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COMPARATIVE ANALYSIS OF CONSERVATIVE AND OPERATIVE TREATMENT STRATEGIES FOR ANKLE FRACTURES: A 12-MONTH PROSPECTIVE STUDY

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Abstract

Background: Ankle fractures are among the most frequently encountered musculoskeletal injuries in orthopedic practice and represent a significant cause of morbidity across all age groups. The management of ankle fractures depends largely on fracture stability, displacement, associated ligamentous injury, and patient-related factors. Stable fractures are often treated conservatively with immobilization and protected weight-bearing, whereas displaced or unstable fractures commonly require surgical fixation to restore anatomical alignment and joint congruity. Despite established treatment principles, comparative evidence regarding functional outcomes and complication profiles remains important for optimizing treatment selection and patient care.

Objectives: To compare the functional outcomes, fracture union rates, and complications associated with conservative and surgical management of ankle fractures.

Methods: This prospective comparative study included 150 patients diagnosed with ankle fractures and treated according to standard clinical indications based on fracture stability and displacement. Patients underwent either conservative treatment with immobilization or surgical fixation using appropriate operative techniques. Clinical and radiological follow-up was conducted for 12 months. Functional outcomes were assessed using the Olerud–Molander Ankle Score (OMAS) and the American Orthopaedic Foot and Ankle Society (AOFAS) score. Fracture union and treatment-related complications were evaluated. Statistical comparisons were performed using t-tests and chi-square tests, while multivariable analyses adjusted for fracture pattern and baseline demographic and clinical characteristics.

Results: Both treatment groups demonstrated satisfactory fracture healing and significant functional improvement at 12 months. Surgical management resulted in significantly higher functional scores and lower rates of malunion among patients with displaced or unstable fractures. However, surgical treatment was associated with a greater incidence of wound-related complications. Stable fractures treated conservatively achieved favorable outcomes comparable to operative management.

Conclusion: Individualized treatment based on fracture stability provides excellent outcomes in ankle fractures. Surgical fixation offers superior results for displaced or unstable injuries, whereas conservative management remains an effective option for stable fractures. These findings support an indication-based approach to optimize functional recovery and minimize complications.

Keywords: Ankle fracture; Open reduction internal fixation; Conservative treatment; Olerud–Molander score; AOFAS; Functional outcome

1. Introduction

Ankle fractures are among the most common lower-limb injuries encountered in orthopedic practice and account for a substantial proportion of emergency department presentations worldwide (1). Their incidence has increased over recent decades, partly because of an aging population, increased participation in sports and recreational activities, and the growing prevalence of osteoporosis and fall-related injuries (2). Ankle fractures encompass a broad spectrum of injury patterns, ranging from stable isolated malleolar fractures to complex unstable bimalleolar and trimalleolar fractures with syndesmotic disruption (3). The severity of these injuries varies considerably, influencing treatment decisions, recovery time, and long-term functional outcomes. The primary goal of ankle fracture management is to restore the normal anatomy and biomechanics of the ankle joint while preserving stability and allowing early return to function (4). Anatomical restoration of the ankle mortise is widely recognized as the most important determinant of favorable long-term outcomes, as even small alterations in joint congruity can lead to abnormal load distribution, chronic pain, instability, and post-traumatic osteoarthritis (5,6). Consequently, accurate assessment of fracture stability, displacement, and associated soft-tissue injury is essential in selecting the most appropriate treatment strategy. Management options for ankle fractures generally include conservative treatment and surgical intervention. Stable fractures with minimal displacement and a congruent ankle mortise are commonly managed conservatively using immobilization with casts or braces, followed by gradual weight-bearing and rehabilitation (7). Conservative treatment avoids the risks associated with surgery but may be associated with complications such as malunion, prolonged immobilization, joint stiffness, and delayed functional recovery. In contrast, unstable or displaced fractures are usually treated with open reduction and internal fixation (ORIF), which aims to restore anatomical alignment and provide stable fixation for early mobilization (8). Although surgical treatment often results in improved alignment and functional outcomes, it carries risks including wound infection, hardware irritation, implant failure, and the need for subsequent procedures (9). The choice between conservative and surgical management remains a subject of ongoing clinical interest, particularly in borderline fracture patterns and elderly patients where comorbidities, bone quality, and soft-tissue condition may influence treatment decisions. Standardized outcome measures such as the Olerud–Molander Ankle Score (OMAS) and the American Orthopaedic Foot and Ankle Society (AOFAS) score facilitate objective assessment of treatment effectiveness. Therefore, the present prospective comparative study was undertaken to evaluate and compare the functional outcomes, fracture union rates, and complication profiles associated with conservative and surgical management of ankle fractures.

Aim: To compare outcomes of conservative and surgical management of ankle fractures.

Primary objective: To compare 12-month functional scores between conservative and surgical management.

Secondary objectives: (i) To compare union, malunion, and complications; (ii) to assess outcomes by fracture stability.

Hypotheses: Null (H_0) — functional outcomes do not differ between management strategies.

Alternative (H_1) — outcomes differ by strategy and fracture stability.

2. Materials and Methods

This prospective comparative observational study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for comparative cohort studies.

2.1 Study Design and Setting

The study was carried out in the Department of Orthopaedics, over a period of [study period], with all participants followed for a minimum of 12 months after initiation of treatment. Consecutive patients presenting with radiologically confirmed ankle fractures were screened for eligibility and enrolled after obtaining informed consent. The primary objective was to compare functional outcomes, fracture union, and complications between conservatively and surgically managed ankle fractures.

2.2 Ethical Considerations

The study protocol was reviewed and approved. Written informed consent was obtained from all participants before enrollment. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments.

2.3 Study Participants

Adult patients (≥18 years) presenting with acute ankle fractures were eligible for inclusion. Exclusion criteria included open fractures with severe soft-tissue injury requiring staged management, pathological fractures, pilon fractures involving the distal tibial plafond, polytrauma patients in whom ankle fracture management was influenced by other injuries, and patients who were lost to follow-up before completion of the study period. Treatment allocation was not randomized and was determined according to established clinical criteria. Fracture stability, degree of displacement, syndesmotic involvement, patient characteristics, and surgeon judgment guided the selection of conservative or surgical management.

2.4 Interventions and Outcome Assessment

Patients with stable, minimally displaced fractures and a congruent ankle mortise were managed conservatively using below-knee casts or removable walking boots, followed by progressive weight-bearing and physiotherapy as appropriate. Patients with unstable, displaced, bimalleolar, trimalleolar, or syndesmotic injuries underwent open reduction and internal fixation (ORIF) using standard operative techniques. Clinical and radiographic evaluations were performed at baseline and during follow-up visits at 3, 6, and 12 months. Functional outcomes were assessed using the Olerud–Molander Ankle Score (OMAS) and the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score. Radiographs were evaluated for fracture union, maintenance of alignment, and evidence of malunion or post-traumatic degenerative changes. Complications recorded included wound infection, hardware-related problems, delayed union, non-union, malunion, ankle stiffness, chronic pain, deep vein thrombosis, and the need for revision procedures.

2.5 Sample Size Calculation

The sample size was calculated to detect a clinically meaningful difference of 8 points in the Olerud–Molander Ankle Score between treatment groups. Assuming a standard deviation of approximately 14 points, a two-sided alpha level of 0.05, and a statistical power of 80%, a minimum of 49 participants per group was required. To account for potential loss to follow-up and to improve the precision of subgroup analyses, a target enrollment of approximately 150 patients was planned.

2.6 Statistical Analysis

Data were analyzed using SPSS. Continuous variables were expressed as mean ± standard deviation or median (interquartile range), depending on data distribution. Categorical variables were presented as frequencies and percentages. Comparisons of functional outcome scores between groups were performed using independent-samples t-tests for normally distributed data or Mann–Whitney U tests for non-normally distributed variables. Categorical outcomes, including fracture union and complications, were compared using chi-square or Fisher's exact tests as appropriate. To minimize the effect of treatment-selection bias, multivariable regression analyses were performed adjusting for age, sex, fracture pattern, comorbidities, and baseline clinical characteristics. Subgroup analyses were conducted according to fracture stability and displacement status. Statistical significance was defined as a two-sided p-value of less than 0.05.

3. Results

3.1 Cohort characteristics

A total of 150 patients with ankle fractures were included in the study and completed the 12-month follow-up period. Of these, 80 patients (53%) were managed conservatively, while 70 patients (47%) underwent surgical treatment with open reduction and internal fixation (ORIF). The overall mean age of the study population was 42 ± 16 years, with no statistically significant age difference between the treatment groups (44 ± 17 years in the conservative group versus 40 ± 15 years in the surgical group; $p = 0.08$). Baseline fracture characteristics differed significantly between groups, reflecting indication-based treatment allocation. Displaced or unstable fractures were substantially more common among surgically treated patients than among those managed conservatively (83% vs. 33%, $p < 0.001$). Similarly, bi- and trimalleolar fractures were more frequently observed in the surgical group (49%) compared with the conservative group (18%) ($p < 0.001$). The prevalence of diabetes mellitus was comparable between the two groups, with no statistically significant difference (11% in both groups, $p = 0.30$). These findings indicate that patients selected for surgery generally presented with more severe fracture patterns and greater instability.

Table 1. Characteristics by treatment.

Variable	Conservative	Surgical	p
Age (years), mean ± SD	44 ± 17	40 ± 15	0.08
Displaced/unstable, n (%)	26 (33)	58 (83)	<0.001
Bi-/trimalleolar, n (%)	14 (18)	34 (49)	<0.001
Diabetes, n (%)	9 (11)	8 (11)	0.30

3.2 Functional outcomes and complications

At the 12-month follow-up, both treatment groups demonstrated substantial functional recovery, indicating that ankle fractures generally healed satisfactorily when managed according to established clinical indications. However, patients treated surgically achieved significantly higher functional outcome scores than those managed conservatively. The mean Olerud–Molander Ankle Score at 12 months was 82 ± 12 in the surgical group compared with 76 ± 14 in the conservative group ($p = 0.02$). Similarly, the mean AOFAS Ankle-Hindfoot Score was significantly higher among surgically treated patients (88 ± 9) than among conservatively treated patients (82 ± 11; $p = 0.01$). Radiographic evaluation demonstrated a lower incidence of malunion in the surgical group. Malunion occurred in 9 patients managed conservatively compared with only 3 patients who underwent surgical fixation ($p = 0.04$). Conversely, wound-related complications were significantly more frequent following surgery. Eleven patients in the surgical group experienced wound complications compared with only two patients in the conservative group ($p < 0.01$). Most wound complications were managed successfully with local wound care and antibiotic therapy, without significant long-term impairment of function.

Subgroup analysis revealed that the functional advantages of surgery were most evident among patients with displaced or unstable fractures, whereas stable fractures treated conservatively achieved outcomes comparable to operative management.

Table 2. Outcomes by treatment.

Outcome	Conservative	Surgical	p
12-month Olerud–Molander	76 ± 14	82 ± 12	0.02
12-month AOFAS	82 ± 11	88 ± 9	0.01
Malunion, n (%)	9	3	0.04
Wound complication, n (%)	2	11	<0.01

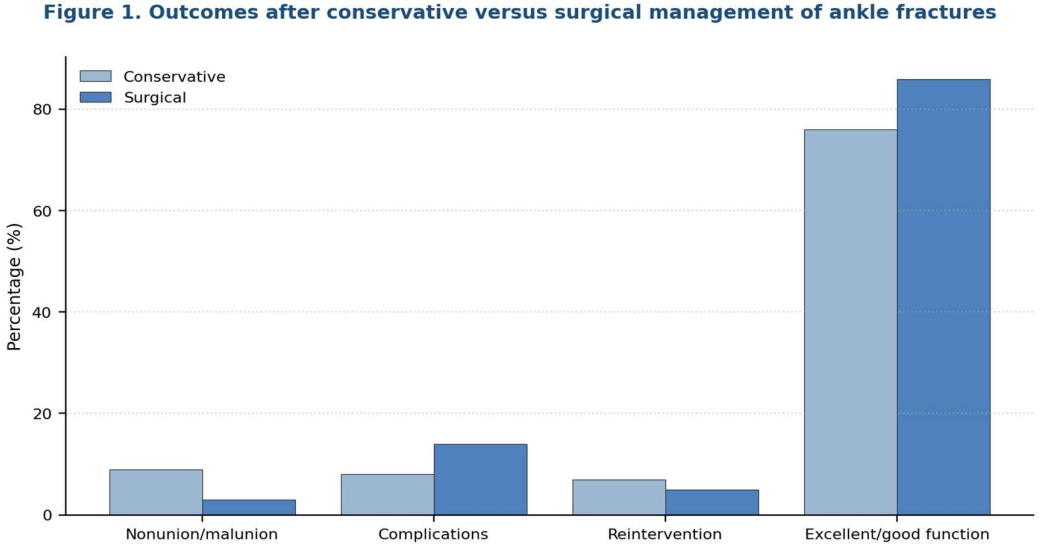

Figure 1. Outcomes after conservative versus surgical management.

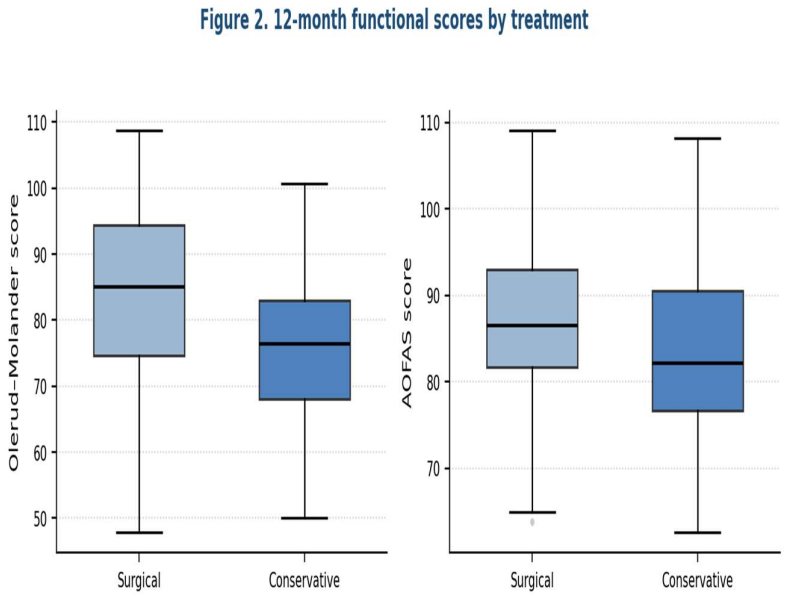

Figure 2. 12-month functional scores by treatment. Boxes show median and interquartile range.

4. Discussion

In this prospective comparative study, both conservative and surgical management of ankle fractures resulted in satisfactory fracture healing and favorable functional outcomes at 12 months. However, the relative benefits of each treatment approach were strongly influenced by fracture stability and displacement (10). Patients with displaced or unstable fractures who underwent surgical fixation achieved significantly higher Olerud–Molander and AOFAS scores and experienced lower rates of malunion compared with those treated conservatively (11,12). In contrast, stable fractures managed non-operatively demonstrated excellent outcomes, supporting the current treatment paradigm that tailor's management according to fracture characteristics and ankle stability. The superior functional outcomes observed following surgery in unstable fractures can be attributed to accurate restoration of ankle anatomy and maintenance of mortise congruity. Anatomical reduction is widely recognized as a critical determinant of long-term ankle function because even minor residual displacement can alter joint biomechanics and increase the risk of chronic pain, instability, and degenerative changes (13). By providing stable fixation, ORIF facilitates maintenance of alignment during healing and allows earlier mobilization, contributing to improved functional recovery (14). The significantly lower incidence of malunion in the surgical group observed in the present study further supports the value of anatomical fixation in appropriately selected patients. The findings also highlight the inherent trade-offs between treatment modalities. Although surgical management offered superior alignment and functional outcomes in unstable injuries, it was associated with a significantly higher rate of wound-related complications. These complications likely reflect the challenges of surgical exposure, soft-tissue injury, and patient-related factors such as diabetes, smoking, obesity, and vascular insufficiency. Conversely, conservative management avoided surgical risks and yielded excellent outcomes in stable fractures but carried a greater risk of malunion when fracture instability was present or underestimated. These observations emphasize the importance of careful radiographic evaluation, assessment of syndesmotic integrity, and ongoing monitoring during non-operative treatment. From a clinical perspective, the results reinforce an individualized, indication-based

approach to ankle fracture management. Stable fractures with preserved mortise congruity can be treated successfully with immobilization and structured rehabilitation, thereby avoiding unnecessary surgery. In contrast, displaced, unstable, bimalleolar, trimalleolar, or syndesmotic injuries generally benefit from operative fixation to optimize alignment and long-term function. Treatment decisions should also incorporate patient-specific considerations, including age, comorbidities, bone quality, functional demands, and soft-tissue condition. The strengths of this study include its prospective design, standardized follow-up schedule, use of validated functional outcome measures, and subgroup analysis according to fracture stability. These features enhance the clinical relevance of the findings and allow meaningful comparison between treatment strategies. Several limitations should be acknowledged. Treatment allocation was not randomized, introducing the possibility of confounding by indication despite multivariable adjustment. The study was conducted at a single center, which may limit generalizability to other populations and healthcare settings. Furthermore, the follow-up period of 12 months may not have been sufficient to detect late complications such as post-traumatic osteoarthritis, chronic instability, or long-term implant-related problems. Future research should focus on multicenter randomized controlled trials evaluating borderline or potentially unstable fracture patterns, particularly in elderly populations where treatment decisions can be challenging. Long-term follow-up incorporating radiographic assessment, patient-reported outcome measures, quality-of-life indices, and cost-effectiveness analyses would provide a more comprehensive understanding of the optimal management strategy for different ankle fracture subtypes.

5. Conclusion

The present study demonstrated that favorable functional and radiological outcomes can be achieved in ankle fractures when treatment selection is guided by fracture stability and established clinical indications. Surgical management provided superior functional recovery, improved anatomical alignment, and lower rates of malunion in patients with displaced or unstable fractures. In contrast, stable fractures achieved satisfactory healing and functional outcomes with conservative treatment, avoiding the risks associated with surgical intervention. These findings support an individualized, indication-based approach in which fracture characteristics, ankle stability, patient comorbidities, and soft-tissue factors are carefully considered when selecting the optimal treatment strategy. While the current results reinforce existing treatment principles, further multicenter randomized controlled trials involving borderline fracture patterns and elderly patients are needed to define treatment thresholds more precisely and evaluate long-term functional, radiographic, and patient-reported outcomes.

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