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Functional outcome of surgically treated Trimalleolar ankle fractures

Dr. Govindagouda R Timmanagoudar, Dr. Ranganath N, Dr. Roshan S D
Department of Orthopaedics, KVGMCH, Sullia, Karnataka, India

Abstract
Introduction: Trimalleolar fractures are one of the complex fractures in the ankle joint involving lateral, medial and posterior malleolus often resulting from high energy trauma. These fractures usually require prompt surgical reduction and internal fixation. Surgical intervention is commonly indicated to restore anatomical alignment and good functional outcome to prevent long term complications.
Objectives: To evaluate functional outcome of surgically treated trimalleolar fractures by specific modalities and the complications involved in a study of 33 patients.
Materials and Methods: This study comprised of 33 patients with trimalleolar fractures treated surgically from November 2022 to November 2024. The patients underwent open reduction and internal fixation using plates and screws. Preoperative and postoperative clinical evaluations were performed along with radiographs. Functional outcome was assessed using Olerud and Molander ankle score with a follow up period of minimum 2 years.
Results: In this study of 33 patients with trimalleolar fractures treated by open reduction and internal fixation, excellent results were observed in 20(60.6%), good in 6(18.1%), fair in 5(15.1%) and poor in 2(6.06%). The common complications observed were persistent swelling, residual pain and surgical site infection in postoperative period.
Conclusion: Surgical treatment of trimalleolar fractures using open reduction and internal fixation leads to favourable functional outcomes. Early intervention and good anatomical reduction along with guided postoperative mobilization and rehabilitation are critical in the functional outcome of these individuals.

Keywords: Trimalleolar fractures, posterior malleolus, open reduction and internal fixation, posterolateral approach, Olerud and Molander score.

Introduction

Fractures around the ankle are among the most common injuries encountered in orthopedic practice, contributing significantly to the burden of emergency care cases [1]. Ankle fractures are classified based on the number of malleoli involved, categorized into unimalleolar, bimalleolar, and trimalleolar fractures [2]. Among these, trimalleolar fractures are the most complex, involving the lateral, medial, and posterior malleolus. These injuries often result from high-energy trauma, such as motor vehicle accidents, falls from height, or sports-related injuries [3].

Trimalleolar fractures account for approximately 7–10% of all ankle fractures, making them a notable concern due to their complexity and the potential for long-term functional impairment, if not managed appropriately [4]. The presence of a posterior malleolar fragment further complicates management decisions. Traditionally, the size of the posterior malleolar fragment has been a critical factor in determining whether to leave or fix the posterior fragment [6,7]. However, recent studies suggest that anatomical reduction and stabilization of the posterior malleolus are essential for achieving favourable clinical and functional outcomes, irrespective of the size of the fragment [8,9]. Proper fixation of the posterior malleolus restores joint stability, improves load distribution, and minimizes the risk of post-traumatic arthritis, thereby enhancing functional recovery [5].

The primary goal in managing trimalleolar fractures is to restore joint stability, axial alignment, and anatomic reduction of the articular surface, enabling early mobilization and minimizing the risk of long-term complications [5]. Despite advancements in surgical techniques, controversy persists regarding the optimal fixation method and the extent of posterior malleolar fixation required for improved functional outcomes. Given these uncertainties, further research is warranted to establish standardized protocols and assess long-term outcomes following surgical intervention.

The functional outcome of surgically treated trimalleolar fractures remains a subject of ongoing investigation, with variations in clinical practices regarding posterior malleolus fixation. While numerous studies have highlighted the importance of anatomical reduction in achieving favourable outcomes [8], there is limited consensus on the appropriate criteria for fixation of the posterior malleolar fragment [6]. Furthermore, there is a lack of comprehensive data from population-based studies assessing the long-term functional results of these fractures, particularly in high-energy trauma cases.

A growing body of evidence indicates that posterior malleolus fixation plays a pivotal role in restoring articular congruency, enhancing load-bearing capacity, and reducing the risk of post- traumatic arthritis [7,9]. However, differences in surgical techniques and patient demographics may influence outcomes, necessitating further exploration of the impact of various fixation strategies on functional recovery.

This study aims to evaluate the functional outcomes of surgically treated trimalleolar fractures with an emphasis on

posterior malleolus fixation and its correlation with postoperative stability, range of motion, and complication rates. By addressing these gaps, the study seeks to provide critical insights that can guide clinical decision-making and improve the quality of care for patients with complex ankle fractures.

Methodology

Study Design

This study was a prospective observational study conducted in the Department of Orthopedics, KVG Medical College and Hospital, Sullia, over a period of 2 years from November 2022 to November 2024. The study aimed to assess the functional outcomes of surgically treated trimalleolar fractures using the Olerud and Molander Ankle Score (O&M Score) and to document postoperative complications.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee (IEC) of KVG Medical College and Hospital, Sullia. Written informed consent was obtained from all participants before enrollment. Confidentiality of patient information was maintained throughout the study.

Study Population Inclusion Criteria

Patients were included in the study if they met the following criteria:

1. Age ≥ 18 years at the time of injury.
2. Diagnosis of trimalleolar ankle fractures involving the medial, lateral, and posterior malleoli, confirmed through radiographic evaluation.
3. Ability to understand the study information and provide written informed consent.
4. Willingness to comply with the defined follow-up protocol to assess functional outcomes.

Exclusion Criteria

Patients were excluded if they met any of the following criteria:

1. Compound ankle fractures with extensive soft tissue damage.
2. Pathological fractures resulting from underlying diseases.
3. History of previous ankle injury in the same limb.
4. Concomitant fractures involving the same limb.
5. Presence of associated neurovascular deficits.
6. Patients with polio-affected limbs.

Sample Size and Sampling Method

The calculated sample size was 30, A consecutive sampling method was used to enroll all eligible patients presenting with trimalleolar fractures during the study period. A total of 33 patients were included in the study after meeting the inclusion and exc lusion criteria.

Preoperative Assessment

All patients underwent:

- X-ray of the ankle joint in anteroposterior, lateral, and mortise views.
- CT scan of the ankle joint to assess the extent of fracture, posterior malleolar involvement, and intra-articular fragments.

Fig 1: Pre operative clinical and radiological images

Surgical Procedure

Patient Positioning

- The patient was positioned in a floating lateral position with a sandbag placed under the ipsilateral buttock after administering appropriate anesthesia.

Posterior Malleolus Fixation

A posterolateral approach to the ankle was used, following the internervous plane between the peroneal muscles and the flexor hallucis longus (FHL). The fracture site was exposed, and anatomical reduction was achieved. The posterior malleolus was fixed using: Anatomical locking compression plate (LCP) in 4 cases and T-plate in 23 cases. Cannulated cancellous (CC) screws in 6 cases. Fixation was performed under fluoroscopic guidance to confirm reduction.

Lateral Malleolus Fixation

Through the same posterolateral approach, the lateral malleolus was reduced and fixed using:

- One-third tubular plate
- Tubular locking plate
- 3.5 mm dynamic compression plate (DCP)
- Distal fibular locking plate

Syndesmosis evaluation was done intraoperatively, and if required, syndesmotic fixation was performed with a 3.5 mm screw placed 2 cm above the tibiotalar joint with tricortical purchase.

Medial Malleolus Fixation

The patient was repositioned to a supine position. A vertical incision was made over the medial malleolus. The fracture was reduced and held with clamps. Fixation was performed using:

- 4 mm CC screws in 24 cases.
- Tension band wiring (TBW) in 9 cases.

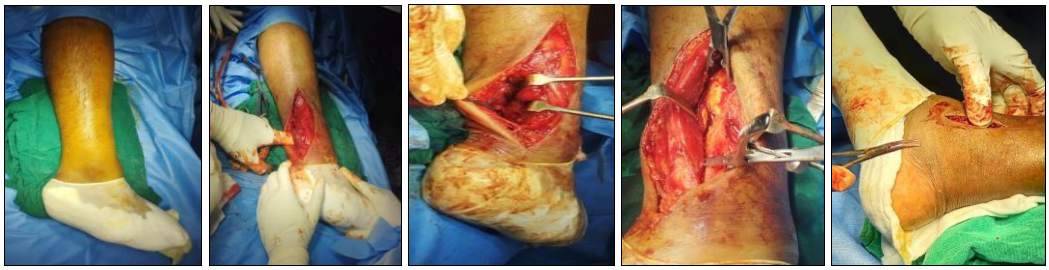

Fig 2: Intra operative images

Postoperative Care and Follow-Up Protocol Immediate Postoperative Care

A below-knee posterior slab was applied postoperatively with the ankle in a plantigrade position. Wound inspection and suture removal were performed on the 14th postoperative day.

Fig 3: Immediate post op x ray and 2 years follow up x ray respectively

Rehabilitation Protocol

At 6 weeks**:** POP slab was removed, and partial weight-bearing with ankle range of motion (ROM) exercises was initiated. Full weight-bearing was gradually introduced based on clinical and radiological union.

Fig 4: Post operative follow up images assessing functional outcome

parameter	Degree	score
Pain	None	25
	While walking on uneven surface	20
	While walking on surface outdoors	10
	While walking indoors constant and severe	5
Stiffness	None	10
	Stiffness	0
Swelling	None	10
	Only in evenings	5
	Constant	0
Stair climbing	No problems	10
	Impaired	5
	Impossible	0
Running	Possible	5
	Impossible	0
Jumping	Possible	5
	Impossible	0
Squatting	No Problems	5
	Impossible	0
Supports	None	10
	Taping, Wrapping	5
	Stick or Crutch	0
Work. Activities	Same as before injury	20
of daily life	Loss of Tempo	15
	Change to simpler job	15
	Severely impaired work capacity	0
Scores range from a minimum (zero) to a maximum (100) points.		

Follow-Up Visits

Patients were followed up regularly at the following intervals:3 months,6 months, 1 year, 2 years Functional outcomes were evaluated at each follow-up using the Olerud and Molander Ankle Score (O&M Score), and postoperative complications were documented.

Outcome Assessment

Olerud and Molander Ankle Score (O&M Score)

The O&M Score was used to assess functional outcomes. It is a validated, patient-reported scoring system with a maximum score of 100 points. The score assesses the following domains: Pain, Stiffness, Swelling, Stair climbing, Running, Jumping, Squatting, Activities of daily living. Scoring Interpretation-Excellent**:** 91–100 points**,** Good: 61–90 points**,** Fair: 31–60 points**,** Poor: ≤ 30 points

Data Collection and Statistical Analysis

Data Collection Demographic data, clinical details, intraoperative findings, and postoperative outcomes were documented using a structured case report form (CRF). The O&M scores were recorded at defined follow-up intervals.

Statistical Analysis

Descriptive statistics (mean, standard deviation, and percentages) were used to summarize demographic and clinical data. Complication rates were reported as proportions. P-value will be evaluated using chi square test, Repeated measure ANOVA and post hoc Bonferroni. A p-value < 0.05 was considered statistically significant**.**

Results

Table 1: Clinical profile of patients with ankle fracture

Variabl e	N=33	%	p-value[c]
Gender			
Males	13	39.39	0.223
Females	20	60.60	
Age			
18-50	19	57.57	0.384
>50	14	42.42	
Mode of injury			
RTA	23	69.69	0.024*
Self-fall	10	30.33	
Side involved			
Right	20	60.60	0.223
Left	13	39.39	

p-value[c]- Chi square test, *<0.05 considered statistically significant

Table 2: Functional outcome of surgically treated trimalleolar fractures.

Follow up period	Excellent results	Good results	Fair results	Poor results	Total patients	P-value[R]
3 months	5 (15.2%)	10 (30.3%)	10 (30.3%)	8 (24.2%)	33 (100%)	<0.001
6 months	8 (24.2%)	12 (36.4%)	8 (24.2%)	5 (15.2%)	33 (100%)	
1 year	13 (39.4%)	12 (36.4%)	5 (15.2%)	3 (9.1%)	33 (100%)	
2 years	20 (60.6%)	6 (18.2%)	5 (15.2%)	2 (6.1%)	33 (100%)	

p-value[c]- RMANOVA, *<0.05 considered statistically significant

Table 3: Post-hoc Pairwise Comparisons Between follow up periods (Bonferroni corrected)

Comparison	p-value
3 Month vs. 6 Month	0.043*
3 Month vs. 1 Year	<0.001*
3 Month vs. 2 Year	<0.001*
6 Month vs. 1 Year	0.009*
6 Month vs. 2 Year	<0.001*
1 Year vs. 2 Year	0.001*

*<0.05 considered statistically significant

Table 4: Complications associated with surgical intervention of trimalleolar fractures.

Complications	N	%	p-value
Superficial infection	4	12.12%	0.135
Deep infection	2	6.06%	
Residual pain and swelling	3	9.09%	
Total	9	27.27%	

A total of 33 patients with trimalleolar ankle fractures were included in this study. Table 1 demonstrates the clinical profile of the patients. The study population comprised 13 males (39.39%) and 20 females (60.60%) (p=0.223). Age distribution showed 19 patients (57.57%) in the 18-50 years age group and 14 patients (42.42%) in the >50 years age group (p=0.384). Road traffic accidents were the predominant mode of injury, accounting for 23 cases (69.69%), which was significantly higher (p=0.024) compared to self-fall injuries (10 cases, 30.33%). Right ankle involvement (60.60%) was more common than left ankle involvement (39.39%), though this difference was not statistically significant (p=0.223) as in Table 1.

Table 2 shows the functional outcomes of surgically treated trimalleolar fractures at different follow-up periods. There was a statistically significant improvement in outcomes over time (p<0.001). At 3 months post-operation, only 15.2% of patients showed excellent results, with 24.2% having poor outcomes. By 6 months, there was notable improvement with 24.2% achieving excellent results and reduction in poor outcomes to 15.2%. The improvement continued at 1 year follow-up with 39.4% excellent results and further reduction in poor outcomes to 9.1%. By the 2-year follow-up, the majority of patients (60.6%) demonstrated excellent results, while only 6.1% had poor outcomes.

Further analysis through post-hoc pairwise comparisons (Table 3) revealed statistically significant differences between all time periods. The comparison between 3 months and 6 months showed significant improvement (p=0.043). The improvements between 3 months and 1 year (p<0.001) and between 3 months and 2 years (p<0.001) were highly significant. Significant improvements were also observed between 6 months and 1 year (p=0.009) and between 6 months and 2 years (p<0.001). Even the comparison between 1 year and 2 years showed statistically significant improvement (p=0.001), indicating that recovery continues well beyond the first-year post-surgery as in Table 3.

Table 4 outlines the complications associated with surgical intervention. Overall, 27.27% of patients experienced at least one complication. Superficial infection was the most common complication (12.12%), followed by residual pain and swelling (9.09%), and deep infection (6.06%). The distribution of complications did not show statistically significant difference (p=0.135).

Discussion

The present study demonstrates a significant improvement in functional outcomes following surgical management of trimalleolar ankle fractures over a two-year follow-up period, with 60.6% of patients achieving excellent results by the final assessment. The progressive improvement observed across all time intervals ($p<0.001$) suggests that recovery continues well beyond the first year post-surgery, emphasizing the importance of extended rehabilitation protocols. Female predominance (60.60%) and road traffic accidents as the primary mechanism of injury (69.69%, $p=0.024$) align with the demographic and etiological patterns typically observed in trimalleolar fractures. The complication rate of 27.27%, primarily consisting of superficial infections (12.12%), deep infections (6.06%), and residual pain and swelling (9.09%), falls within acceptable ranges for complex ankle fractures. These findings validate the efficacy of surgical intervention with particular attention to posterior malleolus fixation using anatomical plates or cannulated screws, supporting the contemporary approach of addressing all malleoli to restore ankle joint congruity and stability [10].

Our results are comparable with those reported by Hong *et al*. [16], who found that 53% of patients with surgically treated trimalleolar fractures achieved good to excellent functional outcomes, though they noted greater limitations in sporting activities compared to less complex ankle fractures. Similarly, Verhage *et al*. [17] documented 79% satisfactory outcomes in their long-term follow-up of surgically treated ankle fractures, supporting our findings that appropriate surgical management leads to favourable results in the majority of cases. The female predominance and RTA as the predominant cause in our study align with findings by Subba Reddy and Raghavendra [15], who reported female predominance (65%) and RTA as the major mechanism of injury (55%) in their prospective study. Our findings also correspond with S.K. and Nyamagond [14], who reported excellent to good outcomes in 80% of patients with surgically treated trimalleolar fractures at final follow-up. Our complication rate of 27.27% is consistent with the range reported by Monestier *et al*. [13] in their systematic review, which described complication rates between 14-36% in surgically managed unstable ankle fractures. The posterolateral approach utilized in our study for simultaneous access to both posterior and lateral malleoli corresponds with techniques advocated by Gonzalez *et al*. [11] and Abdelgawad *et al*. [12], potentially contributing to the favourable outcomes observed.

The strengths of this study include its prospective design, standardized surgical protocols with specific attention to posterior malleolus fixation, and comprehensive two-year follow-up using the validated Olerud and Molander Ankle Score [10]. The consistent surgical approach and detailed documentation of functional outcomes at regular intervals provide valuable insights into the recovery trajectory following trimalleolar fracture fixation. However, several limitations must be acknowledged. The relatively small sample size (n=33) and single-center design may limit the generalizability of findings. The absence of a control group or comparison with alternative fixation techniques restricts our ability to definitively establish the superiority of the employed approach. Additionally, the study does not extensively analyze patient-specific factors such as comorbidities, compliance with rehabilitation protocols, or detailed radiological correlations with functional outcomes, which could influence recovery patterns.

The findings have important clinical implications, supporting the current trend toward fixation of all malleoli in trimalleolar fractures, particularly emphasizing the role of posterior malleolus fixation in achieving optimal functional outcomes. The continued improvement in functional scores beyond one year suggests that patients should be counselled about the prolonged recovery trajectory and the importance of extended rehabilitation protocols. Future research should focus on comparative studies with larger cohorts, randomized designs comparing different fixation techniques, and investigation of factors influencing persistent functional deficits in the minority of patients with suboptimal outcomes. Long-term follow-up studies extending beyond five years would also be valuable to assess the incidence of post-traumatic arthritis and its correlation with initial management strategies. In conclusion, surgical management of trimalleolar ankle fractures with attention to all malleoli, particularly the posterior malleolus, yields favourable functional outcomes, with the majority of patients achieving excellent results by two years post-surgery, supporting the anatomic reduction principle in managing these complex injuries.

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