radiological evidence of healing.

Patients were followed up at regular intervals at 6 weeks, 3 months, and 6 months postoperatively. At each follow-up, clinical and radiological assessment was performed to evaluate fracture union, range of motion, pain, and complications such as infection, implant failure, malunion, or stiffness. Functional outcome was assessed using the Olerud-Molander Ankle Score and American Orthopaedic Foot and Ankle Society score at the final follow-up.



Figure 2: X-rays taken at 6 months revealing a healed ankle fracture

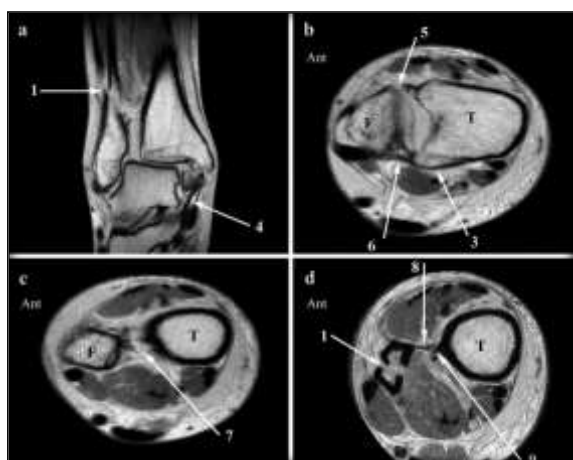


Figure 3: Coronal (a), 45° oblique (b, c), and axial proton-density-weighted (d) MR image

The coronal MRI shows the laterally dislocated talus, with a distal fibula fracture (1) and an avulsion

fracture of the medial malleolus (2) attached to a thickened but intact superficial deltoid ligament (4). In b, the ATIFL (5) is ruptured, whereas the PTIFL (6) is intact and attached to an avulsion fracture of the posterolateral malleolus (3). In c, the ruptured interosseous ligament (7) is visible. In d, the fibula fracture (1) runs proximal to the interosseous membrane (8), which has a small tibial avulsion (9) up to this level. Ant Anterior, T tibia, F fibula

The collected data were compiled and entered into Microsoft Excel and analyzed using appropriate statistical software. Quantitative variables were expressed as mean and standard deviation, while qualitative variables were presented as frequencies and percentages. Comparison of preoperative and postoperative functional scores was performed using paired t-test or Wilcoxon signed-rank test based on the distribution of data. A p-value of less than 0.05 was considered statistically significant.

Ethical clearance for the study was obtained from the Institutional Ethics Committee prior to commencement of the study. All participants were informed about the study protocol and written informed consent was obtained. The study was conducted in accordance with ethical principles outlined in the Declaration of Helsinki.

RESULTS

A total of 150 patients were included in the present study. [Table 1] shows the age distribution of the study population. The majority of patients were in the age group of 31–40 years accounting for 52 patients (34.67%), followed by 21–30 years with 46 patients (30.67%). Patients in the 41–50 years group were 28 (18.67%), while younger patients aged 18–20 years constituted 14 cases (9.33%). The least number of patients were seen in the age group above 50 years with 10 cases (6.67%). The mean age of the study population was 34.2 ± 9.1 years, indicating that bimalleolar fractures are more common in the active middle-aged population.

[Table 2] describes the distribution of co-morbidities among patients. Diabetes mellitus was the most common co-morbidity observed in 42 patients (28.00%), followed by smoking in 36 patients (24.00%) and hypertension in 30 patients (20.00%). Coronary artery disease and bronchial asthma were less common, seen in 8 patients (5.33%) and 6 patients (4.00%) respectively. A total of 28 patients (18.67%) had no associated co-morbidities, indicating that systemic conditions may influence fracture occurrence and recovery.

[Table 3] represents the type of injury distribution among the study population. Supination external rotation (SER) type was the most common injury pattern observed in 68 patients (45.33%), followed by pronation external rotation (PER) in 36 patients (24.00%). Supination adduction (SADD) accounted for 22 cases (14.67%) and pronation adduction (PABD) for 24 cases (16.00%). This distribution

highlights that rotational injuries are the predominant mechanism in bimalleolar fractures.

[Table 4] shows the implants used in the present study. For medial malleolus fixation, cancellous screws were used in 102 cases (68.00%) and malleolar screws in 48 cases (32.00%). For lateral malleolus fixation, one-third tubular plate was used in 96 patients (64.00%) while reconstruction plate was used in 54 patients (36.00%). Syndesmotic fixation using cortical screws was required in 30 patients (20.00%), while 120 patients (80.00%) did not require syndesmotic stabilization.

[Table 5] presents the final functional score according to subjective, objective, and radiological criteria. Pain assessment showed Grade A in 52 patients (34.67%) and Grade B in 88 patients (58.67%), with no patients in lower grades. Stability of ankle was excellent in all patients with Grade A observed in 150 cases (100.00%). Ability to walk was Grade A in 90 patients (60.00%), Grade B in 45 patients (30.00%), and Grade C in 15 patients (10.00%). Ability to run

showed Grade A in 72 patients (48.00%), Grade B in 54 patients (36.00%), Grade C in 18 patients (12.00%), and Grade D in 6 patients (4.00%). Ability to work was Grade A in 96 patients (64.00%) and Grade B in 54 patients (36.00%). Ankle movements were normal (Grade A) in 132 patients (88.00%), while minimal restriction was seen in 12 patients (8.00%) and mild limitation in 6 patients (4.00%). Radiological outcomes showed Grade A in 134 patients (89.33%), Grade B in 10 patients (6.67%), and Grade C in 6 patients (4.00%).

[Table 6] shows the composite score distribution. Excellent outcome (96–100) was achieved in 48 patients (32.00%), good outcome (91–95) in 60 patients (40.00%), fair outcome (81–90) in 30 patients (20.00%), and poor outcome (0–80) in 12 patients (8.00%). Overall, 108 patients (72.00%) had good to excellent outcomes, indicating favorable functional recovery following open reduction and internal fixation.

Table 1: Age Distribution

Age Group (years)	Number	Percentage (%)
18–20	14	9.33
21–30	46	30.67
31–40	52	34.67
41–50	28	18.67
>50	10	6.67
Total	150	100.00

Table 2: Co-morbidities

Co-morbidity	Number	Percentage (%)
HTN	30	20.00
DM	42	28.00
CAD	8	5.33
BA	6	4.00
Smoker	36	24.00
None	28	18.67
Total	150	100.00

Table 3: Type of Injury

Type of Injury	Number	Percentage (%)
SER	68	45.33
SADD	22	14.67
PER	36	24.00
PABD	24	16.00
Total	150	100.00

Table 4: Implants Used

Fixation Site	Implant Type	Number	Percentage (%)
Medial malleolus	Cancellous screw	102	68.00
	Malleolar screw	48	32.00
Lateral malleolus	1/3 tubular plate	96	64.00
	Recon plate	54	36.00
Syndesmotic fixation	Yes	30	20.00
	No	120	80.00

Table 5: Final Score According to Subjective, Objective and Radiological Criteria

Criteria	Grade A	Grade B	Grade C	Grade D	Grade E	Total
Pain	52	88	10	0	0	150
Stability of ankle	150	0	0	0	0	150
Ability to walk	90	45	15	0	0	150
Ability to run	72	54	18	6	0	150
Ability to work	96	54	0	0	0	150
Ankle movements	132	12	6	0	0	150
Radiography	134	10	6	0	0	150

Table 6: Composite Score

Composite Score	Number of Patients	Percentage (%)
96–100 (Excellent)	48	32.00
91–95 (Good)	60	40.00
81–90 (Fair)	30	20.00
0–80 (Poor)	12	8.00
Total	150	100.00

DISCUSSION

The present study evaluated the functional outcome of bimalleolar ankle fractures treated with open reduction and internal fixation in 150 patients and demonstrated favorable clinical and functional results. The age distribution in the present study showed that the majority of patients were in the 21–40 years age group (65.34%), with a mean age of 34.2 ± 9.1 years, indicating that these injuries predominantly affect the active working population. Similar findings have been reported in previous studies where ankle fractures were more common in young and middle-aged individuals due to increased exposure to trauma and physical activity.^[11]

The distribution of co-morbidities revealed that diabetes mellitus (28.00%), smoking (24.00%), and hypertension (20.00%) were the most common associated conditions. These factors are known to influence fracture healing, wound complications, and overall functional recovery. Previous studies have emphasized that systemic co-morbidities, especially diabetes and smoking, are associated with delayed healing and increased postoperative complications in ankle fracture management.^[12]

In the present study, the most common mechanism of injury was supination external rotation type (45.33%), followed by pronation external rotation (24.00%), which is consistent with the widely accepted Lauge-Hansen classification patterns. Rotational injuries are commonly implicated in ankle fractures due to twisting forces acting on the joint, and similar distributions have been reported in other clinical studies evaluating ankle fracture patterns.^[13] The implant distribution showed that cancellous screws were predominantly used for medial malleolus fixation (68.00%), while one-third tubular plates were most commonly used for lateral malleolus fixation (64.00%). Syndesmotic fixation was required in 20.00% of patients, indicating that a significant proportion of fractures involved syndesmotic instability. Proper implant selection and restoration of fibular length and alignment are critical factors in achieving optimal functional outcomes, as highlighted in previous literature.^[14]

Functional outcome assessment in the present study demonstrated excellent to good results in the majority of patients. According to composite scoring, 72.00% of patients achieved good to excellent outcomes, with 32.00% classified as excellent and 40.00% as good. Pain assessment showed that 93.34% of patients were in Grade A or B, indicating effective pain relief following surgery. Stability of the ankle was restored in all patients (100.00%), reflecting the effectiveness

of anatomical reduction and stable fixation. Ability to walk was preserved in 90.00% of patients with Grade A and B scores, while running ability showed slightly lower performance, with 84.00% in Grade A and B, likely due to higher functional demand. These findings are comparable with previous studies which have demonstrated that anatomical fixation leads to satisfactory restoration of ankle function and mobility.^[11]

Ankle movement was normal or near normal in 96.00% of patients, and radiological outcomes were satisfactory in 96.00% of cases, indicating proper fracture union and alignment. The restoration of ankle congruity is essential in preventing long-term complications such as post-traumatic arthritis. Studies have shown that even minimal malalignment can lead to altered biomechanics and poor outcomes, emphasizing the importance of accurate reduction.^[15] Complication rates in the present study were low, with minimal incidence of infection, stiffness, or residual deformity, which further supports the safety of open reduction and internal fixation in managing bimalleolar fractures. The overall findings of the study indicate that early surgical intervention, anatomical reduction, appropriate implant selection, and structured rehabilitation contribute significantly to achieving favorable functional outcomes.

CONCLUSION

Open reduction and internal fixation of bimalleolar ankle fractures is an effective treatment modality that provides excellent to good functional outcomes in the majority of patients. The procedure ensures restoration of ankle stability, alignment, and mobility with minimal complications when performed with proper surgical technique. Functional recovery is influenced by factors such as fracture pattern, co-morbidities, and rehabilitation. Therefore, timely surgical intervention combined with appropriate postoperative care plays a crucial role in achieving optimal results.

REFERENCES

1. Deshpande S, Dudhanale A. Functional outcome of surgical management of bimalleolar ankle fractures. *Asian J Med Sci.* 2025;16(1):95-99.
2. Dwivedi R, Karki A, Bhattarai R, Rijal B. Functional outcome estimation of bimalleolar ankle fractures treated by open reduction and internal fixation at a tertiary care center: a descriptive cross-sectional study. *J Nepal Med Assoc.* 2020;58(230):740-743.
3. Vsv K, Kumar R, Reddy S, Prasad V, Naik S, Rao P. Clinical and radiological outcomes of bimalleolar ankle fractures

- treated with open reduction and internal fixation. *Cureus*. 2023;15(6):e40000.
4. Teimouri M, Ahmadi A, Rezaei H, Kazemi M, Rahimi F, Mohammadi S. Short-term outcomes and quality of life following surgical fixation of supination-external rotation type bimalleolar ankle fractures. *Cureus*. 2022;14(9):e30000.
 5. Barber HF, Randall ZD, Strok MJ, Goldfarb JH, Yaeger L, Berkes MB. Functional outcomes after ankle fracture-dislocation: a systematic review. *Arch Orthop Trauma Surg*. 2022;142(5):901-910.
 6. Lewis SR, Macey R, Parker MJ, Cook JA, Griffin XL. Rehabilitation for ankle fractures in adults. *Cochrane Database Syst Rev*. 2020;9:CD005595.
 7. Bretherton CP, Achten J, Jogarah V, Petrou S, Peckham N, Achana F. Early versus delayed weight-bearing following operatively treated ankle fracture (WAX): a non-inferiority, multicentre, randomised controlled trial. *Lancet*. 2024;403(10434):2787-2797.
 8. Le V, Velasco B, Alsobrook M, Lindeman R, Sinatro A, Konda SR. Immediate unprotected weightbearing versus two weeks nonweightbearing after ankle fracture open reduction and internal fixation. *J Orthop Trauma*. 2024;38(4):197-203.
 9. Loubignac F. Treatment of bimalleolar fractures in elderly. *Orthop Traumatol Surg Res*. 2022;108(1 Suppl):103137.
 10. Mazzella GG, Grassi A, D'Hooghe P, Zaffagnini S, Mosca M, Samuelsson K. Return to sport in athletes after surgical ankle fractures: a systematic review. *J Exp Orthop*. 2022;9(1):45.
 11. Daly PJ, Fitzgerald RH, Melton LJ, Ilstrup DM. Epidemiology of ankle fractures in Rochester, Minnesota. *Acta Orthop Scand*. 1987;58(5):539-544.
 12. SooHoo NF, Krenke L, Eagan MJ, Gurbani B, Ko CY, Zingmond DS. Complication rates following open reduction and internal fixation of ankle fractures. *J Bone Joint Surg Am*. 2009;91(5):1042-1049.
 13. Lauge-Hansen N. Fractures of the ankle. II. Combined experimental-surgical and experimental-roentgenologic investigations. *Arch Surg*. 1950;60(5):957-985.
 14. Michelson JD. Ankle fractures resulting from rotational injuries. *J Am Acad Orthop Surg*. 2003;11(6):403-412.
 15. Ramsey PL, Hamilton W. Changes in tibiotalar area of contact caused by lateral talar shift. *J Bone Joint Surg Am*. 1976;58(3):356-357.