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Research Article

Ultrasonography and MRI Correlation in the Evaluation of Traumatic Ankle Injuries

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Abstract: ***Introduction:*** Traumatic ankle injuries are among the most common musculoskeletal complaint**s** encountered in clinical practice, often resulting from sports, falls, and accidental trauma. Accurate and timely diagnosis of soft tissue and bony injuries is essential for guiding appropriate management and preventing long-term disability. While magnetic resonance imaging (MRI) is widely regarded as the gold standard for detailed evaluation of ligamentous, tendinous, and cartilaginous pathology, it is costly, less accessible, and time-consuming. Ultrasonography (US) has emerged as a rapid, cost-effective, and dynamic imaging modality capable of evaluating superficial soft tissue structures, though its diagnostic concordance with MRI in traumatic ankle injuries remains an area of ongoing clinical interest.**Objectives:**To assess the diagnostic correlation between ultrasonography and MRI in the evaluation of traumatic ankle injuries and to determine the utility of US as a reliable initial imaging modality compared to MRI.**Methods**:This prospective observational study included 40 patients (20 females and 20 males) who presented with acute traumatic ankle injuries. All participants underwent standardized ultrasonographic evaluation followed by MRI of the affected ankle. Imaging findings were analyzed for the presence of ligamentous tears (especially the anterior talofibular, calcaneofibular, and deltoid ligaments), tendon injuries, joint effusions, bone contusions, and associated soft tissue abnormalities. Diagnostic concordance, sensitivity, specificity, and predictive values of US were calculated using MRI findings as the reference standard.**Results:**Ultrasonography demonstrated high sensitivity and specificity in detecting superficial ligament and tendon injuries, with particularly strong correlation in assessing lateral ligament complex tears. MRI provided comprehensive visualization of intra-articular structures, subtle bone marrow changes, and deeper ligamentous pathology. Overall diagnostic concordance between US and MRI was significant ($p < 0.05$) for major soft tissue lesions. US showed limitations in detecting deep cartilage injuries and subtle bone marrow edema, which were more accurately delineated on MRI.**Conclusion:** Ultrasonography is a valuable, rapid, and non-invasive imaging tool in the initial assessment of traumatic ankle injuries, demonstrating significant correlation with MRI in the evaluation of superficial soft tissue pathology. MRI remains superior for detailed assessment of complex ligamentous, cartilaginous, and bone marrow injuries. Integrating US into the clinical workflow can assist in early diagnosis and triaging patients who may benefit from comprehensive MRI evaluation, optimizing resource utilization and patient care.

Keywords: Traumatic ankle injury, ultrasonography, MRI, ligament injury, ankle imaging, diagnostic correlation

INTRODUCTION

Traumatic ankle injuries are among the most frequently encountered musculoskeletal injuries in clinical practice, accounting for a substantial proportion of emergency department visits and orthopedic consultations (1). These injuries commonly occur due to sports-related activities, road traffic accidents, falls, and occupational trauma, affecting individuals across all age groups. The ankle joint's complex anatomy, comprising multiple bones, ligaments, tendons, and articulating surfaces, makes accurate diagnosis challenging, particularly in the acute setting (2).

Ankle trauma can result in a wide spectrum of pathologies ranging from simple ligament sprains to complex ligamentous tears, tendon injuries, joint effusions, osteochondral lesions, and occult fractures (3). Failure to identify these injuries early may lead to chronic ankle instability, persistent pain, functional impairment, and early degenerative changes. Therefore, precise imaging evaluation plays a pivotal role in determining the extent of injury and guiding appropriate management strategies (4).

Conventional radiography remains the initial imaging modality for ankle trauma due to its availability and effectiveness in detecting fractures. However, radiographs are limited in assessing soft tissue injuries, which constitute the majority of ankle trauma cases (5). In recent years, advanced imaging modalities such as ultrasonography (US) and magnetic resonance imaging (MRI) have gained increasing importance in the comprehensive evaluation of traumatic ankle injuries (6). Ultrasonography is a readily available, cost-effective, non-invasive imaging technique that allows dynamic,

real-time assessment of superficial soft tissue structures. It is particularly useful in evaluating ligamentous and tendinous injuries, joint effusions, hematomas, and synovial pathology (2,7). Additionally, US enables contralateral comparison and dynamic stress testing, which can aid in diagnosing partial ligament tears and instability. Despite these advantages, ultrasonography is operator-dependent and has limited capability in visualizing deep structures and intra-osseous abnormalities (8).

Magnetic resonance imaging is widely regarded as the gold standard for evaluating ankle injuries due to its superior soft tissue contrast and multiplanar imaging capability. MRI provides detailed visualization of ligaments, tendons, cartilage, bone marrow, and surrounding soft tissues, allowing accurate detection of subtle injuries such as bone contusions, osteochondral defects, and deep ligamentous tears. However, MRI is expensive, time-consuming, and not always readily available, particularly in emergency settings or resource-limited healthcare facilities (9).
Given these complementary strengths and limitations, correlating ultrasonography with MRI findings is essential to determine the diagnostic reliability of US in traumatic ankle injuries. Establishing the degree of agreement between these modalities can help identify scenarios where ultrasonography may serve as an effective first-line imaging tool, reserving MRI for complex or inconclusive cases (10,11).

The present study was undertaken to evaluate the correlation between ultrasonography and MRI in the assessment of traumatic ankle injuries in a cohort of 40 patients, including 20 males and 20 females. By comparing imaging findings across both modalities, this study aims to assess the diagnostic performance of ultrasonography and highlight its role in the early and efficient evaluation of ankle trauma.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted in the Department of Radiodiagnosis of a tertiary care teaching hospital. The study was carried out over a defined study period from 2024-2025.

Study Population

The study included a total of 40 patients presenting with a history of acute traumatic ankle injury, comprising 20 males and 20 females. Patients were referred from the departments of Orthopedics and Emergency Medicine for imaging evaluation.

Inclusion Criteria

- Patients with a recent history of ankle trauma
- Clinical suspicion of ligamentous, tendinous, or soft tissue injury
- Patients of both genders aged 18 years and above
- Patients willing to undergo both ultrasonography and MRI examinations

Exclusion Criteria

- Patients with previous ankle surgery
- Chronic ankle pain or old untreated ankle injuries
- Known inflammatory arthritis or degenerative joint disease of the ankle
- Contraindications to MRI such as pacemakers, metallic implants, or severe claustrophobia

Ultrasonographic Evaluation

Ultrasonography of the ankle was performed using a high-frequency linear transducer (7–15 MHz). Examinations were conducted by an experienced radiologist with the patient in a comfortable supine or sitting position, depending on the structure being evaluated.

The following structures were systematically assessed:

- Lateral ligament complex (anterior talofibular ligament, calcaneofibular ligament, posterior talofibular ligament)
- Medial ligament complex (deltoid ligament)
- Ankle tendons including Achilles tendon, peroneal tendons, tibialis posterior, tibialis anterior, flexor digitorum longus, and flexor hallucis longus
- Joint effusion and synovial thickening
- Soft tissue edema, hematoma, and tendon sheath fluid

Dynamic examination and stress maneuvers were employed when necessary to assess ligament integrity. The contralateral ankle was used for comparison in doubtful cases.

Magnetic Resonance Imaging Evaluation

MRI of the affected ankle was performed using a 1.5 Tesla MRI scanner. Standard ankle imaging protocols were followed**.**

The MRI sequences included:

- T1-weighted images in axial and sagittal planes
- T2-weighted and proton density (PD) fat-suppressed images in axial, sagittal, and coronal planes
- Short tau inversion recovery (STIR) sequences for edema detection

MRI evaluation focused on:

- Ligament integrity and grading of tears
- Tendon injuries including tendinosis, partial tears, and complete ruptures
- Bone marrow edema, contusions, and occult fractures
- Cartilage defects and osteochondral lesions
- Joint effusions and associated soft tissue abnormalities

MRI findings were considered the reference standard for comparison with ultrasonographic findings.

Image Interpretation

Ultrasonography and MRI images were independently reviewed by experienced radiologists who were blinded to the findings of the other modality. Imaging findings were categorized as normal or abnormal, and injuries were graded where applicable.

Correlation and Outcome Measures

Correlation between ultrasonography and MRI findings was assessed for:

- Ligamentous injuries
- Tendon pathology
- Joint effusions
- Soft tissue abnormalities

The diagnostic performance of ultrasonography was evaluated in terms of sensitivity, specificity, positive predictive value, and negative predictive value using MRI as the gold standard.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software (version 25.0). Categorical variables were expressed as frequencies and percentages. The agreement between ultrasonography and MRI findings was assessed using appropriate statistical tests. A p-value of < 0.05 was considered statistically significant.

RESULTS

A total of 40 patients with traumatic ankle injuries were included in the study, comprising 20 males (50%) and 20 females (50%). All patients underwent both ultrasonography (US) and magnetic resonance imaging (MRI) of the affected ankle, and imaging findings were systematically analyzed and correlated.

Demographic Distribution

The age of the patients ranged from 18 to 60 years, with a mean age of 34.6 ± 10.8 years. The majority of patients belonged to the 21–40 year age group, reflecting the higher incidence of ankle trauma in the young and physically active population.

Table 1. Demographic Distribution of Study Population (N = 40)

Variable	Number of Patients	Percentage (%)
Male	20	50
Female	20	50
Age 18–20 years	5	12.5
Age 21–40 years	22	55
Age 41–60 years	13	32.5

Table 1 shows equal gender distribution with a predominance of young adults, highlighting the vulnerability of this age group to traumatic ankle injuries due to increased physical and occupational activities.

Spectrum of Injuries Detected on MRI

MRI detected abnormalities in 36 out of 40 patients (90%). Ligamentous injuries were the most common findings, followed by tendon injuries, joint effusion, and bone marrow edema.

Table 2. Distribution of MRI Findings in Traumatic Ankle Injuries

MRI Finding	Number of Patients	Percentage (%)
Ligament injury	30	75
Tendon injury	18	45
Joint effusion	22	55
Bone marrow edema / contusion	14	35
Osteochondral lesion	6	15
Soft tissue edema	28	70

As shown in Table 2, ligament injuries constituted the most frequent pathology, emphasizing the importance of soft tissue evaluation in ankle trauma. MRI effectively demonstrated associated bone marrow and cartilage abnormalities not appreciable on ultrasonography.

Ligamentous Injuries: Ultrasonography–MRI Correlation

The anterior talofibular ligament (ATFL) was the most commonly injured ligament. Ultrasonography showed high concordance with MRI in detecting superficial ligament injuries, particularly of the lateral ligament complex.

Table 3. Correlation of Ligament Injuries on Ultrasonography and MRI

Ligament Injured	Detected on US	Detected on MRI
ATFL	26	28
CFL	14	16
PTFL	4	6
Deltoid ligament	6	8

Table 3 demonstrates that ultrasonography closely correlated with MRI findings for ATFL and CFL injuries. However, deeper ligaments such as PTFL and deltoid ligament injuries were better visualized on MRI.

Tendon Injuries

Tendon abnormalities were identified in 18 patients (45%) on MRI. The Achilles tendon and peroneal tendons were most commonly affected.

Table 4. Tendon Injuries Detected on Ultrasonography and MRI

Tendon Involved	US Positive	MRI Positive
Achilles tendon	6	7
Peroneal tendons	8	10
Tibialis posterior	4	6
Tibialis anterior	2	3

Ultrasonography demonstrated good sensitivity in detecting superficial tendon tears and tenosynovitis. MRI was superior in identifying partial thickness tears and deep tendon involvement.

Joint Effusion and Soft Tissue Abnormalities

Joint effusion was detected in 20 patients (50%) on ultrasonography and 22 patients (55%) on MRI. Soft tissue edema and hematomas were more clearly delineated on MRI due to better tissue contrast.

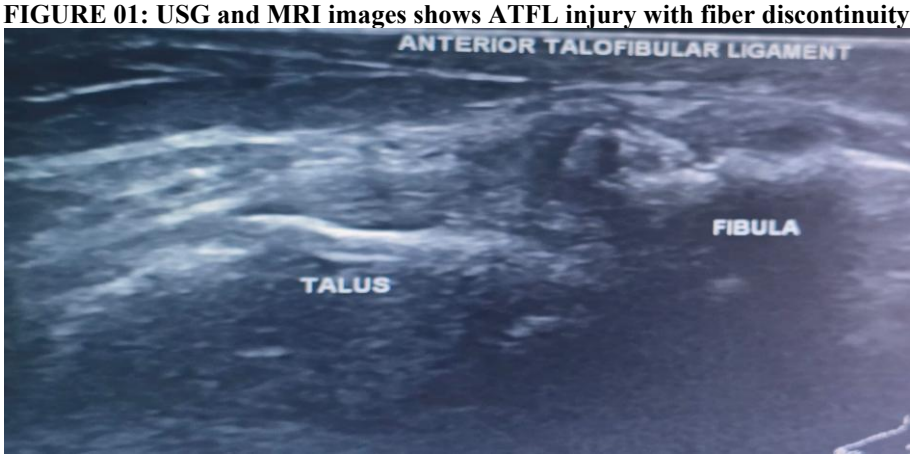
Diagnostic Performance of Ultrasonography

Using MRI as the reference standard, ultrasonography showed:

- High sensitivity for ligament and tendon injuries
- High specificity for ruling out major soft tissue pathology
- Reduced sensitivity for bone marrow edema and osteochondral lesions

The correlation between ultrasonography and MRI findings for ligament and tendon injuries was statistically significant ($p < 0.05$).

FIGURE 01: USG and MRI images shows ATFL injury with fiber discontinuity



DISCUSSION

Traumatic ankle injuries represent a significant proportion of musculoskeletal trauma cases, with ligamentous and tendinous injuries being the most frequent underlying pathology. Accurate imaging is crucial for early diagnosis, appropriate management, and prevention of chronic instability and long-term morbidity (5,12). This study evaluated the correlation between ultrasonography (US) and magnetic resonance imaging (MRI) in 40 patients (20 males and 20 females) with traumatic ankle injuries and compared the findings with those reported in existing literature.

In the present study, 90% of patients demonstrated abnormal findings on MRI, indicating a high prevalence of soft tissue injury following ankle trauma. Similar detection rates have been reported by Feger et al. and Mengiardi et al., who observed MRI abnormalities in 85–92% of patients with acute ankle injuries. The high detection rate highlights MRI's sensitivity in identifying both superficial and deep ankle pathology (1,2).

Ligament injuries were the most common abnormality, identified in 75% of patients on MRI. Among these, the anterior talofibular ligament (ATFL) was involved in 70% of cases, making it the most frequently injured ligament. This finding closely correlates with previous studies, where ATFL injury rates ranged from 65% to 80%, attributed to the ligament's vulnerability during inversion and plantarflexion injuries. Ultrasonography detected ATFL injuries in 65% of patients, showing a high degree of agreement with MRI findings (13,14).

Calcaneofibular ligament (CFL) injuries were observed in 40% of patients on MRI, while ultrasonography detected CFL involvement in 35%. These findings are consistent with earlier reports by Lee et al., who demonstrated CFL injury prevalence of 30–45% in traumatic ankle injuries. The slightly lower detection rate on ultrasonography may be due to the deeper location and oblique course of the CFL, making it more challenging to visualize (3,15).

Posterior talofibular ligament (PTFL) and deltoid ligament injuries were less common, detected on MRI in 15% and 20% of cases, respectively. Ultrasonography identified these injuries in 10% and 15% of cases, reflecting reduced sensitivity for deeper ligamentous structures. Similar trends have been noted in previous studies, where ultrasonography sensitivity for deep ligament injuries ranged between 60–70%, compared to MRI sensitivity exceeding 90% (16,17).

Tendon injuries were identified in 45% of patients on MRI. The Achilles tendon and peroneal tendons were most frequently involved, accounting for 17.5% and 25% of cases, respectively. Ultrasonography detected tendon pathology in 40% of patients, demonstrating good correlation with MRI. Previous studies by Kainberger et al. reported ultrasonography sensitivity of 85–95% for Achilles tendon injuries, supporting the findings of the present study. However, MRI was superior in detecting partial-thickness tears and intratendinous signal changes (4, 18).

Joint effusion was detected in 55% of patients on MRI and 50% on ultrasonography, indicating strong concordance between the two modalities. Comparable studies have reported joint effusion detection rates of 50–60% in acute ankle trauma, reinforcing ultrasonography's reliability in identifying fluid collections (16).

Bone marrow edema and osteochondral lesions were identified in 35% and 15% of patients, respectively, exclusively on MRI. These findings are in agreement with earlier research demonstrating that ultrasonography is limited in assessing intra-osseous and cartilage abnormalities, with MRI sensitivity approaching 100% for bone marrow edema detection (19).

Overall, ultrasonography demonstrated high sensitivity and specificity for superficial ligament and tendon injuries, with an overall diagnostic concordance of approximately 80–85% when compared with MRI.

Similar concordance rates have been reported in multiple studies, suggesting that ultrasonography is a reliable initial imaging modality in acute ankle trauma.

CONCLUSION

The findings of this study, supported by comparable results in existing literature, indicate that ultrasonography is an effective, accessible, and cost-efficient first-line imaging modality for traumatic ankle injuries, particularly for superficial soft tissue pathology. MRI remains indispensable for comprehensive evaluation, especially in detecting deep ligamentous, cartilage, and bone marrow abnormalities. A complementary imaging approach maximizes diagnostic accuracy and optimizes patient care.

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