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Ankle Mortise Fractures as a Cause of Functional Impairment: Current Concepts in Diagnosis, Treatment, and Rehabilitation

Katarzyna Fabiś

ORCID : <https://orcid.org/0009-0004-6077-3168>

E-mail: katrzyna.fabis@stud.umed.lodz.pl

Medical University of Lodz, al. Kościuszki 4, 90-419 Łódź

Mateusz Zbylut

ORCID: <https://orcid.org/0009-0002-4666-5684>

E-mail: mateusz.zbylut.md@gmail.com

Provincial Hospital in Zgierz them. M. Skłodowska-Curie, 95-100 Zgierz, ul. Parzęczewska 35

Daniel Filip Kossakowski

ORCID: <https://orcid.org/0009-0006-6828-6983>

E-mail: daniel.kossakowski@stud.umed.lodz.pl

Medical University of Lodz, al. Kościuszki 4, 90-419 Łódź

Ewa Byjoś

ORCID: <https://orcid.org/0009-0005-4759-156X>

E-mail: chmielowska.ewa137@gmail.com

John Paul II Memorial City Hospital, Rycerska 4, 35-241 Rzeszów, Poland

Sylwia Buczek

ORCI Corresponding Author D: <https://orcid.org/0009-0004-3088-6655>

E-mail: sylwiabuczek00@gmail.com

Specialist Hospital of Śniadecki in Nowy Sącz, Młyńska 10, 33-300 Nowy Sącz, Poland

Weronika Mstowska

ORCID: <https://orcid.org/0009-0003-4524-8106>

E-mail: weronika.mstowska@stud.umed.lodz.pl

Lower Silesian Center of Oncology, Pulmonology and Hematology, pl. Ludwika Hirszfelda 12, 53-413 Wrocław

Karolina Bury

ORCID: <https://orcid.org/0009-0006-1871-1259>

E-mail: 13karolinab@gmail.com

City Hospital of John Paul II in Rzeszow, St. Rycerska 4, 35-214 Rzeszów, Poland

Hanna Naliuka

ORCID: <https://orcid.org/0009-0006-0133-1559>

E-mail: anna.nalivko.2000@gmail.com

M. Kopernik Regional Multispecialty Center of Oncology and Traumatology, Łódź 93-513,
Poland

Katarzyna Młynarczyk

ORCID: <https://orcid.org/0009-0006-1535-6837>

E-mail: katarzyna.b.mlynarczyk@gmail.com

City Hospital of John Paul II in Rzeszow, St. Rycerska 4, 35-214 Rzeszów, Poland

Patrycja Mateja

ORCID: <https://orcid.org/0009-0005-7665-1162>

E-mail: patrycja.mateja3@gmail.com

Prelate J. Glowatzki District Hospital, Opolska 36A, 47-100 Strzelce Opolskie, Poland

Corresponding author

Katarzyna Fabiś

e-mail : katrzyna.fabis@stud.umed.lodz.pl

Abstract

Background. Ankle mortise fractures represent a common injury of the lower extremity and are associated with a wide spectrum of instability and functional impairment. Due to the complex anatomy of the ankle joint and the critical role of the distal tibiofibular syndesmosis in maintaining joint congruency, these fractures may lead to prolonged disability, chronic pain, and post-traumatic osteoarthritis if not properly managed.

Aim. To review current evidence regarding ankle mortise fractures, with particular emphasis on etiology, classification, diagnostic strategies, treatment options, rehabilitation protocols, and functional outcomes.

Material and methods. A narrative review of the literature was conducted using PubMed, Scopus, and Google Scholar. Peer-reviewed articles published in English concerning adult patients with ankle mortise fractures were included. Original studies, systematic reviews, and clinical practice guidelines were analyzed qualitatively.

Results. The literature indicates that ankle mortise fractures account for a significant proportion of ankle injuries and frequently result from rotational mechanisms. Accurate assessment of fracture stability and syndesmotic integrity is essential for treatment selection. Conservative management yields favorable outcomes in stable fracture patterns, whereas unstable injuries typically require surgical fixation. Early mobilization and structured rehabilitation improve functional recovery, while delayed or inadequate management increases the risk of long-term complications.

Conclusion. Ankle mortise fractures are a clinically relevant cause of functional limitation and reduced mobility. Optimal outcomes depend on accurate diagnosis, appropriate treatment selection, and early, individualized rehabilitation. A comprehensive, evidence-based approach is essential to restore function and minimize long-term complications.

Keywords: ankle fracture, ankle mortise, rehabilitation, functional outcome, orthopedic trauma

1. Introduction

The ankle joint is a highly complex anatomical structure characterized by multidirectional mobility, which is essential for weight bearing, balance, and the execution of daily functional activities. Its ability to withstand significant mechanical loads while maintaining mobility is the result of a precise anatomical and biomechanical organization of osseous and ligamentous elements. Due to this complexity, injuries involving the ankle joint may lead to substantial functional impairment if not properly managed [1,2].

The ankle mortise is formed by the distal ends of the tibia and fibula articulating with the talus. Stability of this articulation is primarily ensured by the distal tibiofibular syndesmosis, composed of the interosseous membrane and the anterior, posterior, and transverse tibiofibular ligaments. Additional stabilization is provided by the medial and lateral collateral ligament complexes. The lateral ligament complex consists of the anterior talofibular, calcaneofibular,

and posterior talofibular ligaments, while the medial side is reinforced mainly by the deltoid ligament and the plantar calcaneonavicular ligament [2,3].

Although the ankle is traditionally classified as a hinge joint, it also demonstrates rotational properties due to the asymmetric shape of the talar dome. From a biomechanical perspective, the ankle joint can be conceptualized as a ring-like structure surrounding the talus. Disruption of this ring at a single point generally results in a stable injury, whereas disruption at two or more points leads to mechanical instability and loss of congruency of the ankle mortise [1,4].

Because multiple osseous and ligamentous structures contribute to ankle stability, fractures involving the ankle mortise represent a heterogeneous group of injuries with varying degrees of instability and clinical severity. A thorough understanding of ankle anatomy, biomechanics, and injury mechanisms is therefore essential for accurate diagnosis, classification, and selection of appropriate treatment strategies in patients with ankle mortise fractures [1,2].

2. Etiology and Epidemiology

2.1. Etiology

Ankle mortise fractures most commonly result from rotational forces applied to the ankle joint, typically during low-energy trauma such as twisting injuries occurring in daily activities or sports. The specific mechanism of injury determines the characteristic pattern of osseous and ligamentous damage, frequently involving the distal fibula, medial malleolus, and the distal tibiofibular syndesmosis. In more complex injury patterns, direct blunt trauma and axial loading may also contribute to fracture development [1,3].

High-energy mechanisms, including motor vehicle accidents and falls from height, are less frequent but are often associated with severe fracture configurations, extensive soft tissue damage, and syndesmotic disruption. In elderly patients, even low-energy trauma may result in ankle mortise fractures due to reduced bone quality, impaired balance, and multiple comorbidities, which contributes to the increasing incidence of these injuries in aging populations [4,5].

2.2. Epidemiology

From an epidemiological perspective, ankle mortise fractures account for approximately 15% of all ankle injuries. Over the past two decades, their incidence has risen significantly and is currently estimated at around 174 per 100,000 persons per year. This trend is attributed both to increased participation in physical activity and to demographic changes associated with

population aging [5,7,8]. A clear age- and sex-related distribution has been observed. In individuals under 50 years of age, ankle mortise fractures occur predominantly in men and are most commonly related to sports or occupational activities. In contrast, in patients over 60 years of age, these fractures are more frequently observed in women and are typically associated with low-energy falls and decreased bone mineral density [2,6].

In the pediatric population, ankle fractures remain relatively uncommon, with an estimated incidence of approximately 1 per 1,000 children per year. Despite their lower frequency, accurate diagnosis is essential in this group due to the risk of physal involvement and potential long-term functional consequences [5,8].

3. Classification and Clinical Relevance

Several classification systems are used to describe ankle mortise fractures, primarily to assess injury severity and predict mechanical stability. The Danis–Weber classification categorizes fractures according to the level of the fibular fracture in relation to the distal tibiofibular syndesmosis (types A, B, and C). Owing to its simplicity and good reproducibility, it is commonly used in clinical practice. However, this system does not adequately account for associated syndesmotoc disruption or medial ligament injury and therefore provides limited information regarding functional instability of the ankle joint [3,9].

In contrast, the Lauge–Hansen classification is based on the mechanism of injury and the position of the foot at the time of trauma. By defining the direction of applied forces and the sequential pattern of ligamentous and osseous failure, this system offers greater insight into fracture morphology and concomitant soft tissue damage. Although its complexity and limited interobserver reliability restrict routine clinical use, the Lauge–Hansen classification remains clinically relevant for predicting ankle instability and supporting treatment decision-making in ankle mortise fractures, particularly when syndesmotoc injury is suspected [4,9].

4. Clinical Presentation and Physical Examination

4.1. Clinical Presentation

Patients with ankle mortise fractures typically present with acute ankle pain, swelling, and impaired ability to bear weight following trauma. The clinical picture may vary depending on fracture stability and associated ligamentous injury. Visible deformity, extensive soft tissue

swelling, and skin tension should raise suspicion of an unstable fracture pattern or impending soft tissue compromise [5,11].

4.2. Physical Examination

A thorough physical examination is essential and should include inspection for swelling, ecchymosis, skin lesions, or open wounds, followed by systematic palpation to localize tenderness over the malleoli, distal fibula, and syndesmotoc region. Evaluation of neurovascular status is mandatory both before and after any manipulation, with particular attention to distal pulses, capillary refill, sensory deficits, and motor function. Assessment of proximal structures, including the fibula and knee, is important to exclude associated injuries such as Maisonneuve fractures [2,5,10]. Pain provoked by palpation of the syndesmosis or instability on stress examination may indicate syndesmotoc injury, which has significant implications for treatment planning. In high- energy trauma or severe pain disproportionate to clinical findings, clinicians should remain vigilant for complications such as compartment syndrome or extensive soft tissue injury [10,11].

5. Imaging and Diagnostic Strategy

5.1. Initial Assessment

Initial imaging in suspected ankle mortise fractures should follow a structured diagnostic approach. The Ottawa Ankle Rules are widely used in emergency settings to reduce unnecessary radiographs while maintaining high sensitivity for fracture detection. Although their sensitivity approaches 100%, limited specificity and operator-dependent interpretation mean that fractures cannot be fully excluded solely on the basis of clinical decision rules [8,10].

5.2. Radiographic Imaging

Standard radiographic evaluation includes three views: anteroposterior, lateral, and mortise views. The mortise view, obtained with the ankle internally rotated approximately 15 degrees, is particularly important for assessing talar alignment and detecting widening of the distal tibiofibular syndesmosis. Radiographs of the entire tibia and fibula are indicated when proximal tenderness is present or when syndesmotoc injury is suspected, to exclude a Maisonneuve fracture [2,5].

5.3. Advanced Imaging

Computed tomography is recommended in complex fracture patterns, posterior malleolar fractures, and suspected intra-articular involvement, as it provides superior visualization of fracture morphology and aids surgical planning. Magnetic resonance imaging is reserved for selected cases, primarily to evaluate ligamentous, chondral, or occult injuries when radiographic findings are inconclusive. Ultrasonography may assist in the assessment of soft tissue structures; however, its diagnostic value is highly operator dependent [2,5].

6. Treatment Strategies

6.1. Conservative Management

Management of ankle mortise fractures depends primarily on fracture stability, degree of displacement, and the integrity of the distal tibiofibular syndesmosis. Stable, non-displaced fractures without syndesmotoc or medial ligament injury may be treated conservatively with immobilization and protected weight-bearing. Functional outcomes in these cases are generally favorable, provided that joint congruency is preserved and close radiographic follow-up is maintained [12].

6.2. Surgical Management

Surgical treatment is indicated in unstable fractures, displaced fractures, and injuries associated with syndesmotoc disruption or medial instability. Open reduction and internal fixation (ORIF) remains the gold standard for restoring anatomical alignment of the ankle mortise. Accurate reduction of the fibula and restoration of syndesmotoc stability are critical determinants of long-term outcomes, as even minimal malreduction may lead to altered joint biomechanics and post-traumatic osteoarthritis [13].

6.3. Syndesmotoc Fixation

Fixation of the distal tibiofibular syndesmosis may be achieved using trans-syndesmotoc screws or dynamic fixation devices such as suture-button systems. Current evidence suggests comparable functional outcomes between these methods, although dynamic fixation may allow earlier physiological motion of the syndesmosis and reduce the need for routine implant removal. The choice of fixation should be individualized based on fracture pattern, patient activity level, and surgeon experience [14].

6.4. Posterior Malleolus Considerations

Posterior malleolar fractures play an increasingly recognized role in ankle stability and treatment decision-making. Fixation of the posterior malleolus may contribute to syndesmotic stability and improve functional outcomes, particularly when the fragment involves a significant portion of the articular surface or contributes to posterior instability. Computed tomography is essential for accurate assessment and surgical planning in these cases [15].

7. Rehabilitation and Functional Outcomes

7.1. General Principles

Rehabilitation is a critical component of treatment following ankle mortise fractures and has a direct impact on functional recovery and long-term outcomes. Early mobilization, when clinically appropriate, is associated with improved joint mobility, reduced stiffness, and faster return to daily activities. In stable fractures and after secure surgical fixation, gradual progression to weight-bearing is increasingly recommended as part of modern rehabilitation protocols [18].

7.2. Weight-Bearing and Mobilization

The optimal timing of weight-bearing after surgical treatment remains a subject of ongoing research. Recent randomized controlled trials suggest that early weight-bearing does not increase the risk of fixation failure or complications in appropriately selected patients and may lead to improved functional outcomes and patient satisfaction. However, rehabilitation strategies should be individualized based on fracture pattern, fixation stability, bone quality, and patient compliance [18,19].

7.3. Special Considerations in Elderly Patients

Elderly patients represent a distinct clinical group with increased risk of complications, delayed recovery, and functional decline. Advanced age, osteoporosis, comorbidities, and reduced baseline mobility significantly influence rehabilitation potential and prognosis. In this population, multidisciplinary management and tailored rehabilitation programs are essential to reduce the risk of prolonged immobilization, loss of independence, and increased mortality [17].

7.4. Rehabilitation-Focused Evidence

Rehabilitation following ankle mortise fractures should be based on structured, progressive protocols emphasizing early range of motion, gradual loading, proprioceptive training, and restoration of neuromuscular control. Evidence-based rehabilitation programs have been shown to improve functional outcomes, reduce stiffness, and accelerate return to work and physical activity, particularly when initiated early after stable fixation or confirmed fracture stability [19,21]. Standardized rehabilitation protocols typically progress through phases, including initial immobilization with edema control, followed by controlled mobilization, strengthening, balance training, and sport- or activity-specific exercises. Proprioceptive and balance-focused interventions are especially important in preventing recurrent injury and chronic ankle instability [20–22]. Clinical practice guidelines recommend early functional rehabilitation over prolonged immobilization when fracture stability allows, as this approach is associated with superior ankle function, faster recovery, and no increased risk of complications. Individualization of rehabilitation protocols remains essential, particularly in elderly patients and those with comorbidities affecting bone healing or balance [17,18,23].

8. Complications and Prognosis

8.1. Early Complications

Complications following ankle mortise fractures may occur after both conservative and surgical treatment and significantly affect long-term functional outcomes. Early complications include wound healing disturbances, infection, neurovascular injury, malreduction, and fixation failure. Soft tissue complications are particularly relevant in high-energy injuries and in patients with compromised vascular status or diabetes mellitus [24,25].

8.2. Late Complications

Late complications primarily involve post-traumatic ankle osteoarthritis, chronic pain, stiffness, and residual instability. Even minor incongruities of the ankle mortise or unrecognized syndesmotic malreduction may lead to altered joint biomechanics and progressive cartilage degeneration. Post-traumatic osteoarthritis remains one of the most common long-term sequelae and is strongly associated with fracture severity and quality of reduction [26,27].

8.3. Prognosis

Patient-related factors play a crucial role in prognosis. Advanced age, osteoporosis, smoking, diabetes, and peripheral vascular disease are associated with delayed healing, higher complication rates, and poorer functional outcomes. Elderly patients are at increased risk of loss of independence and reduced mobility following ankle fractures, highlighting the importance of early mobilization and comprehensive postoperative care [17,24].

Overall prognosis depends on fracture pattern, stability, accuracy of reduction, and adherence to rehabilitation protocols. Stable fractures treated conservatively usually have excellent outcomes, while unstable fractures treated surgically may require prolonged recovery. Full functional recovery may take up to 12–24 months, particularly in complex fracture patterns or older patients [26–28].

9. Discussion

The management of ankle mortise fractures remains a subject of ongoing debate, primarily due to the heterogeneity of fracture patterns and the varying degrees of instability associated with these injuries. Although classification systems such as Danis–Weber and Lauge–Hansen provide a useful framework for describing fracture morphology, treatment decisions should not rely solely on classification but rather on a comprehensive assessment of fracture stability, syndesmotic integrity, and patient-related factors.

One of the key challenges in clinical practice is distinguishing truly stable fractures suitable for conservative management from those that require surgical intervention. While several studies have demonstrated favorable outcomes following non-operative treatment of selected fracture patterns, underestimation of instability—particularly in the presence of subtle syndesmotic or deltoid ligament injury—may result in malreduction and long-term functional impairment. This highlights the importance of careful clinical and radiological evaluation, including stress imaging when appropriate.

The choice between conservative and surgical treatment remains particularly relevant in physically active patients. Although surgical fixation offers more predictable anatomical reduction and may facilitate earlier mobilization, it is also associated with procedure-related risks. Current evidence suggests that functional outcomes between operative and non-operative management may be comparable in selected cases; however, surgical treatment may provide

advantages in terms of earlier return to activity and reduced risk of secondary displacement in unstable fractures.

Syndesmotic injury represents another area of persistent controversy. Despite advances in fixation techniques, including dynamic suture-button systems, there is no universal consensus regarding optimal fixation strategy, timing of weight-bearing, or routine implant removal. Overdiagnosis and overtreatment of syndesmotic injuries remain potential concerns, underscoring the need for individualized decision-making based on fracture morphology, intraoperative assessment, and patient activity level.

Rehabilitation has emerged as a critical determinant of outcome following ankle mortise fractures. Increasing evidence supports early mobilization and progressive weight-bearing in both conservatively and surgically treated patients, provided that fracture stability is ensured. Importantly, functional recovery does not always correlate directly with radiographic healing, emphasizing the role of structured physiotherapy in restoring proprioception, strength, and joint mobility.

Elderly patients constitute a distinct clinical subgroup in whom treatment decisions must balance fracture stability with the risks associated with prolonged immobilization. In this population, early mobilization and multidisciplinary management are essential to prevent loss of independence and deterioration in overall functional status.

10. Conclusions

Ankle mortise fractures represent a heterogeneous group of injuries with significant clinical and functional implications. Accurate assessment of fracture stability, syndesmotic integrity, and associated soft tissue injury is essential for appropriate treatment selection and optimal outcomes. While stable fractures can be successfully managed conservatively, unstable injury patterns typically require surgical intervention to restore anatomical alignment of the ankle mortise. Modern management emphasizes not only anatomical reduction and stable fixation but also early functional rehabilitation and individualized postoperative care. Increasing evidence supports early mobilization and weight-bearing in selected patients, provided that fracture stability is ensured. Rehabilitation plays a pivotal role in restoring function, preventing long-term complications, and facilitating return to daily activities.

Despite advances in surgical techniques and rehabilitation protocols, complications such as post-traumatic osteoarthritis and residual functional impairment remain common, particularly in elderly patients and in complex fracture patterns. A multidisciplinary approach combining accurate diagnosis, evidence-based treatment strategies, and structured rehabilitation is therefore essential to optimize long-term outcomes in patients with ankle mortise fractures.

Statement of the Authors Contributions

Conceptualization: Katarzyna Fabiś, Mateusz Zbylut

Methodology: Katarzyna Fabiś, Sylwia Buczek, Mateusz Zbylut

Formal analysis: Katarzyna Młynarczyk, Patrycja Mateja, Hanna Naliuka

Investigation: Katarzyna Fabiś, Weronika Mstowska, Karolina Bury

Resources: Karolina Bury, Hanna Naliuka, Daniel Filip Kossakowski

Data curation: Daniel Filip Kossakowski, Patrycja Mateja

Writing – original draft preparation: Katarzyna Fabiś, Katarzyna Młynarczyk

Writing – review and editing: Mateusz Zbylut, Weronika Mstowska, Sylwia Buczek, Ewa

Byjoś Visualization: Mateusz Zbylut, Sylwia Buczek

Supervision: Katarzyna Fabiś, Ewa Byjoś

Project administration: Katarzyna Fabiś, Daniel Filip Kossakowski

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