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Original Research Article

Diagnostic Concordance of Musculoskeletal Radiologist–Performed Ultrasound with MRI in Patients Presenting with Ankle Pain

Article History:

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Abstract: ***Background:*** Ankle pain is a common clinical presentation requiring imaging techniques for accurate diagnosis of ligamentous and tendinous injuries. Magnetic resonance imaging (MRI) is widely considered as the reference standard for evaluating soft tissue injuries yet, musculoskeletal (MSK) ultrasound offers easy accessibility and cost-effective alternative. The point of diagnostic concordance between MSK radiologist–performed ultrasound and MRI remains clinically relevant in optimizing imaging pathways. ***Aims & objectives*** of the present study are to evaluate the diagnostic concordance and accuracy of MSK ultrasound compared with MRI in patients presenting with ankle pain. ***Methods:*** In this prospective observational study patient presenting with ankle pain underwent ultrasound followed by MRI done by time gap of 1-5days. Ultrasound was performed by an experienced MSK radiologist using a standardized scanning protocol. MRI served as the reference standard and its reporting was done by another radiologist. Diagnostic performance measures sensitivity, specificity, PPV, NPV, accuracy was calculated. Agreement between modalities was assessed using Cohen's kappa coefficient. ***Results:*** A total of 128 patients were included. Ultrasound demonstrated sensitivity and specificity with accuracy of 0.73 Agreement between ultrasound and MRI was substantial with kappa 0.43, highest concordance was observed for superficial ligament injuries, while discordance was observed in deep intra-articular pathology. ***Conclusion:*** MSK radiologist–performed ultrasound imaging demonstrates high diagnostic accuracy for common ankle soft tissue pathologies and MRI for deeper tissue pathologies. Hence MSK US serve as a reliable first-line imaging modality in appropriately selected patients.

Keywords: MSK radiologist–performed ultrasound MSK US, MRI, Ankle pain, diagnostic concordance..

INTRODUCTION

Ankle pain is a common musculoskeletal complaint encountered in orthopaedic and sports medicine practices and represents a significant cause of functional limitation of daily routine worldwide[1]. Acute ankle injuries like sprains, partial tares or complete tares, particularly involving the lateral ligament complex, are among the most frequent injuries seen in emergency and outpatient settings[2].

Normal radiography is useful in detecting fractures while advanced imaging is often required for evaluation of soft tissue structures including ligaments, tendons, and cartilage[3]. Magnetic resonance imaging (MRI) is widely regarded as the reference standard for broad assessment of ankle pathology due to its excellent soft tissue contrast and multiplanar capability[4]. Conversely, MRI is comparatively expensive and may not be immediately available in many clinical settings. Musculoskeletal (MSK) ultrasound has emerged as a valuable alternative for evaluating superficial ankle structures. High-resolution ultrasound allows dynamic assessment of ligaments and tendons and has demonstrated good diagnostic performance in ankle ligament injuries[5–7].

The ESSR technical guideline for ankle ultrasound provides a structured approach for scanning the anterior, lateral, medial, and posterior compartments, including recommended positioning, transducer orientation, and stress manoeuvres for ligament assessment.[9] These standards are particularly relevant for reproducibility and for ensuring that ligament assessment (ATFL, CFL, PTFL and syndesmotic ligaments) is performed in a consistent manner.[9]

Several comparative studies have reported substantial agreement between ultrasound and MRI in detecting lateral ligament injuries and tendon pathology[6–8]. Nevertheless, ultrasound remains operator-dependent and may have limitations in evaluating deep intra-articular structures[4,7]

Establishing the level of diagnostic concordance between MSK radiologist–performed ultrasound and MRI is essential to optimize imaging pathways and potentially reduce unnecessary MRI utilization. This study aims to evaluate the diagnostic concordance between ultrasound and MRI in patients presenting with ankle pain.

Materials and Methods

Study Design: This was a prospective observational two modality study evaluating the diagnostic performance and concordance of MSK radiologist performed ultrasonography (USG) as a first line imaging tool after normal radiographs, compared with MRI as the reference test. Patients were enrolled during routine care, and data were recorded prospectively in a master chart. The MRI report was issued by a different radiologist with no access to the USG findings at the time of reporting, providing a blinded comparison. This approach aligns with standard imaging pathways where radiography is first line and MRI is used when clinical concern persists or when deeper or occult pathology is suspected. (10-12).

Study area: This study was conducted in the Department of Radio diagnosis, in collaboration with the Department of Orthopaedics', Manipal Hospitals.

Study Duration: Study duration was 2023 to 2025 (3 years), including all eligible cases recorded in the master chart during this period.

Study Population: Patients presenting with ankle pain (traumatic and no traumatic presentations) that had negative or normal radiographs and were clinically planned for further imaging were eligible. In many cases, MRI was already planned and ultrasound was performed while the patient awaited MRI; in other cases, ultrasound was performed first and MRI was advised based on symptoms and ultrasound findings. All imaging was performed with written consent as part of routine care and the study workflow**.**

Inclusion Criteria

- Patients with ankle pain and normal radiographs (X ray negative).
- Availability of both USG and MRI for the same clinical episode for concordance and diagnostic performance analysis.
- Availability of demographic and study variables (age, sex, side, scan interval, and impressions).

Exclusion Criteria

- Records without both ultrasound and MRI reports available.
- MRI performed more than 30 days after the ultrasound (to reduce interval change bias).
- Post operative ankles and incomplete reports or imaging data preventing reliable classification.
- Contraindications to MRI (for the MRI component).

Ultrasound Technique

MSK ultrasound examinations were performed using a Philips Affiniti 70 ultrasound system with a high frequency linear transducer. Ultrasound was performed by one of three MSK radiologists, each with more than 3 years of independent MSK ultrasound experience after fellowship. Scanning followed a standard compartmental approach (anterior, lateral, medial, posterior ankle) and included evaluation of:

- Lateral ligament complex: ATFL, CFL, PTFL
- Medial ligament complex: deltoid ligament
- Tendons: peroneal tendons, tibialis posterior, Achilles
- Joint effusion or haemarthrosis and surrounding soft tissues

Dynamic manoeuvres were performed where clinically indicated

Ultrasound ankle protocol

Component	Details

Patient position	Supine with foot supported; prone for Achilles when required
Transducer	High frequency linear probe (typically 10 to 18 MHz)
Lateral ligaments	ATFL (anterior), CFL (inferior), PTFL (posterior) with dynamic maneuvers when needed
Medial structures	Deltoid ligament assessment; evaluate medial malleolus region
Tendons	Peroneus longus/brevis, tibialis posterior, Achilles; look for tear, tendinopathy, tenosynovitis and subluxation
Joint and soft tissues	Assess for joint effusion/haemarthrosis, synovitis, soft tissue edema and collections
Reporting	Structured description of each structure; grade sprain/partial/complete tear when applicable; document effusion and relevant associated findings

MRI Technique
MRI examinations were performed on a 1.5T Siemens Aera scanner using dedicated MSK ankle specific coils and a routine ankle protocol, typically including multiplanar sequences such as:
- PD fat suppressed axial, coronal, sagittal
- T1 weighted sequences for anatomy

MRI was treated as the reference standard for comparison due to its established role in comprehensive ankle soft tissue and marrow evaluation in persistent symptoms and suspected occult pathology. MRI reporting was performed by a different radiologist who did not perform the ultrasound and who was blinded to the USG findings and operator identity at the time of reporting. [10][12]

MRI ankle protocol (typical departmental sequences)

Component	Details
Scanner	1.5T or 3T ankle MRI (as per departmental availability)
Standard planes	Axial, coronal and sagittal
Core sequences	PD or T2 fat suppressed (axial/coronal/sagittal) and T1 weighted for anatomy
Optional sequences	STIR or additional fat suppressed sequences; gradient echo when required
Key assessment	Ligaments (ATFL/CFL/PTFL, deltoid, syndesmosis), tendons, cartilage/osteochondral lesions, marrow oedema and occult fracture, effusion and infection
Reference standard	MRI impression used as reference in this thesis analysis

Ethical Approval: The study protocol was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants.

Image Interpretation

Ultrasound findings were recorded prospectively. MRI interpretation was performed independently and blinded to ultrasound findings when feasible.

Each structure was classified as:
Normal
Tendinopathy
Partial tear
Complete tear

Statistical Analysis

Statistical analysis is Descriptive type and performed using SPSS (version 23)
Mean ± SD for continuous variables
Frequencies and percentages for categorical variables
Diagnostic Accuracy Measures
Using MRI as the reference standard
Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value
Overall accuracy
95% confidence intervals will be calculated.
Agreement Analysis-Cohen's kappa (κ) coefficient will be used to assess inter-modality agreement.
Interpretation :< 0.20: Poor
0.21–0.40: Fair
0.41–0.60: Moderate

0.61–0.80: Substantial
0.81–1.00: Almost perfect
Statistical significance will be set at $p < 0.05$.

RESULT

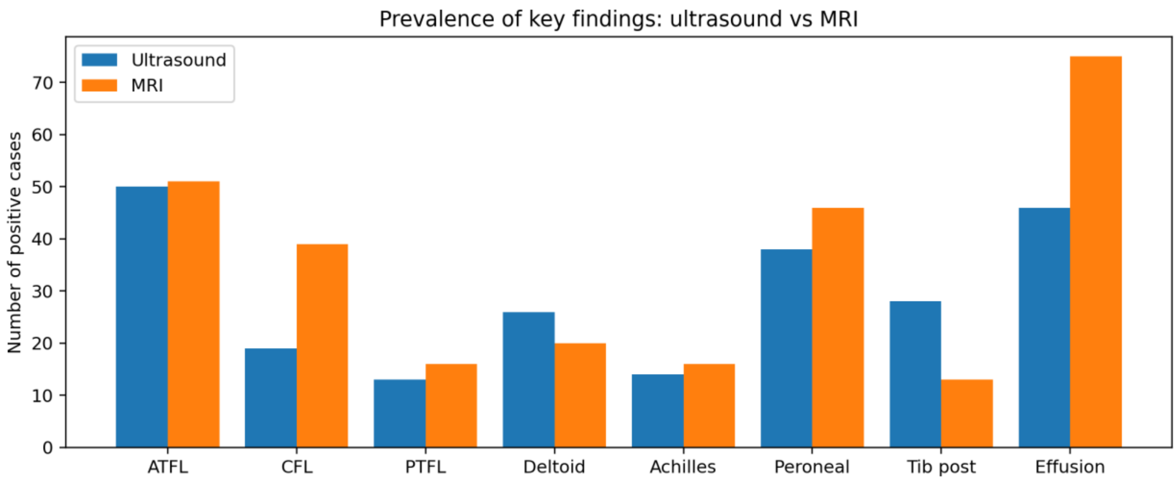
Patient Demographics

Variable	Value
Total included cases	128
Age (median, IQR)	36 years (28 to 44)
Sex	Female 71, Male 56, Not recorded 1
Side	Left 67, Right 61
USG to MRI time gap (median, IQR)	1 days (1 to 5)

Prevalence of Key Finding: USG versus MRI

The prevalence of key findings on ultrasound and MRI was calculated in the study cohort. Paired discordance was assessed using McNemar exact test,
A p-value less than 0.05 were considered statistically significant.

Endpoint	USG positive n (%)	MRI positive n (%)	Direction	McNemar p
ATFL injury (any)	50 (39.1%)	51 (39.8%)	MRI > USG	1.0000
CFL injury (any)	19 (14.8%)	39 (30.5%)	MRI > USG	0.0005
PTFL injury (any)	13 (10.2%)	16 (12.5%)	MRI > USG	0.6291
Any lateral ligament injury	60 (46.9%)	54 (42.2%)	USG > MRI	0.3616
Deltoid ligament injury (any)	26 (20.3%)	20 (15.6%)	USG > MRI	0.4050
Achilles tendon pathology (any)	14 (10.9%)	16 (12.5%)	MRI > USG	0.6875
Peroneal tenosynovitis or pathology	38 (29.7%)	46 (35.9%)	MRI > USG	0.2153
Tibialis posterior pathology	28 (21.9%)	13 (10.2%)	USG > MRI	0.0059
Joint effusion	46 (35.9%)	75 (58.6%)	MRI > USG	<0.0001



Key discordance results (McNemar test):
- Significant paired discordance for CFL injury (any): MRI more frequently positive (McNemar p 0.0005).
- Significant paired discordance for Tibialis posterior pathology: USG more frequently positive (McNemar p 0.0059).
- Significant paired discordance for Joint effusion: MRI more frequently positive (McNemar p <0.0001).

Diagnostic Performance of USG Using MRI as Reference

Diagnostic performance of ultrasound was calculated using MRI as reference standard. Sensitivity and specificity are shown with 95% confidence intervals (Wilson score method). Agreement is summarised using Cohen kappa (binary endpoints).

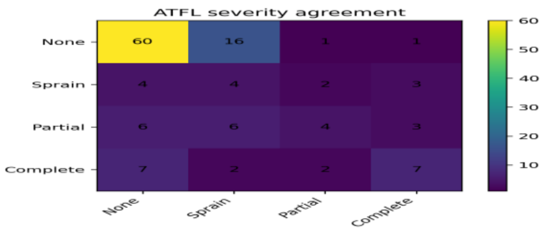
Endpoint	TP	FP	FN	TN	Sensitivity (95%	Specificity (95%	PPV	NPV	Accuracy	Kappa	McNemar p

					CI)	CI)					
ATFL injury (any)	33	17	18	60	0.65 (0.51 to 0.76)	0.78 (0.67 to 0.86)	0.66	0.77	0.73	0.43	1.0000
CFL injury (any)	13	6	26	83	0.33 (0.21 to 0.49)	0.93 (0.86 to 0.97)	0.68	0.76	0.75	0.31	0.0005
PTFL injury (any)	6	7	10	105	0.38 (0.18 to 0.61)	0.94 (0.88 to 0.97)	0.46	0.91	0.87	0.34	0.6291
Any lateral ligament injury	42	18	12	56	0.78 (0.65 to 0.87)	0.76 (0.65 to 0.84)	0.70	0.82	0.77	0.53	0.3616
Deltoid ligament injury (any)	5	21	15	87	0.25 (0.11 to 0.47)	0.81 (0.72 to 0.87)	0.19	0.85	0.72	0.05	0.4050
Achilles tendon pathology (any)	12	2	4	110	0.75 (0.51 to 0.90)	0.98 (0.94 to 1.00)	0.86	0.96	0.95	0.77	0.6875
Peroneal tenosynovitis or pathology	26	12	20	70	0.57 (0.42 to 0.70)	0.85 (0.76 to 0.91)	0.68	0.78	0.75	0.44	0.2153
Tibialis posterior pathology	7	21	6	94	0.54 (0.29 to 0.77)	0.82 (0.74 to 0.88)	0.25	0.94	0.79	0.24	0.0059
Joint effusion	36	10	39	43	0.48 (0.37 to 0.59)	0.81 (0.69 to 0.89)	0.78	0.52	0.62	0.27	<0.0001
Management proxy (complete tear or rupture)	8	14	9	97	0.47 (0.26 to 0.69)	0.87 (0.80 to 0.92)	0.36	0.92	0.82	0.31	0.4049

Severity agreement is presented for ATFL, CFL and overall lateral ligament severity using none, sprain, partial tear and complete tear categories. Weighted kappa (quadratic) is also provided for ordinal agreement
ATFL severity weighted kappa (quadratic): 0.48

USG severity \ MRI severity	None	Sprain	Partial	Complete
None	60	16	1	1
Sprain	4	4	2	3
Partial tear	6	6	4	3
Complete tear	7	2	2	7

ATFL severity heat map

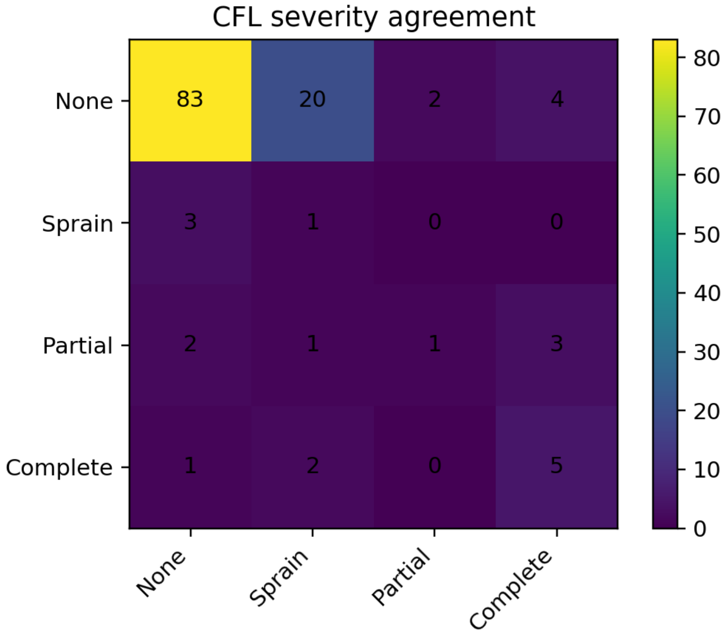


CFL severity weighted kappa (quadratic): 0.53

USG severity \ MRI severity	None	Sprain	Partial	Complete
None	83	20	2	4

Sprain	3	1	0	0
Partial tear	2	1	1	3
Complete tear	1	2	0	5

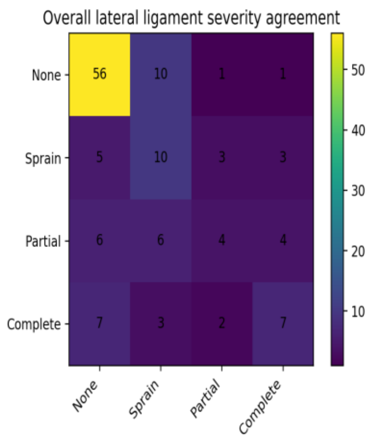
CFL severity heatmap



Overall lateral ligament severity weighted kappa (quadratic): 0.49

USG severity \ MRI severity	None	Sprain	Partial	Complete
None	56	10	1	1
Sprain	5	10	3	3
Partial tear	6	6	4	4
Complete tear	7	3	2	7

Overall lateral ligament severity heatmap



DISCUSSION

This study supports the use of ultrasonography (USG) as a first line imaging tool after normal radiographs when the primary clinical question relates to superficial ligament and tendon integrity. This aligns with evidence that ultrasound can achieve high diagnostic accuracy for ATFL injury and lateral ankle ligament injuries, particularly when performed by trained operators using standardised techniques. (9,13-15) In the matched cohort, McNemar testing showed statistically significant paired discordance for peroneal tenosynovitis (USG more frequently positive) and for joint effusion or haemarthrosis (MRI more frequently positive), with p values < 0.05.

The lateral ligament complex (ATFL, CFL, PTFL) is the most common site of injury in ankle sprains. Ultrasound can depict ligament fibres directly and accuracy can be improved using stress manoeuvres. ESSR technical guidelines describe probe positioning and dynamic evaluation for ATFL assessment. (9) Meta analyses report high sensitivity of ultrasound for ATFL tears and, in some datasets, higher sensitivity than MRI, supporting ultrasound as a first line triage test in suspected lateral sprains. (13-15)

Despite the strengths of ultrasound, MRI remains critical when deeper structures or bony pathology are suspected, such as marrow oedema, occult fracture, osteochondral lesions, syndesmotic injury, and complex multi ligament involvement. Appropriateness frameworks position MRI as a problem solving modality in persistent symptoms and suspected occult injury. (10)(12) Osteochondral lesion assessment and staging are also MRI centred in most clinical algorithms. (16)(25)

Syndesmotic injuries can prolong recovery and cause instability. Dynamic ultrasound has shown good diagnostic performance in some surgical reference comparisons; however, MRI remains valuable due to its broader depiction of associated marrow and intra articular injury. (17-19)

Peroneal tendon disorders may accompany chronic lateral ankle symptoms. Studies with intraoperative reference show that both ultrasound and MRI can be accurate, with ultrasound particularly useful for dynamic subluxation assessment, while MRI provides a comprehensive evaluation for tears and associated pathology. (20-21) Tibialis posterior dysfunction similarly benefits from MRI due to high accuracy for tears, but ultrasound remains a cost effective initial assessment tool, especially for tendinopathy and peritendinosis patterns. (22-24)

Proposed Imaging Algorithm (Based on Study and Literature)

A pragmatic pathway can be recommended:

1. Perform radiographs first to exclude fracture (Ottawa rules guided as appropriate). (26-27)
2. If radiographs are normal and clinical suspicion is for ligament or tendon injury, perform MSK ultrasound first (operator performed, guideline based). (9)(13)(15)
3. Reserve MRI for the following situations:
   a. Suspected complete tears requiring operative planning
   b. Suspected syndesmotic instability
   c. Suspected osteochondral lesion, marrow oedema, or occult fracture
   d. Suspected infection or collection
   e. Persistent symptoms with non-diagnostic or discordant ultrasound findings

(10)(12)(16)(17)

MSK radiologist performed ultrasound is a valuable first line imaging modality following normal ankle radiographs, enabling rapid detection of common ligament and tendon abnormalities and supporting early conservative management decisions. Evidence supports high diagnostic accuracy of ultrasound for lateral ankle ligament injury, particularly ATFL injury, when performed using standardised technique. (9)(13)(14)(15)

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