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Timing Of MRI in Acute Lateral Ankle Sprain: Impact On Diagnostic Findings And Clinical Interpretation – A Retrospective Observational Cohort Study

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ABSTRACT

Background: This study aimed to investigate the impact of magnetic resonance imaging (MRI) timing on radiological findings and diagnostic interpretability in patients with acute lateral ankle sprain.

Methods: In this retrospective observational cohort study, 75 adult patients with acute inversion-type ankle sprain were divided into three equal groups based on MRI timing: hyperacute (0–7 days), subacute (8–21 days), and late (>21 days). All MRIs were performed using a 3.0T scanner and evaluated by a blinded musculoskeletal radiologist. Ligament integrity, bone marrow edema, joint effusion, and soft tissue edema were assessed, along with a 3-point diagnostic interpretability scale. Multivariate analyses adjusted for age, sex, and clinical severity.

Results: ATFL tear classification differed significantly across groups ($p<0.05$), with higher rates of complete tears in the hyperacute group. Bone marrow edema and joint effusion were most pronounced in early imaging and progressively decreased over time ($p<0.05$). Diagnostic interpretability was lowest in the hyperacute group and highest in the subacute group ($p<0.05$). MRI timing remained an independent predictor of ligament injury classification and edema visibility after adjustment.

Conclusion: MRI timing significantly influences both the radiological appearance and interpretability of acute lateral ankle sprain. Subacute imaging appears to provide the most balanced diagnostic clarity, suggesting that MRI should be optimally timed based on clinical objectives.

Trial registration: Not applicable (retrospective study)

Keywords: Ankle Injuries; Anterior Talofibular Ligament; Magnetic Resonance Imaging; Bone Marrow Edema

ÖZET

Amaç: Bu çalışmanın amacı, akut lateral ayak bileği burkulması olan hastalarda manyetik rezonans görüntüleme (MRG) zamanlamasının radyolojik bulgular ve tanısal yorumlanabilirlik üzerindeki etkisini araştırmaktır.

Yöntem: Bu retrospektif gözlemsel kohort çalışmasına akut inversiyon tipi ayak bileği burkulması bulunan 75 erişkin hasta dahil edildi. Hastalar, MRG çekim zamanına göre hiperakut (0–7 gün), subakut (8–21 gün) ve geç dönem (>21 gün) olmak üzere eşit sayıda üç gruba ayrıldı. Tüm MRG incelemeleri 3.0 T cihaz ile gerçekleştirildi ve bir kas-iskelet sistemi radyoloğu tarafından değerlendirildi. Ligament bütünlüğü, kemik iliği ödemi, eklem effüzyonu ve yumuşak doku ödemi ile birlikte tanısal yorumlanabilirlik ölçeği değerlendirildi. Çok değişkenli analizlerde yaş, cinsiyet ve klinik şiddet için düzeltme yapıldı.

Bulgular: Ön talofibular ligament (ATFL) yırtık sınıflaması gruplar arasında anlamlı farklılık gösterdi ($p<0,05$) ve hiperakut grupta tam yırtık oranları daha yüksek bulundu. Kemik iliği ödemi ve eklem effüzyonu erken dönem görüntülemelerde daha belirgin olup zamanla progresif olarak azalma gösterdi ($p<0,05$). Tanısal yorumlanabilirlik hiperakut grupta en düşük, subakut grupta ise en yüksek düzeydeydi ($p<0,05$). Düzeltme sonrası analizlerde de MRG zamanlamasının ligament yaralanması sınıflaması ve ödem görünürlüğü açısından bağımsız bir belirleyici olduğu saptandı.

Sonuç: MRG zamanlaması, akut lateral ayak bileği burkulmasının hem radyolojik görünümünü hem de tanısal yorumlanabilirliğini anlamlı düzeyde etkilemektedir. Subakut dönemde yapılan görüntülemeler, en dengeli tanısal netliği sağlıyor görünmekte olup, MRG'nin klinik amaçlara göre optimal zamanda planlanması gerektiğini düşündürmektedir.

Anahtar Kelimeler: Ayak Bileği Yaralanmaları; Anterior Talofibular Ligament; Manyetik Rezonans Görüntüleme; Kemik İliği Ödemi

Lateral ankle sprain is one of the most common musculoskeletal injuries encountered in orthopedic practice. Although often considered a self-limiting condition, a considerable amount of patients is confronted with persistent pain, recurrent instability, and long-term functional impairment (1,2). Magnetic resonance imaging (MRI) is widely accepted as the standard for evaluating ankle injuries due to its high sensitivity and multiplanar imaging capability. However, MRI findings in acute musculoskeletal injuries reflect a dynamic biological process involving acute inflammation, edema formation, resorption, and tissue remodeling (3,4,5).

The primary objective of this study is to evaluate the effect of MRI timing on radiological findings in patients with acute inversion type ankle injury, so assessing variations in ATFL and CFL injury detection across timing of the imaging, analyzing temporal changes in bone marrow edema and joint effusion, evaluating differences in diagnostic interpretability across MRI timing groups and determining whether MRI timing influences injury severity or not.

Material and Method

This retrospective observational cohort study was conducted at a tertiary-care orthopedic center. Patients admitted between 2022 and 2026 with an acute ankle injury were investigated. Inclusion criteria were age ≥18 years, patients with acute inversion-type (lateral) ankle injury, patients with MRI performed within three different periods as early (in the first week of admission), subacute (between 1 and 3 weeks from the inital injury) and late (>3 weeks of injury). Exclusion criteria also included associated fractures identified on initial radiographs, patients with high energy trauma, previous ankle surgery, chronic ankle instability and inadequate MRI image quality. Institutional review board approval was obtained prior to data collection.

25 patients were selected per MRI timing group using stratified sampling based on age, sex, and baseline clinical severity to ensure group comparability. A composite severity score derived from standardized initial examination findings was used to balance groups. Residual differences were further controlled through multivariate analysis with age, sex, and severity score, thereby minimizing selection bias.

All patients were initially evaluated by the same attending orthopedic surgeon, ensuring consistency in clinical assessment. A standardized clinical examination protocol was applied with palpation of lateral and medial anatomical structures around ankle and foot, inspected severity of ecchymosis and swelling, evaluating the capability of bearing weight on the affected extremity, anterior drawer test and talar tilt test. A clinical severity score was constructed using documented parameters at presentation to account for potential confounding by indication. These parameters were inability to bear weight (yes/no), presence of significant swelling inproportional to the trauma mechanism, positive anterior drawer test, positive talar tilt test, severity of the pain (based on recorded clinical notes). Patients were categorized into low-, moderate-, and high-severity groups based on cumulative findings (6).

MRI was requested based on clinical judgment for patients with suspicion of high-grade ligament injury, persistent pain despite initial conservative management, functional limitation disproportionate to physical examination findings, diagnostic uncertainty, instability findings during follow-up and high functional demand. Patients were stratified according to time from injury to MRI: Group 1 (hyperacute): 0-7 days ; Group 2 (Subacute): 7–21 days; Group 3 (Late): >21days.

The MRI stratification of patients according to MRI timing was predefined based on both the phases of ligament healing and the known temporal evolution of MRI signal characteristics following acute ankle sprain. The time frames (0-7 days, 8-21 days and >21 days) were chosen to reflect clinically relevant and pathophysiologically distinct stages of tissue response rather than calendar based intervals as described in prior musculoskeletal imaging ang ligament healing literature (7,8).

Importantly, the use of discrete time intervals rather than continuous time analysis was a deliberate method to enhance clinical interpretability and to reflect real-world imaging practices, where MRI is typically obtained within broad, clinically driven time frames rather than at certain time points. Our approach in this study further allows exploration of whether a specific temporal window exists in which MRI provides optimal diagnostic clarity, thereby offering potential implications for imaging strategies and clinical decision-making in the management of acute lateral ankle sprain.

All MRI examinations were performed using the same 3.0 Tesla scanner (MAGNETOM Vida, Siemens Healthineers, Erlangen, Germany) with a dedicated ankle coil.

Sequences included T1-weighted spin echo, T2-weighted fat-suppressed sequences, and proton density fat-suppressed sequences. Images were evaluated by an experienced radiologist that is specialized in musculoskeletal injuries, blinded to clinical severity. The following parameters were assessed: Ligament rupture (ATFL/CFL), bone marrow edema (BME), joint effusion, and soft tissue edema. A 3-point scale was used for diagnostic interpretability: 1 = limited confidence, 2 = moderate confidence, 3 = high confidence (9,10,11).

Collected data were analyzed statistically using SPSS Version 25 (IBM Corp, N.Y., USA). Normality of continuous variables was assessed using the Shapiro–Wilk test. Data were presented as mean ± standard deviation or median (interquartile range), as appropriate. Between-group comparisons were conducted using the Student's t-test or Mann–Whitney U test, while multiple group comparisons were performed using one-way ANOVA or the Kruskal–Wallis test. Categorical variables were compared using the Chi-square test or Fisher's exact test. Correlations were evaluated using Pearson or Spearman coefficients. A p-value < 0.05 was considered statistically significant.

Results

A total of 75 patients (39 female and 36 male patients) with a mean age of 38 (range:18-62 years) met inclusion criteria. Each group had 25 patients. There were no statistically significant differences in age or sex distribution between groups (p > 0.05). However, clinical severity scores were higher in Group 1, reflecting earlier imaging in more symptomatic patients. ATFL injury was identified in the majority of patients across all groups. However, injury classification differed significantly by MRI timing (p < 0.05). Group 1 showed a higher proportion of complete tears, Group 2 showed an increased proportion of partial tears, and Group 3 showed an increased proportion of intact or indeterminate findings (Table 1).

Table 1. Baseline Characteristics of the Study Population

Variable	Group 1 (n=25)	Group 2 (n=25)	Group 3 (n=25)	p-value
Age, years (mean ± SD)	38.6 ± 11.2	37.9 ± 10.8	38.1 ± 11.5	0.942
Sex, female (n, %)	13 (52%)	13 (52%)	13 (52%)	>0.999
Sex, male (n, %)	12 (48%)	12 (48%)	12 (48%)	>0.999
Clinical severity score (mean ± SD)	3.8 ± 0.9	2.9 ± 0.8	2.1 ± 0.7	<0.001
Low Severity (Score 0-1)	2 (8.0%)	5 (20.0%)	14 (56.0%)	<0.001
Moderate Severity (Score 2-3)	7 (28.0%)	14 (56.0%)	8 (32.0%)	0.038
High Severity (Score 4-5)	16 (64.0%)	6 (24.0%)	3 (12.0%)	<0.001

Data are presented as mean ± SD or n (%). Groups were compared using one-way ANOVA or Chi-square test.1

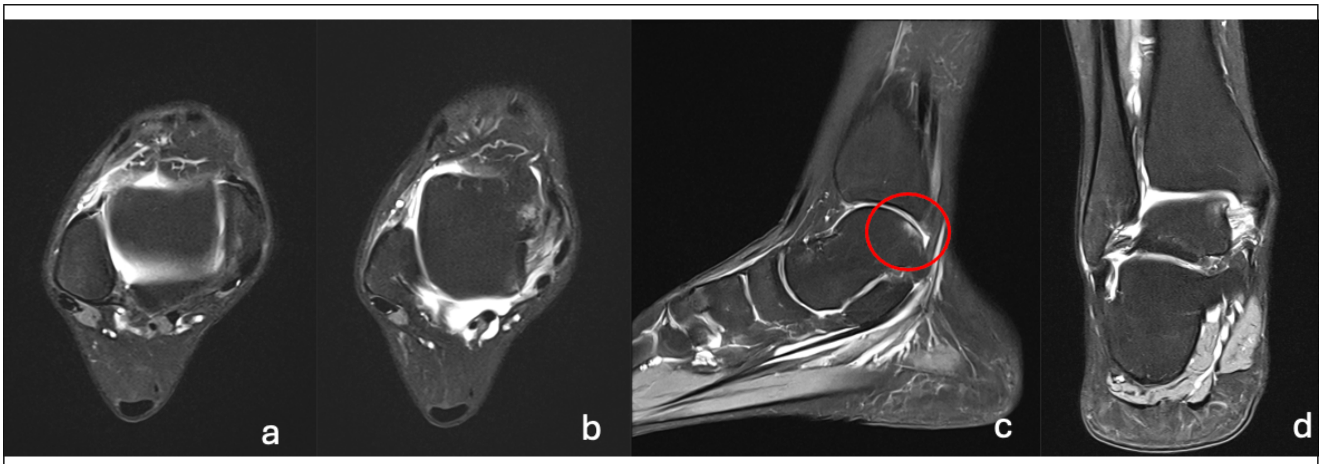

Figure 1. A 40-year-old female patient presented with an acute inversion-type ankle injury. Magnetic resonance imaging (MRI) was performed in the hyperacute period. Axial (a, b), sagittal (c), and coronal (d) sequences reveal a partial-to-complete disruption of the anterior talofibular ligament (ATFL). There is prominent subcutaneous and periarticular soft tissue edema, as well as marked tibiotalar joint effusion. Additionally, diffuse medullary trabecular edema (highligthed with a red circle) is observed within the talus, consistent with acute bone marrow edema.

Table 2. Quantitative Radiological Findings Across MRI Timing Groups				
MRI Finding	**Group 1 (Hyperacute)**	**Group 2 (Subacute)**	**Group 3 (Late)**	**p-value**
ATFL Injury Classification				0.002
- Complete Tear	16 (64.0%)	9 (36.0%)	3 (12.0%)	
- Partial Tear	7 (28.0%)	13 (52.0%)	11 (44.0%)	
- Intact / Indeterminate	2 (8.0%)	3 (12.0%)	11 (44.0%)	
Bone Marrow Edema (BME)				<0.001
- Severe / Moderate	21 (84.0%)	13 (52.0%)	3 (12.0%)	
- Mild / Absent	4 (16.0%)	12 (48.0%)	22 (88.0%)	
Joint Effusion Volume				<0.001
- High / Distended	18 (72.0%)	6 (24.0%)	1 (4.0%)	
- Minimal / None	7 (28.0%)	19 (76.0%)	24 (96.0%)	
Diagnostic Interpretability Scale				<0.001
- Score 3 (High Confidence)	3 (12.0%)	19 (76.0%)	10 (40.0%)	
- Score 2 (Moderate Confidence)	14 (56.0%)	5 (20.0%)	12 (48.0%)	
- Score 1 (Limited Confidence)	8 (32.0%)	1 (4.0%)	3 (12.0%)	

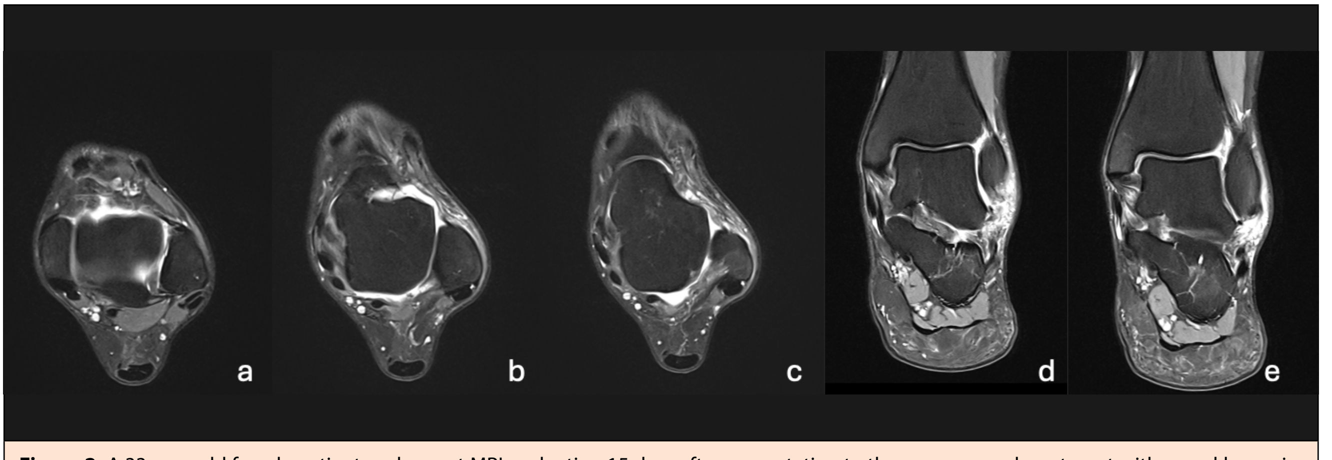

Figure 2. A 33-year-old female patient underwent MRI evaluation 15 days after presentation to the emergency department with an ankle sprain. MRI findings obtained in the subacute phase. Axial (a–c) and coronal (d, e) images show a clearly defined complete rupture of the anterior talofibular ligament (ATFL), with discontinuity and retraction of ligament fibers. Compared to the acute phase, there is a relative decrease in surrounding soft tissue edema, allowing better visualization of ligament morphology. Minimal residual tibiotalar joint effusion is present. The reduced inflammatory background enhances diagnostic interpretability and facilitates more confident grading of ligament injury.

Bone marrow edema demonstrated a clear temporal pattern ($p < 0.05$). Group 1 showed predominantly moderate-to-severe edema, while Group 3 showed predominantly mild or absent edema. Both joint effusion and periarticular soft tissue edema decreased progressively with time ($p < 0.05$), with highest grades observed in Group 1 (Table 2).

Diagnostic interpretability differed significantly between groups ($p < 0.05$); lowest in Group 1, highest in Group 2, and intermediate in Group 3. After adjustment for age, sex, and clinical severity; hyperacute MRI remained independently associated with higher likelihood of complete ATFL tear classification ($p < 0.05$). Late MRI was independently associated with reduced detection of bone marrow edema while subacute MRI was independently associated with higher diagnostic interpretability (Table 1,2).

Table 3. Multivariate Logistic Regression Models for Primary Outcomes				
Dependent Variable	**Independent Predictor**	**Adjusted Odds Ratio (OR)**	**95% Confidence Interval (CI)**	**p-value**
Complete ATFL Tear (vs. Partial/Intact)	Group 1	3.42	1.25 – 9.38	0.016
	Group 3	0.28	0.07 – 1.14	0.075
	Clinical Severity Score	1.84	0.92 – 3.68	0.086
High Interpretability (Score 3)	Group 2	4.15	1.58 – 10.88	0.004
	Group 1	0.18	0.04 – 0.76	0.021
	Clinical Severity Score	0.74	0.35 – 1.55	0.420

Discussion

The key finding of this study was that the timing of MRI is not merely a technical detail, but a clinically significant determinant in the classification of injury severity and the visualisation of bone marrow edema and joint effusion; furthermore, the timing of the MRI answers how confidently the radiologist could interpret the ligament complex. This is important because MRI is one of the commonly used imaging modalities in ankle trauma, and our findings suggest that the apparent confidence of the imaging is partly shaped by the biological phase. From a practical point of view, the same injury may appear more severe in the acute inflammatory period and less conspicuous later, which has direct implications for diagnosis or treatment. This temporal variability in MRI appearance has also been highlighted in comprehensive imaging reviews of acute ankle sprains (12).

One of the main deductions of this study was the higher incidence of complete ATFL tears in the early MRI group. This likely reflects the interaction between structural damage and the acute inflammatory phase, in which edema, hemorrhage, and adjacent soft-tissue injury may exaggerate the apparent extent of ligament injury. This finding is consistent with prior studies demonstrating that bone marrow edema and associated soft tissue changes are most prominent findings in the early phase (13). Moreover, studies comparing MRI with surgical findings have suggested that early imaging may overestimate the severity of ligamentous injuries (14), while other investigations confirm that although MRI is generally reliable for ATFL assessment, its diagnostic performance may vary depending on imaging timing (15).

Therefore, an early MRI may not merely detect injury earlier; it may also change the perceived grade of injury, potentially influencing clinical decisions. This could mean that further immobilisation of a patient who could be treated with simple measures such as RICE (rest, ice, compression, elevation) might lead to unnecessary splinting or casting, or to complications arising from these interventions. Although a higher rate of immobilisation was observed among patients who underwent early MRI, this was not specifically evaluated, as it was not the primary objective of the study and it was not possible to follow up these same patients using serial MRI. The influence of imaging timing on diagnostic accuracy has also been demonstrated in other ligament injuries, where earlier imaging may reduce interpretative reliability (16). From a clinical perspective, current literature also suggests a more selective and indication-based use of MRI in acute ankle sprains (17).

The temporal behavior of bone marrow edema in our cohort also provided important details. Early MRI was associated with more pronounced edema, whereas later scans showed progressive decrease in this finding. This is consistent with the biological course, where signal abnormalities of the bone marrow reflect a transient inflammatory and reparative response rather than a static process. In acute ankle sprains, bone marrow oedema is clinically significant as it may be related to the severity of the injury and may occur in conjunction with osteochondral damage, syndesmotic involvement or more extensive ligament tears. Prior studies have shown that joint effusion and associated findings may correlate with structural injury severity (18). However, our findings extend this by demonstrating that although these features are more visible early, they may paradoxically reduce diagnostic clarity.

Joint effusion and periarticular soft-tissue edema similarly diminished as imaging was delayed as expected. This is a biologically plausible scenario; as effusion and edema are expected to peak immediately following an injury and then subside as the healing process progresses. However, from a diagnostic view, this creates a double-edged effect. On the one hand, acute MRI reveals the full extent of trauma-related changes, including associated edema, which helps localize the injury; however, excessive edema may obscure ligament morphology and reduce the reliability of distinguishing between partial tears and complete ruptures. Previous literature has also highlighted that MRI findings do not always correlate perfectly with clinical symptoms, particularly in later phases of injury (19). Our data suggest that the subacute period may provide a more favorable balance between residual inflammatory signal and structural visibility.

The complexity of ankle MRI interpretation, particularly in the presence of multiple coexisting pathologies, has been emphasized in prior imaging literature (20). Additionally, variations in MRI appearance across different patient populations further support the need for contextual interpretation of imaging findings (21,22). In our cohort, the earliest scans had the lowest interpretability scores, likely because widespread inflammatory change made anatomic boundaries less distinct. A particularly novel contribution of this study is the inclusion of diagnostic interpretability as an outcome. Although many studies focus on sensitivity or classification of injury, interpretability is undoubtedly a more clinically significant measure in daily practice. Because it reflects whether the radiology can actually guide management or not.

This study assembles injury classification, inflammatory findings, and diagnostic interpretability within a unified, time-based framework. Our findings extend existing literature beyond accuracy toward clinical use by demonstrating that MRI timing independently influences not only what is detected but also how confidently it is interpreted. The identification of a subacute interval as a potential optimal diagnostic window provides a practical contribution that may help refine imaging strategies in acute ankle sprain management.

This study has also several limitations. First, its retrospective design introduces inherent risks of selection bias. MRI timing was not randomized but determined by clinical decision-making, raising the possibility of confounding by indication. Second, although a clinical severity score was incorporated into multivariate analysis, residual confounding cannot be entirely excluded. Third, imaging interpretation was performed by a single radiologist. Fourth, the cross-sectional design precludes direct observation of temporal evolution within the same patient. Finally, clinical outcomes were not included, preventing correlation between imaging timing and long-term functional prognosis.

Conclusion

In patients with acute lateral ankle sprain, the timing of MRI significantly influences the appearance and interpretation of ligamentous and associated soft-tissue injury. Early MRI is associated with more pronounced edema and a higher likelihood of complete tear classification, whereas subacute MRI appears to offer the best diagnostic interpretability. These findings indicate that MRI is not merely a static confirmation tool but a time-sensitive diagnostic modality whose yield depends on when it is performed. In routine practice, MRI timing should therefore be individualized according to the clinical question, with early imaging reserved for suspected complex injury and subacute imaging considered when precise ligament grading is the primary goal.

Declarations

Funding

No funding was received for this study.

Conflicts of interest/Competing interests

The authors declare that they have no conflicts of interest or competing interests relevant to this study.

Ethics approval

This retrospective observational cohort study was approved by the Institutional Review Board of Acıbadem University and Acıbadem Healthcare Group (approval date and number: 2026-08/327). The study was conducted in accordance with the Declaration of Helsinki.

Availability of data and material

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

HO: contributed to study conception, data collection, data analysis, and manuscript drafting. BA: contributed to study design, methodological supervision, statistical evaluation, and critical revision of the manuscript. Both authors read and approved the final manuscript.

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