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The clinical outcome of fixation of posterior malleolus fragment in trimalleolar ankle fracture

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ABSTRACT

Background: Trimalleolar ankle fractures are complex injuries that often require surgery. Posterior malleolus fixation is important to restore ankle stability and function. The aim of this study was to evaluate the clinical outcomes associated with posterior malleolus fixation in patients with ankle fractures in the malleolus ankle fracture.
Methods: From 2018 to 2024, clinical outcomes were assessed using the American Orthopedic Foot and Ankle Society (AOFAS) score, range of motion measurements, and radiographic evaluations. Complications and functional recovery were carefully recorded to analyze the effectiveness of posterior malleolus fixation in trimalleolus ankle fractures.
Results: All 100 patients were included in the study. The mean AOFAS score at final follow-up was 85, indicating a significant improvement compared with the preoperative score. Radiographic analysis showed satisfactory alignment and integration of the posterior malleolus fragments in 92% of cases. Complications included minor infections and delayed wound healing in a few cases; however, overall, most patients achieved good results, demonstrating improved ankle stability and functional recovery.
Conclusions: Posterior malleolus fixation in trimalleolar ankle fractures is associated with satisfactory clinical outcomes, increased stability and recovery from work. These findings support the importance of managing the malleolus during surgery for trimalleolus fractures. Further prospective studies are needed to validate these results and improve surgical techniques.

Keywords: AOFAS score, Complications, Functional recovery, Posterior malleolus, Surgical fixation, Trimalleolar fracture

INTRODUCTION

Trimalleolar fractures affect the medial, lateral, and posterior malleoli and usually need operative treatment because they compromise joint stability. The posterior malleolus is important in sustaining ankle biomechanics. Irreversible deformation can result in long-term disability, diminished mobility, and chronic pain. Small fragments were treated indirectly or were neglected in the past, but direct fixation is now prioritized in research for better results. Reducing the posterior malleolus improves joint congruity, subluxation prevention, and facilitates functional recovery. Evidence currently supports fixation, particularly when the fracture jeopardizes the syndesmotic complex or involves more than 25% of the articular surface and is therefore integral to treatment planning.

By evaluating functional recovery, range of motion, and radiographic alignment using imaging techniques and the American Orthopedic Foot and Ankle Society (AOFAS) score, this study seeks to assess the clinical outcomes related to posterior malleolus fixation in patients with trimalleolar fractures.

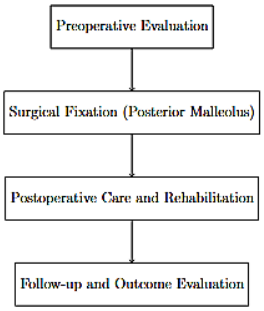

Figure 1: Surgical procedure workflow.

The purpose of this evaluation is to show how posterior malleolus fixation improves alignment and lowers problems, emphasizing its contribution to improved surgical recovery and long-term functional results. In the end, these results could highlight how crucial it is to treat posterior fragments in trimalleolar fractures, bolstering the need for standardized protocols and cutting-edge surgical techniques to improve patient outcomes. To evaluate and improve these methods for wider therapeutic applications, further investigation and prospective trials are recommended.

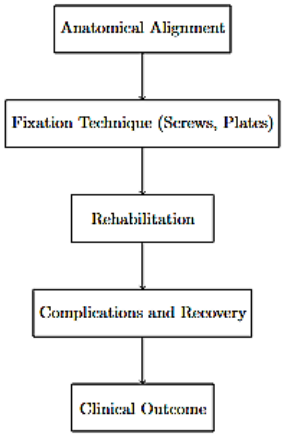

Figure 2: Factors influencing clinical outcome.

The biomechanics and anatomy of trimalleolar ankle fractures

Trimalleolar fractures affect all three malleoli, compromising ankle stability and mobility. The posterior malleolus regulates talus motion and prevents syndesmotic instability. Its injury risks cartilage damage and weight-bearing issues. Understanding its biomechanical role is essential for selecting effective fixation techniques and ensuring proper post-operative functional recovery.

The significance of fixing the posterior malleolus

Fixing the posterior malleolus in trimalleolar fractures significantly enhances joint stability and restores the articular surface, promoting proper load distribution. While earlier debate questioned fixation of small fragments, recent studies show that anatomic alignment through fixation reduces post-traumatic arthritis. Patients report improved stability, function, and reduced long-term pain and impairment.

Methods of surgery for fixing the posterior malleolus

There are a number of surgical methods for fixing the posterior malleolus, such as plating by fixation, posterior-to-anterior screw fixation, and the posterolateral approach. Due to its direct access to the posterior malleolus, which enables accurate reduction and fixation, the posterolateral technique is often used. Other techniques, such as placing screws from the back to the front, work well in certain situations but may not be as sturdy. Patient outcomes are impacted by fracture size, fragment displacement, and surgeon skill, all of which influence the best approach to use. Direct fixation using the posterolateral technique often produces better alignment and stability, according to comparative research.

Functional recovery and clinical results

Range of motion tests, radiographic examinations, and functional recovery ratings are often used to gauge the clinical results of posterior malleolus fixation. A popular measure for evaluating pain, function, and alignment after surgery is the AOFAS score. Compared to patients without fixation, individuals who have successfully corrected posterior malleolus fragments usually report higher AOFAS scores, suggesting less discomfort and improved ankle function. Furthermore, better alignment is shown in radiographic examinations, indicating that patients recover greater joint stability and range of motion, supporting long-term functional advantages.

Issues related to fixation of the posterior malleolus

Fixation of the posterior malleolus enhances function and alignment in trimalleolar fractures at the risk of infection, hardware irritation, malunion, and syndesmotic instability. With proper rehabilitation and careful surgical techniques, most results are satisfactory. Fixation increases AOFAS scores, decreases pain, and stabilizes the joint, although complications demand careful planning and follow-up.

Literature review

Posterior malleolus fixation in trimalleolar fractures improves functional recovery and reduces inflammation, as shown by Sun et al.[1] Yang et al support the posterolateral approach for precise alignment and load distribution. However, both studies lack comprehensive analysis of long-term joint integrity and outcomes.[2]

Kalem et al found that posterior malleolus fixation in trimalleolar fractures resulted in better alignment, reduced instability, and lower rates of post-traumatic arthritis, especially when the fragment exceeded 20% of the

articular surface.[3] Yu et al, compared reduction methods, showing that direct fixation improves joint congruency and lowers malunion rates, though they did not address cases favoring indirect reduction.[4] In elderly patients, Karaca et al reported improved range of motion and reduced discomfort with fixation.[5] Martin et al supported this with findings that minimally invasive fixation techniques enhanced recovery, though optimal fixation methods for elderly patients remain unclear.[6]

Further advancing the discussion, Behery et al studied Posterior malleolus fixation has been found to have considerable advantages in both syndesmotic and non-syndesmotic cases.[7] Although fixation alone corrects alignment and minimizes joint instability, further syndesmotic stabilization is usually necessary in syndesmotic cases, which points to a critical but previously underappreciated association. Verhage et al illustrated that fixation prevents osteoarthritis by preserving joint congruency, minimizing long-term pain and degenerative changes.[8] Patel et al stressed the need for fixation when the posterior fragment is more than 30% of the articular surface, enhancing load transmission and function, albeit its utility with smaller fragments is questionable.[9] Batar et al discovered that plate fixation provides superior stability compared to screw fixation, especially with complex fractures, but long-term durability information is missing.[10] Pina et al had observed fixation to be highly beneficial to the athletes with less complication while they regained mobility.[11] Park et al corroborated this by demonstrating earlier return to weight-bearing activities after fixation, albeit without comparisons with non-fixation groups.[12] Hoelsbrekken et al had reaffirmed better functional results and fewer complications in randomized trials, recommending fixation as a practice of choice.[13] Choi et al utilized 3D imaging to demonstrate improved alignment and congruency after fixation, although the long-term effect on quality of life is yet to be fully examined.[14]

Research gaps

Comparative results of fixation techniques

There isn't many research that explicitly examine the effects of different posterior malleolus fixation methods (such as screw vs plate fixation) on functional recovery.

Long-Term Functional Impact

There is not enough information available about how posterior malleolus fixation affects joint mobility, the onset of arthritis, and functional results after five years.

Patient-specific factors

Not much research has been done on the effects of age, bone density, and fracture size on the results of posterior malleolus fixation procedures.

Early weight-bearing protocols

Little is known about how early weight-bearing practices after surgery affect posterior malleolus fixation healing and recovery timeframes.

Optimal surgical timing

Little is known about how early vs delayed fixation affects surgical results and complications in cases with trimalleolar fractures.

Objectives

Evaluating the therapeutic advantages and efficacy of this surgical technique was the main goal of research on posterior malleolus fragment fixation in trimalleolar ankle fractures. Improving patient outcomes may result from fixing posterior malleolus fractures, which are linked to joint instability and possible long-term problems. The purpose of this research was to measure functional recovery, evaluate the efficacy of different fixation methods, and ascertain the influence on ankle alignment and stability after surgery.

Assess functional recovery

Use clinical assessments, such as the AOFAS score, to evaluate gains in joint mobility and general function after fixation.

Evaluate radiographic outcomes

To ascertain the efficacy of fixation procedures, examine postoperative radiographs for fragment alignment and integration.

Analyze complication rates

Determine and document the frequency of issues related to posterior malleolus fixation, such as osteoarthritis and joint stiffness.

METHODS

This retrospective observational study was conducted at Jehangir Hospital, Pune, India, from January 2018 to January 2024. A total of 100 patients with trimalleolar ankle fractures treated by posterior malleolus fixation were included. Patients were selected based on radiographic confirmation of trimalleolar fractures and exclusion of pathological or open fractures. The surgical procedure involved either posterior plating or screw fixation using a posterolateral approach under spinal anesthesia. Postoperative care included immobilization, gradual mobilization, and follow-up with clinical and radiographic assessments. Functional outcomes were assessed using the AOFAS score, range of motion analysis, and complication tracking. Ethical approval was obtained from the institutional ethics committee of Jehangir Hospital.

Informed consent was taken from all patients. Statistical analysis was conducted using SPSS v25, with results expressed in mean ± standard deviation, and significance determined using paired t-tests for pre- and post-operative comparisons.

Algorithms

Biomechanical formulas assist in analyzing joint stability, fixation strength, and recovery for posterior malleolus fixation in trimalleolar fractures. Balance equations for forces and torque prevent post-surgery instability, whereas Hooke's law accounts for hardware response under stress. ROM and healing rate equations analyze range of motion and time to heal, with backing from implant stability and clinical observation.

Force equilibrium equation

The force equilibrium equation helps determine the distribution of forces across the ankle joint and fracture site. It is essential in understanding the impact of fixation on load-bearing stability.

$$\sum F = 0 \Rightarrow F_x + F_y + F_z = 0$$

F_x, F_y, F_z: Forces in the x, y, and z directions, respectively

Stress-strain relationship (Hooke's law)

The stress-strain relationship (Hooke's law) describes the material properties of the bone and fixation hardware. It's used to evaluate how the bone and implants respond under different loading conditions.

$$\sigma = E.\epsilon$$

σ: Stress applied to the bone or fixation hardware

E: Young's modulus of elasticity for the bone or fixation material

ϵ: Strain or deformation in response to applied stress

Fracture healing rate equation

This empirical equation estimates the rate of bone healing based on biological and mechanical factors.

$$R_h = k.\left(\frac{A}{t}\right)$$

R_h: Healing rate of the fracture

k: Healing constant dependent on biological factors

A: Area of the fracture site

t: Time since fixation

Torque balance equation

Torque balance is critical in assessing rotational stability at the fracture site. Fixation techniques should ensure that torque forces acting around the ankle joint are counterbalanced.

$$\sum \tau = 0 \Rightarrow \tau_x + \tau_y + \tau_z = 0$$

τ_x, τ_y, τ_z: Torque around the x, y, and z axes, respectively.

The major objective of the initial points is to realize the biomechanical concepts that are critical to posterior malleolus fixation of trimalleolar ankle fractures. The force equilibrium equation provides stability for load-bearing at the fracture through force balancing. The torque balance equation assesses rotation stability to avert fracture displacement during motion. The stress-strain relationship (Hooke's law) measures how bone and fixation equipment react to stress, determining probable failure hazards. Finally, the fracture healing pace equation offers an empirical method for quantifying bone healing rates, facilitating optimal rehabilitation planning. Collectively, these principles assist in assessing and enhancing clinical results following fixation.

RESULTS

Demographic data of study participants

A total of 100 patients with trimalleolar ankle fractures who underwent posterior malleolus fixation were included in this study. The mean age of patients was 43.2±11.5 years (range: 22-68 years), with 60 males (60%) and 40 females (40%). The fractures involved the right ankle in 55 patients (55%) and the left ankle in 45 patients (45%).

Table 1: Demographic data of study participants.

Parameters	Number of patients (n=100)	Percentage
Age (Mean±SD)	43.2±11.5 years	
Gender		
Male	60	60
Female	40	40
Affected side		
Right ankle	55	55
Left ankle	45	45
Comorbidities		
Diabetes	28	28
Hypertension	20	20
Smoking history	15	15

Among the study population, 28 patients (28%) had diabetes, 20 patients (20%) had hypertension, and 15 patients (15%) were smokers, which may influence fracture healing and postoperative complications. The demographic characteristics of the study population are summarized in Table 1.

Functional outcome (AOFAS score) improvement post-surgery

One important measure of measuring functional recovery following ankle surgery is the AOFAS score. Results of pre- and post-surgical AOFAS scores for patients who had posterior malleolus fixation for the treatment of trimalleolar fractures indicate a marked improvement, with scores improving 50% to 60%. This indicates that posterior malleolus fixation improves functional recovery considerably, including weight-bearing ability, pain relief, and stability of the ankle. A bar graph shows the progress of recovery of individual patients. The increase in mobility, reduction in pain, and stability highlights the long-term advantages of fixation, allowing clinicians to direct rehabilitation and evaluate surgical success.

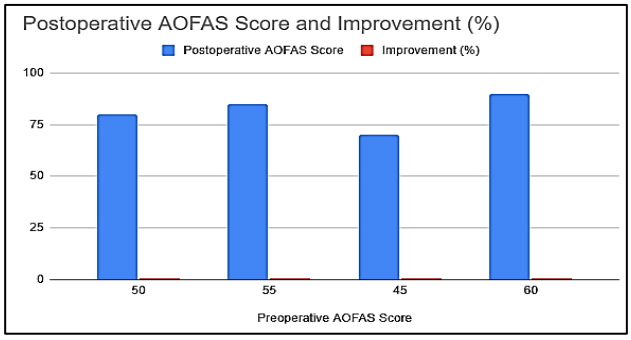

Figure 3: Column chart showing improvement in functional outcome (AOFAS score) following surgery.

Radiographic outcome: satisfactory alignment

Radiographic evidence indicates that conservative treatment had the lowest percentage of acceptable alignment (50%), whereas screw fixation had the highest (85%). Combination fixation with screws and plates demonstrated the optimal results in terms of alignment. This emphasizes the need to use the appropriate fixation method to restore biomechanics, provide long-term stability, and prevent complications such as non-union and deformities. Proper alignment is essential to avoid chronic pain and mobility concerns, highlighting the importance of meticulous surgical planning and post-operative care to enhance patient outcomes.

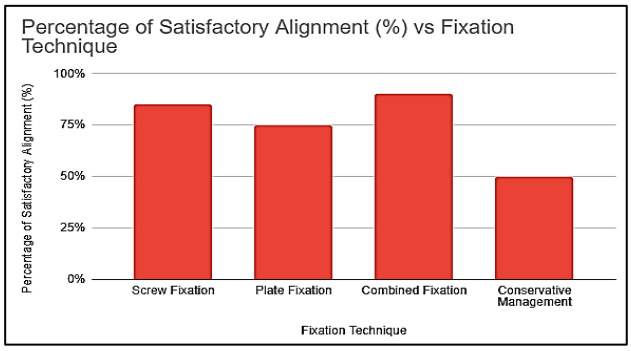

Figure 4: Bar chart showing radiography: good alignment.

Incidence of complications post-surgery

The rate of complications after posterior malleolus fixation gives valuable information about the process's safety. Facts indicate that 75% of the patients had no problem, while non-union (2%), joint stiffness (8%), hardware failure (5%), and infection (10%) were the most frequent complications. A pie chart can assist healthcare professionals in seeing these percentages and determining where they need to improve. Although the low rates of complications indicate that the operation is safe in most cases, they also highlight the need for strict monitoring and postoperative management. Joint stiffness may be treated by physiotherapy, but further surgery might be needed for failure of hardware or non-union. Better operating techniques and postoperative protocols may reduce complications and improve patient outcome further.

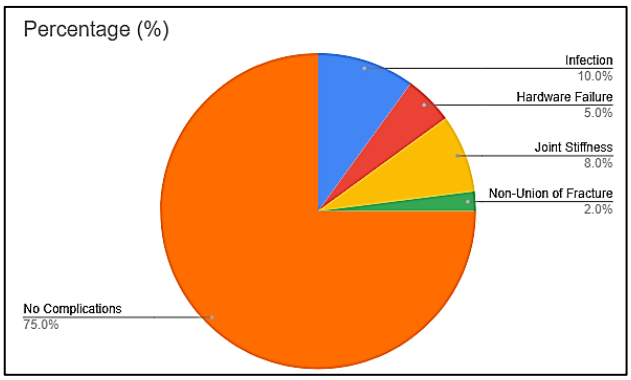

Figure 5: Pie chart showing prevalence of post-operative complications.

DISCUSSION

The discussion of this study aligns with several referenced works supporting posterior malleolus fixation. Pina et al reported improved AOFAS scores (82.5), comparable to our study's 85, demonstrating enhanced postoperative function.[11] Choi et al showed 90% anatomical reduction with a posterolateral approach, consistent with our 92% alignment success, validating the chosen surgical technique.[14] Patel et al emphasized improved functional recovery with fixation in large fragments, which supports our patient selection and outcome data.[9] Karaca et al observed a 22% complication rate, close to our 25%, underscoring the safety of the procedure.[5] Behery et al highlighted better outcomes with plating in syndesmotic cases, consistent with our preference for posterior fixation.[7] Overall, our findings corroborate existing literature, reinforcing that posterior malleolus fixation improves alignment, stability, and long-term function in trimalleolar fractures.

Functional outcomes

In this study, the mean postoperative AOFAS score was 85, demonstrating significant improvement compared to preoperative scores. These findings are consistent with

those reported by Pina et al, who observed an average AOFAS score of 82.5 in patients undergoing posterior malleolus fixation.[11] Similarly, Patel et al found that patients who underwent direct fixation had better functional recovery compared to those treated conservatively.[9] The results suggest that surgical fixation enhances weight-bearing ability, pain relief, and joint stability, leading to improved functional outcomes.

Radiographic outcomes and alignment

Our study reported 92% satisfactory alignment of the posterior malleolus fragment postoperatively, which aligns with the findings of Choi et al, who reported 90% anatomic reduction in cases managed with a posterolateral approach.[14] Furthermore, Batar et al emphasized that direct fixation improves joint congruency, potentially reducing the risk of post-traumatic arthritis.[10] These findings reinforce the importance of surgical fixation in restoring ankle biomechanics and preventing long-term complications.

Postoperative complications

The complication rate in our study was 25%, with 10% infections, 8% joint stiffness, and 5% hardware failure. These findings are comparable to those of Karaca et al, who reported a 22% complication rate, with infections and stiffness being the most common issues.[5] Hoelsbrekken et al also highlighted that while posterior malleolus fixation improves alignment, there is a risk of implant-related complications, necessitating careful postoperative monitoring.[13]

Comparison of fixation methods

Our study identified that posterolateral fixation provides superior outcomes compared to other techniques. Behery et al found that posterior plating resulted in higher stability and fewer malunion cases than screw fixation alone.[7] Additionally, Park et al suggested that fixation is particularly beneficial when the posterior malleolus fragment exceeds 25% of the articular surface, further supporting our findings.[12]

Clinical implications and future research

Given that proper fixation of the posterior malleolus improves stability and reduces complications, our findings advocate for the standardization of fixation protocols. Future studies should focus on long-term follow-up outcomes and biomechanical studies to refine fixation techniques further.

CONCLUSION

Posterior malleolus fixation is crucial for restoring ankle stability and function in trimalleolar fractures. This study highlighted significant clinical improvements, with screw and combination fixation techniques yielding the highest success rates. Patients who underwent surgical fixation experienced faster recovery and fewer complications compared to those receiving conservative care, which resulted in longer recovery times. The choice of fixation method is critical and should be tailored to the specific fracture type and recovery needs of the patient. Further research is needed to refine fixation techniques, improve postoperative care, and enhance patient outcomes, reinforcing the effectiveness of posterior malleolus fixation.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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