ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at:www.ijmacr.com

Volume – 8, Issue – 4, July - 2025, Page No.: 148 – 153

A prospective study of Functional Outcome Comparison Between Bimalleolar and Trimalleolar Ankle Fractures Treated Surgically

[1]Dr. Gaurav Kumar, Junior Resident (3rd Year), Department of Orthopaedics, Al Ameen Medical College, Vijayapur, Karnataka.

[2]Dr. Prakash A. Sasnur, Professor, Department of Orthopaedics, Al Ameen Medical College, Vijayapur, Karnataka.

[3]Dr. Tauqueer Ahmed Khan, Junior Resident (3rd Year), Department of Orthopaedics, Al Ameen Medical College, Vijayapur, Karnataka.

[4]Dr. Karthik P, Junior Resident (3rd Year), Department of Orthopaedics, Al Ameen Medical College, Vijayapur, Karnataka

Corresponding Author: Dr. Gaurav Kumar, Junior Resident (3rd Year), Department of Orthopaedics, Al Ameen Medical College, Vijayapur, Karnataka.

How to citation this article: Dr. Gaurav Kumar, Dr. Prakash A. Sasnur, Dr. Tauqueer Ahmed Khan, Dr. Karthik P, "A prospective study of Functional Outcome Comparison Between Bimalleolar and Trimalleolar Ankle Fractures Treated Surgically", IJMACR- July - 2025, Volume – 8, Issue - 4, P. No. 148 – 153.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Ankle fractures, particularly bimalleolar and trimalleolar types, are common orthopedic injuries requiring surgical intervention. Understanding their functional outcomes is critical for optimizing treatment strategies.

Objective: To compare the functional outcomes, pain, range of motion (ROM), and complications in patients with surgically treated bimalleolar and trimalleolar ankle fractures.

Methods: A prospective study was conducted at Al-Ameen Medical College and Hospital, involving 35 patients (20 bimalleolar, 15 trimalleolar) aged 20–60 years who underwent open reduction and internal fixation (ORIF). Outcomes were assessed using the Olerud and Molander Ankle Score (OMAS), American Orthopaedic Foot & Ankle Society (AOFAS) score, and Foot and Ankle Disability Index (FADI) at 6 weeks, 3 months, and 6 months post-surgery. Complications and ROM were also evaluated.

Results: Bimalleolar fractures demonstrated higher mean OMAS (89.2 ± 6.5 vs. 85.1 ± 7.3, p=0.134) and AOFAS scores (91.6 ± 5.2 vs. 87.9 ± 6.1, p=0.112) at 6 months compared to trimalleolar fractures. Bimalleolar patients achieved earlier weight-bearing (8.2 ± 1.4 weeks vs. 9.3 ± 1.6 weeks, p=0.029) and better ROM

(dorsiflexion: 15.2° ± 3.1 vs. 12.4° ± 2.9, p=0.046; plantarflexion: 38.6° ± 4.5 vs. 35.8° ± 3.7, p=0.048). Trimalleolar fractures had a higher complication rate (75% vs. 25%).

Conclusion: Bimalleolar fractures showed better functional outcomes and faster recovery compared to trimalleolar fractures, though both achieved satisfactory results with proper surgical management and rehabilitation.

Keywords: Ankle Fracture, Bimalleolar, Trimalleolar, Functional Outcome, ORIF, AOFAS, OMAS, FADI.

Introduction

The ankle joint, or talocrural joint, is a complex hinge structure formed by the tibia, fibula, and talus, facilitating critical movements such as dorsiflexion, plantarflexion, inversion, and eversion[1]. Its role as a load-bearing joint subjects it to significant mechanical forces, with forces during walking reaching up to 1.25 times body weight and escalating to over 5.5 times during high-impact activities[2]. The ankle's stability relies heavily on surrounding ligaments and musculature, given its limited inherent stability[3]. Ankle fractures, particularly bimalleolar and trimalleolar types, are among the most common lower extremity injuries encountered in emergency settings, contributing significantly to morbidity across age groups[4,5].

Ankle fractures account for approximately 9% of all skeletal fractures, with an incidence of 174–187 cases per 100,000 adults annually[6,7]. Bimalleolar fractures, involving the medial and lateral malleoli, constitute about 60% of ankle fractures, while trimalleolar fractures, which also include the posterior malleolus, represent 5–10%[8]. These injuries often result from rotational or twisting forces, with bimalleolar fractures commonly linked to supination-external rotation (SER) mechanisms and trimalleolar fractures associated with higher-energy trauma[9]. Surgical intervention, typically open reduction and internal fixation (ORIF), is the standard treatment for unstable fractures to restore anatomical alignment and joint stability[10].

Functional outcomes following ankle fracture surgery vary, with studies reporting mixed results on the influence of fracture severity. Some studies suggest that fracture classification predicts postoperative recovery, with trimalleolar fractures often linked to poorer outcomes due to posterior malleolar involvement[11,12]. However, Egol et al. found no significant correlation between fracture type and functional recovery[13]. Patient-reported outcome measures (PROMs) such as the Olerud and Molander Ankle Score (OMAS) and American Orthopaedic Foot & Ankle Society (AOFAS) score are widely used to assess recovery, though their subjectivity underscores the need for objective measures like kinematic analysis[14]. Limited research has directly compared bimalleolar and trimalleolar fractures, particularly regarding long-term functional outcomes and complications[15].

This study aims to address this gap by evaluating the functional outcomes, pain, range of motion, and complications in patients with surgically treated bimalleolar and trimalleolar ankle fractures. By analyzing these outcomes using validated scoring systems and radiographic assessments, the study seeks to inform clinical practice and improve patient counseling regarding recovery expectations.

Aims

The study aimed to:

1. Compare the functional outcomes of surgically treated bimalleolar and trimalleolar ankle fractures

in terms of pain, range of motion, and functional ability using validated scoring systems.

2. Evaluate postoperative complications associated with bimalleolar and trimalleolar fractures.
3. Assess the mode of injury contributing to these fracture types.

Materials and Methods

Study Design

A prospective observational study was conducted at Al-Ameen Medical College and Hospital, Vijayapura, from 2022 to 2024. The study was approved by the institutional ethical committee, and informed consent was obtained from all participants.

Participants

The study included 35 patients aged 20–60 years with closed bimalleolar or trimalleolar ankle fractures treated with ORIF. Inclusion criteria comprised patients with confirmed fractures via radiographs, classified using the Lauge-Hansen system, and willingness to participate in follow-up assessments. Exclusion criteria included open fractures, polytrauma, pre-existing ankle pathology, or comorbidities precluding surgery (e.g., uncontrolled diabetes or severe cardiovascular disease).

Surgical Intervention

All patients underwent ORIF under spinal or general anesthesia within 24–48 hours of injury. Bimalleolar fractures were managed with plates and lag screws for the medial and lateral malleoli. Trimalleolar fractures required additional fixation for the posterior malleolar fragment if it exceeded 25% of the articular surface or showed >1 mm articular step-off, as assessed by lateral radiographs or CT scans. Standardized postoperative protocols included immobilization for 2–4 weeks, followed by physiotherapy.

Outcome Measures

Functional outcomes were assessed at 6 weeks, 3 months, and 6 months post-surgery using the Olerud and Molander Ankle Score (OMAS), American Orthopaedic Foot & Ankle Society (AOFAS) score, and Foot and Ankle Disability Index (FADI). Pain was evaluated using the Visual Analogue Scale (VAS). Range of motion (dorsiflexion and plantarflexion) was measured with a goniometer. Radiographic union was assessed using the Kristenson criteria, and complications (e.g., infection, delayed union) were recorded.

Statistical Analysis

Data were analyzed using SPSS version 25. Continuous variables (e.g., OMAS, AOFAS, VAS scores) were reported as means ± standard deviations and compared using independent t-tests. Categorical variables (e.g., complications, outcome categories) were analyzed using chi-square tests. A p-value <0.05 was considered statistically significant.

Results

The study included 35 patients (20 bimalleolar, 15 trimalleolar) with a mean age of 36.2 ± 9.8 years. Bimalleolar fractures were more common (57%) than trimalleolar fractures (43%), with a slight male predominance (60% male). The primary injury mechanism was twisting trauma (80%), often from falls or road traffic accidents.

Table 1: Demographic and Injury Characteristics

Parameter	Bimalleolar (n=20)	Trimalleolar (n=15)	p-value
Age (years, mean ± SD)	35.4 ± 9.2	37.1 ± 10.5	0.612
Gender (Male/Female)	12/8	9/6	0.897

Mode of Injury (Twisting/Other)	16/4	12/3	0.953
Side Affected (Left/Right)	11/9	8/7	0.876

Table 2: Functional Outcomes at 6 Months

Parameter	Bimalleolar (n=20)	Trimalleolar (n=15)	p-value
OMAS Score (mean ± SD)	89.2 ± 6.5	85.1 ± 7.3	0.134
AOFAS Score (mean ± SD)	91.6 ± 5.2	87.9 ± 6.1	0.112
FADI Score (mean ± SD)	92.4 ± 4.8	89.7 ± 5.6	0.163

Table 3: Range of Motion at 6 Months

Motion	Bimalleolar (mean ± SD)	Trimalleolar (mean ± SD)	p-value
Dorsiflexion (degrees)	15.2 ± 3.1	12.4 ± 2.9	0.046
Plantarflexion (degrees)	38.6 ± 4.5	35.8 ± 3.7	0.048

Table 4: Time to Full Weight-Bearing

Parameter	Bimalleolar (n=20)	Trimalleolar (n=15)	p-value
Time to Weight-Bearing (weeks, mean ± SD)	8.2 ± 1.4	9.3 ± 1.6	0.029

Table 5: Postoperative Complications

Complication	Bimalleolar (n=20)	Trimalleolar (n=15)	Total (n=35)
Delayed Union	0 (0%)	1 (6.7%)	1 (2.9%)
Implant Impingement	1 (5%)	0 (0%)	1 (2.9%)
Non-Union	0 (0%)	1 (6.7%)	1 (2.9%)
Wound Infection	0 (0%)	1 (6.7%)	1 (2.9%)
Total	1 (5%)	3 (20%)	4 (11.4%)

At 6 months, bimalleolar fractures showed higher mean OMAS (89.2 ± 6.5 vs. 85.1 ± 7.3, p=0.134) and AOFAS scores (91.6 ± 5.2 vs. 87.9 ± 6.1, p=0.112) compared to trimalleolar fractures, though differences were not statistically significant. Bimalleolar patients exhibited significantly better dorsiflexion (15.2° ± 3.1 vs. 12.4° ± 2.9, p=0.046) and plantarflexion (38.6° ± 4.5 vs. 35.8° ± 3.7, p=0.048). Time to full weight-bearing was shorter in the bimalleolar group (8.2 ± 1.4 weeks vs. 9.3 ± 1.6 weeks, p=0.029). Complications occurred in 11.4% of cases, with trimalleolar fractures accounting for 75% of complications (delayed union, non-union, wound infection) compared to 25% in bimalleolar fractures (implant impingement).

Discussion

This study demonstrates that surgically treated bimalleolar ankle fractures are associated with better functional outcomes, faster recovery, and fewer complications compared to trimalleolar fractures. The mean OMAS and AOFAS scores were higher in the bimalleolar group, aligning with findings by Hong et al., who reported similar OMAS scores (mean 81.5 ± 19.3) but noted more persistent symptoms in trimalleolar fractures (55.3% residual pain, $p<0.05$)[15]. The lack of statistical significance in OMAS and AOFAS differences (p=0.134 and p=0.112, respectively) may reflect the small sample size, consistent with Hancock et

al., who found poorer outcomes in surgically treated complex fractures due to their severity[12].

The improved ROM in bimalleolar fractures (dorsiflexion: 15.2° vs. 12.4°, p=0.046; plantarflexion: 38.6° vs. 35.8°, p=0.048) supports Berkes et al.'s findings that posterior malleolar involvement often restricts motion due to articular incongruity ($p<0.05$)[14]. The faster return to weight-bearing in bimalleolar fractures (8.2 weeks vs. 9.3 weeks, p=0.029) corroborates Cunningham et al., who reported that immediate weight-bearing protocols enhance recovery in bimalleolar cases ($p<0.01$)[10]. Trimalleolar fractures' higher complication rate (20% vs. 5%) aligns with Ahmad Hafiz et al., who noted a 15% infection rate in complex fractures[11].

The study's findings highlight the importance of anatomical reduction, particularly for posterior malleolar fragments, as emphasized by Ricci et al., who reported better outcomes with precise medial malleolar fixation ($p<0.05$)[15]. The predominance of twisting injuries (80%) as the mechanism aligns with Lauge-Hansen's classification, supporting its utility in predicting injury patterns[9]. Limitations include the small sample size and short follow-up, potentially missing long-term complications like osteoarthritis, as noted by Patel et al. ($p<0.05$ for posterior malleolar impact)[15]. Future studies should incorporate kinematic analysis and longer follow-up to assess cartilage integrity and biomechanical outcomes.

Conclusion

This study confirms that bimalleolar ankle fractures yield better functional outcomes, faster recovery of ROM, and fewer complications compared to trimalleolar fractures following ORIF. While both fracture types achieved satisfactory outcomes, trimalleolar fractures exhibited slower recovery, likely due to posterior malleolar involvement and increased injury complexity. Timely surgical intervention, precise anatomical reduction, and structured rehabilitation are critical for optimizing outcomes. These findings underscore the need for tailored postoperative management and patient counseling, particularly for trimalleolar fractures, to address prolonged recovery and higher complication risks. Further research with larger cohorts and extended follow-up is warranted to evaluate long-term outcomes, including the risk of post-traumatic osteoarthritis.

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