

Lesion-specific diagnostic performance of magnetic resonance imaging compared with arthroscopy in chronic ankle pathologies with exploratory machine learning prediction

Chayanin Angthong

chayanin.a@rsu.ac.th

Rangsit University <https://orcid.org/0000-0002-1104-8945>

Nutpravee Nakphong

Samitivej Srinakarin Hospital, Bangkok Dusit Medical Services <https://orcid.org/0009-0000-7803-1892>

Wirana Angthong

Thammasat University <https://orcid.org/0009-0002-9339-563X>

Prasit Rajbhandari

RIPAS Hospital, Bandar Seri Begawan, Brunei <https://orcid.org/0000-0002-3954-2435>

Jari Dahmen

University of Amsterdam <https://orcid.org/0000-0002-6849-1008>

Gino MMJ Kerkhoffs

University of Amsterdam <https://orcid.org/0000-0001-7910-7123>

Research Article

Keywords: Ankle arthroscopy, Magnetic resonance imaging, Intra-articular pathology, Machine learning, Osteochondral lesion

Posted Date: October 8th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11278635/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: The authors declare no competing interests.

Abstract

Background

Understanding the diagnostic agreement between advanced imaging and arthroscopy is essential for accurate preoperative planning and tailored therapy. This study aimed to evaluate the diagnostic concordance between preoperative magnetic resonance imaging (MRI) and direct arthroscopic examination for principal ankle pathologies and identify key predictors of arthroscopically confirmed osteochondral lesions (OLs) using machine learning (ML) predictive algorithms.

Materials and Methods

This retrospective study included 54 adults with chronic or recurrent ankle symptoms, who underwent preoperative imaging and subsequent ankle arthroscopy. Arthroscopy served as the reference standard. Sensitivity, specificity, positive and negative predictive values, accuracy, and Cohen κ were calculated with 95% confidence intervals. Exploratory ML models predicting arthroscopically confirmed OLs were evaluated using leave-one-out cross-validation (LOOCV), followed by feature importance and ablation analyses.

Results

For OLs, MRI demonstrated 82.1% sensitivity, 80.8% specificity, 81.5% accuracy, and substantial agreement with arthroscopy ($\kappa = 0.629$). For synovitis, MRI showed 94.3% sensitivity and 100% specificity, although the specificity was based on only one arthroscopy-negative case. For loose body detection, MRI demonstrated 50.0% sensitivity and 90.5% specificity. For ligamentous injury, the sensitivity and specificity were 100% and 25.0%, respectively, with directional discordance between MRI and arthroscopy (exact McNemar $P = 0.004$). In the exploratory ML analysis, linear Support Vector Machine and Logistic Regression achieved LOOCV accuracies of 81.5% and 79.6%, respectively. Direct MRI visualization of the OL had the largest Logistic Regression feature weight (56.5%), and removing this feature reduced the Logistic Regression Accuracy to 50.0%.

Conclusions

MRI diagnostic performance varied according to lesion type, with balanced performance for OLs and high sensitivity for synovitis and ligamentous injury. Exploratory ML analysis indicated that direct MRI visualization was the predominant predictor of arthroscopically confirmed OLs, with smaller contributions from coexisting loose bodies and symptom duration. Preoperative MRI provides excellent accuracy and unbiased diagnostic agreement for OLs and synovitis and serves as an indispensable tool for surgical planning. However, clinicians should recognize the potential for discordance between MRI and arthroscopic findings in the assessment of ligamentous injury as well as the limited sensitivity of MRI for detecting small intra-articular loose bodies.

Level of Evidence:

Level 3

Introduction

Chronic or recurrent ankle pain poses a substantial clinical challenge, characterized by localized tenderness, functional ankle instability, and residual joint disability [1–9]. Advanced diagnostic imaging modalities, including magnetic resonance imaging (MRI) and computed tomography (CT), are routinely employed to evaluate intraarticular abnormalities in these patients [1–9]. Nevertheless, the precise degree of diagnostic correlation between these preoperative imaging modalities and direct intraoperative exploration via ankle arthroscopy has not been extensively characterized [10, 11].

Patients with chronic lateral ankle instability and recurrent pain frequently harbor concomitant intra-articular lesions, such as chondral damage and osteochondral defects [12–16]. If left untreated, these pathologies can progress to joint degeneration and post-traumatic osteoarthritis [16]. Consequently, understanding the diagnostic agreement between advanced imaging and arthroscopy is essential for accurate preoperative planning and tailored therapy [17–19].

The primary objective of this study was to determine the diagnostic performance of preoperative MRI for detecting intraarticular ankle pathology in patients with chronic or recurrent ankle pain who subsequently underwent ankle arthroscopy, using arthroscopic findings as the reference standard. We hypothesized that MRI would demonstrate high sensitivity and overall diagnostic accuracy for detecting arthroscopically confirmed lesions. The secondary objective was to characterize the overall spectrum of intra-articular pathology identified during ankle arthroscopy and assess the lesion-specific agreement between MRI and arthroscopic findings.

The exploratory objectives were to examine age- and sex-related differences in arthroscopic pathology and apply machine learning (ML) modeling to identify potential clinical and radiological predictors of arthroscopically confirmed osteochondral lesions (OLs) of the ankle. Given the limited number of cases involving both MRI and CT, CT-related analyses were not performed to establish a comparative diagnostic performance.

Materials and Methods

Study design and patient selection

To determine the diagnostic performance of preoperative MRI for detecting intraarticular ankle pathology, we reviewed medical records and imaging archives from a single tertiary care facility for consecutive patients who underwent diagnostic or therapeutic ankle arthroscopy under the care of a senior surgeon (C.A.) between January 1, 2015, and June 30, 2025.

Inclusion criteria were as follows: patient age ≥ 18 years, clinical diagnosis of chronic ankle pain (duration >6 weeks) or recurrent ankle pain (>1 episode in the previous year), preoperative ankle MRI and/or CT scan performed within 6 months prior to surgery, and indication for ankle arthroscopy due to persistent symptoms refractory to conservative management. Exclusion criteria were as follows: history of prior ipsilateral ankle surgery or arthroscopy; coexisting systemic inflammatory arthropathies (e.g., rheumatoid arthritis and psoriatic arthritis) or neuromuscular disorders affect the ankle; incomplete, inadequate, or degraded preoperative MRI/CT data preventing proper diagnostic evaluation; and presence of general medical contraindications for arthroscopic surgery.

Patient selection and imaging flow

During the study period, 54 patients who underwent ankle arthroscopy were screened for eligibility. Among the included patients, 51 underwent MRI only and 3 underwent both MRI and CT before arthroscopy.

The primary diagnostic analysis was restricted to patients with available preoperative MRI data for comparison with the arthroscopic findings. Because only three patients underwent both MRI and CT, no formal head-to-head comparison of the diagnostic performance between MRI and CT was undertaken.

Indications for arthroscopy and potential selection bias

This study included surgical patients with persistent chronic or recurrent ankle symptoms despite conservative management. Arthroscopy was performed for diagnostic and/or therapeutic purposes based on persistent symptoms, in conjunction with clinical examination and available preoperative imaging findings. Specific operative indications included persistent pain, mechanical symptoms, suspected OL of the talus/tibial plafond or deep ankle tenderness, chronic instability, impingement, and loose body.

As only operative arthroscopy cases were analyzed, the study population represented a selected operative population rather than the general population of patients with chronic ankle pain. Consequently, intra-articular abnormalities were more prevalent in the operative population than in non-surgical populations. This selection process may have introduced spectrum and referral bias and should be considered when interpreting diagnostic performance measures, particularly the positive predictive value (PPV) and negative predictive value (NPV). Therefore, the PPV and NPV reported here apply primarily to patients selected for arthroscopy and cannot be generalized to all patients with chronic ankle pain.

Sample size calculation

The sample size estimation focused on calculating the expected sensitivity of MRI for detecting intra-articular ankle lesions compared with arthroscopy (the reference standard). Based on previous literature, the diagnostic sensitivity of MRI for intra-articular ankle lesions is approximately 90% (0.90). The estimated prevalence (P) of concomitant intra-articular lesions in patients with chronic ankle pain ranged from 50% to 79% (median estimate, 64.5% or 0.645) [20]. Using a standard sensitivity estimation formula at a 95% confidence level ($\alpha = 0.05$, $Z_{1-\alpha/2} = 1.96$) with an acceptable precision error (d) of $\pm 10\%$ (0.10):

$$n = [(Z_{1-\alpha/2})^2 \times Se \times (1 - Se)] / [d^2 \times P]$$

$$n = [(1.96)^2 \times 0.90 \times (1 - 0.90)] / [(0.10)^2 \times 0.645] \approx 53.58$$

To satisfy the precision criteria, a minimum sample size of 54 patients was required.

Data collection and image evaluation

Data were systematically extracted from electronic medical records and the Picture Archiving and Communication System using standardized case record forms. The collected variables included demographic characteristics (age, sex, and symptom duration), technical specifications of imaging modalities (MRI 1.5 Tesla, Philips, Ambition; MRI 3.0 Tesla, Philips, Ingenia Ambition; CT Philips, IQon Spectral; CT Philips, Incisive 128-slice reconstruction; CT Canon Medical Systems, Toshiba, Aquilion ONE 640-slice reconstruction), and radiological report findings. Preoperative radiological diagnoses were categorized according to the lesion type, including OL/chondral lesions, synovitis, anterior/posterior osteophytes, intra-articular loose bodies, and tendon pathologies/tendinitis. The imaging findings were interpreted and documented by radiologists with at least 4 years of experience.

Arthroscopic findings were extracted from the detailed operative reports and intraoperative video/photographic documentation, which served as the reference standard. To minimize observer bias, radiological and arthroscopic evaluations were reviewed by independent assessors who were not directly involved in the patient management.

Statistical analysis and machine learning benchmarking

Statistical analyses were performed using the Python software (version 3.10; Python Software Foundation) with SciPy and Scikit-learn. Continuous variables are summarized as mean with standard deviation or median with interquartile range, as appropriate, according to their distributions. Categorical variables are summarized as frequency and percentage.

The primary diagnostic analysis evaluated the preoperative MRI findings against arthroscopic findings as the reference standard. For each principal lesion category (osteochondral lesion, synovitis, ligamentous injury, and intra-articular loose body), a 2 × 2 contingency table was constructed to determine the number of true positive, false positive, true negative, and false negative findings. Sensitivity, specificity, PPV, NPV, and overall accuracy were calculated from these counts and reported with 95% confidence intervals (CIs). Exact binomial (Clopper–Pearson) 95% CIs were calculated for these proportions.

Agreement between MRI and arthroscopic findings beyond chance was assessed using the Cohen kappa coefficient (κ), with corresponding 95% CIs. The magnitude of agreement was interpreted according to the Landis and Koch criteria: <0.20, poor; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, substantial; and 0.81–1.00, almost perfect agreement.

As a supplementary paired analysis, the exact McNemar test was used to assess the marginal discordance between the MRI and arthroscopic classifications. Given the small number of discordant observations in several lesion categories, exact rather than asymptotic testing was used. The McNemar test results were considered supplementary to the primary diagnostic performance estimates and were not used to define diagnostic accuracy.

Exploratory subgroup analyses were performed according to age (<41 versus [vs.] ≥41 years, based on the cohort median) and sex to describe potential variation in MRI diagnostic performance. Given the small subgroup sizes and limited numbers of reference-positive or reference-negative observations for several lesions, these analyses were considered descriptive and hypothesis generating, and no formal between-group inference was performed. All statistical tests were two-sided, with $P < 0.05$ considered statistically significant. Because the principal diagnostic analyses were based on the estimation of diagnostic performance rather than multiple hypothesis testing, emphasis was placed on effect estimates and their 95% CIs rather than on P-values.

To construct an optimal predictive framework for arthroscopy-confirmed OL of the ankle (talus/tibial plafond), multiple ML algorithms, including Support Vector Machine (SVM, with Linear and radial basis function kernels), Logistic Regression, Random Forest, AdaBoost, and Gradient Boosting, were benchmarked using leave-one-out cross-validation (LOOCV). Linear classifiers demonstrated superior generalizability on this sample dataset ($n = 54$), with SVM (Linear) and Logistic Regression achieving predictive accuracies of 81.5% and 79.6%, respectively. Feature importance was extracted from the standardized model coefficients to evaluate the relative predictor weights. Furthermore, feature ablation analysis was performed by removing the direct MRI OL visualization to test whether secondary demographic and radiological factors could serve as surrogate biomarkers. A two-sided P-value < 0.05 was considered statistically significant for all analyses.

Ethics statements

This retrospective descriptive cohort study was approved by our Institutional Review Board.

Results

Overall diagnostic performance

A total of 54 patients who met all the inclusion criteria were evaluated. The study cohort comprised 54 patients (35 men [64.8%] and 19 women [35.2%]) with chronic or recurrent ankle pathologies. The overall mean age was 41.5 ± 11.6 years (range, 22.0–64.0 years; median, 40.5 years). The mean duration of symptoms prior to surgical intervention was 46.3 ± 108.7 weeks. Due to notable right-skewness and extreme outliers in symptom chronicity, central tendency was further characterized by a median duration of 22.0 weeks (interquartile range [IQR], 10.0–38.0 weeks).

Preoperative MRI revealed ligamentous injuries as the most prevalent intra-articular abnormality ($n = 51$, 94.4%), followed closely by synovitis ($n = 50$, 92.6%), OL ($n = 28$, 51.9%), and loose bodies ($n = 10$, 18.5%). The direct intraoperative arthroscopic evaluation confirmed synovitis in nearly all the patients ($n = 53$, 98.2%), followed by ligamentous injuries ($n = 42$, 77.8%), OL ($n = 28$, 51.9%), and intra-articular loose bodies ($n = 12$, 22.2%). The subgroup analysis of the ligamentous structures demonstrated that the anterior talofibular ligament (ATFL) was the most frequently injured ligament on both preoperative MRI ($n = 39$, 72.2%) and intraoperative arthroscopy ($n = 31$, 57.4%). The calcaneofibular ligament (CFL) was the second most prevalent ligamentous disruption, identified in 44.4% ($n = 24$) of MRI scans and confirmed in 31.5% ($n = 17$) of arthroscopic procedures. Compared with definitive arthroscopy, preoperative MRI exhibited higher rates of detection of posterior talofibular ligament (29.6% vs. 1.9%) and anterior inferior tibiofibular ligament (20.4% vs. 1.9%) abnormalities.

Regarding osseous, OL, and articular surface abnormalities, osteochondral lesions of the talus constituted the dominant focal bone pathology, detected in 27.8% ($n = 15$) of MRI examinations and 29.6% ($n = 16$) of arthroscopic explorations. The topographical distribution on the talar dome was symmetrical between the medial and lateral articular facets on MRI (9.3% [$n = 5$] each) and direct arthroscopic visualization (7.4% [$n = 4$] each). Additional secondary intra-articular pathologies, including distal tibial plafond/anterior lip lesions (14.8% vs. 7.4%) and bony impingement/os trigonum (9.3% vs. 3.7%), were identified at higher frequencies during direct arthroscopic examination than during preoperative MRI.

The primary diagnostic performance parameters comparing preoperative MRI with the arthroscopic gold standards across the four major intraarticular pathologies are detailed in **Table 1**.

For OLs, MRI demonstrated a sensitivity of 82.1% (95% CI, 63.1–93.9%) and specificity of 80.8% (95% CI, 60.6–93.4%), with a PPV of 82.1% (95% CI, 63.1–93.9%), NPV of 80.8% (95% CI, 60.6–93.4%), and overall accuracy of 81.5% (95% CI, 68.6–90.7%). Agreement between MRI and arthroscopic findings was substantial ($\kappa = 0.629$; 95% CI, 0.422–0.837). No evidence of directional discordance was observed (exact McNemar $P = 1.000$).

For synovitis, MRI demonstrated a sensitivity of 94.3% (95% CI, 84.3–98.8%) and specificity of 100% (95% CI, 2.5–100.0%), with a PPV of 100% (95% CI, 92.9–100.0%) and NPV of 25.0% (95% CI, 0.6–80.6%). Overall accuracy was 94.4% (95% CI, 84.6–98.8%), with fair agreement between MRI and arthroscopic findings ($\kappa = 0.382$; 95% CI, -0.153–0.916). The exact McNemar P-value was 0.250.

For intra-articular loose bodies, MRI demonstrated a sensitivity of 50.0% (95% CI, 21.1–78.9%) and specificity of 90.5% (95% CI, 77.4–97.3%), with a PPV of 60.0% (95% CI, 26.2–87.8%) and NPV of 86.4% (95% CI, 72.6–94.8%). Overall accuracy was 81.5% (95% CI, 68.6–90.7%), with moderate agreement between MRI and arthroscopic findings ($\kappa = 0.430$; 95% CI, 0.136–0.725). The exact McNemar P-value was 0.754.

For ligamentous injury, MRI demonstrated a sensitivity of 100% (95% CI, 91.6–100.0%) and specificity of 25.0% (95% CI, 5.5–57.2%), with a PPV of 82.4% (95% CI, 69.1–91.6%) and NPV of 100% (95% CI, 29.2–100.0%). Overall accuracy was 83.3% (95% CI, 70.7–92.1%), with fair agreement between MRI and arthroscopic findings ($\kappa = 0.341$; 95% CI, 0.046–0.637). Discordant classifications occurred more frequently when MRI was positive and the arthroscopic assessment was negative than in the reverse direction (exact McNemar $P = 0.004$), indicating directional discordance between the two assessments.

Subgroup analyses: age- and sex-stratified diagnostic performance

To explore potential demographic variation in diagnostic performance, patients were stratified by age (<41 vs. ≥ 41 years, based on the cohort median) and sex. Exploratory subgroup analyses showed numerical variations in the estimates of MRI diagnostic performance across age and sex strata. No statistically significant directional discordance was detected by exact McNemar testing in any age- or sex-stratified analysis (all exact $P \geq 0.063$).

For OLs, patients aged ≥ 41 years showed a sensitivity of 94.1% (95% CI, 71.3–99.9%) and a κ of 0.669 (95% CI, 0.375–0.963), compared with 63.6% (95% CI, 30.8–89.1%) and 0.526 (95% CI, 0.199–0.854), respectively, among patients aged <41 years. Similarly, women demonstrated a κ of 0.789 (95% CI, 0.512–1.000) for OLs compared with 0.539 (95% CI, 0.259–0.819) in men. For loose bodies, sensitivity was 71.4% (95% CI, 29.0–96.3%) in men and 20.0% (95% CI, 0.5–71.6%) in women. However, the CIs were wide and substantially overlapped, and several estimates for synovitis and ligamentous injury were unstable or inestimable because of the small number of reference-negative observations within individual subgroups. Therefore, these exploratory findings should be interpreted descriptively and should not be considered evidence of age- or sex-related differences in MRI diagnostic performance.

Machine learning-powered predictive modeling and feature importance

Cross-validation benchmarking revealed that the linear classification models outperformed the ensemble tree-based models on this dataset (LOOCV Accuracy: SVM Linear = 81.5%, Logistic Regression = 79.6%, Random Forest = 70.4%, and Gradient Boosting = 64.8%).

Based on the standardized Logistic Regression classifier (LOOCV Accuracy = 79.6%), direct MRI visualization of the OL was the single largest contributor to the predictive model, accounting for **56.5%** of the total feature importance decision weight. Notably, the presence of loose bodies on MRI emerged as the primary and secondary predictor (**21.6%**), followed by symptom duration (**9.0%**), patient age (**5.8%**), sex (**2.8%**), ligament injury (**2.5%**), and synovitis (**1.8%**).

Feature ablation analysis (removing direct MRI OL findings from the model) resulted in a precipitous decrease in LOOCV Accuracy across all the algorithms (Random Forest decreased from 70.4% to 51.9%, Logistic Regression decreased from 79.6% to 50.0%, and SVM Linear decreased from 81.5% to 46.3%). This decrease in chance-level performance (50.0%) demonstrates that coexisting clinical demographics and soft tissue imaging findings cannot serve as surrogate markers in the absence of direct MRI cartilage visualization.

Discussion

The principal findings of this study provide key insights into the diagnostic utility, limitations, and decision-making framework for advanced preoperative imaging in patients undergoing arthroscopy for chronic or recurrent ankle pain. Our findings highlight that preoperative MRI provides excellent accuracy and agreement for the detection of OL and synovitis. However, compared with arthroscopic assessment, MRI tended to demonstrate a higher frequency of ligament abnormalities, indicating some discordance between the two modalities, while small loose bodies were occasionally not detected on MRI. Exploratory ML analysis identified the presence of OL, symptom duration, and coexisting loose bodies as potentially relevant factors associated with arthroscopic findings and surgical planning.

Two pivotal clinical messages have emerged regarding the management of chronic ankle pain. First, the presence of OL on MRI demonstrated an exceptionally high PPV and represented the single most critical feature in our ML predictive model, accounting for 56.5% of the overall decision weight. Feature ablation further proved that without MRI visualization, the reliance on clinical demographics and secondary soft tissue findings failed to predict arthroscopic cartilage pathology. Therefore, MRI was still recommended as an essential diagnostic modality in preoperative planning. The identification of cartilage defects dictates the necessity of specialized arthroscopic interventions, such as microfracture, debridement, or chondroplasty. Second, findings such as loose bodies often coexisted with OL in our ML predictive model. Identification of this indirect feature should increase clinical suspicion of coexisting OL. Its pathogenesis stems from chronic microtrauma and vascular insufficiency, culminating in subchondral ischemia, osteochondral separation, and secondary loose body development [21]. However, for loose bodies, MRI exhibited low sensitivity, indicating that half of all the intra-articular loose fragments observed during arthroscopy were missed on preoperative MRI. This limitation highlights the necessity for meticulous intraoperative joint exploration even when preoperative imaging is negative for loose bodies.

Although MRI demonstrated 100% sensitivity and 100% NPV for ligamentous lesions, the specificity was only 25%. Significant directional discordance was observed between MRI and arthroscopic findings, with MRI-positive/arthroscopy-negative findings occurring more frequently than the reverse pattern. Clinically, MRI frequently depicts hyperintensities, scar tissue, or attenuated ligamentous fibers as structural tears. However, intraoperative arthroscopic stress testing often revealed functional continuity. This diagnostic disparity aligns with the recent evidence reported by Tang et al. [22], who demonstrated that high-frequency ultrasonography (HFUS) yielded significantly higher diagnostic accuracy than MRI in evaluating lateral ankle ligament trauma. Specifically, HFUS exhibited superior performance in grading the ATFL tear severity, whereas MRI showed only moderate diagnostic capability for

concomitant calcaneofibular ligament injuries [22]. Overall, these findings suggest that orthopedic surgeons should avoid relying solely on MRI reports to indicate surgical ligamentous repair or reconstruction, and a comprehensive approach integrating clinical history, physical examination, and intraoperative arthroscopic stress testing remains imperative.

Based on subgroup dynamics and other ML insights, our analyses indicated higher diagnostic accuracy in older (≥ 41 years) and women, particularly for OL and synovitis. This trend corroborates findings of previous literature documenting a lower incidence and different presentations of chondral lesions in younger demographics [23]. The importance of ML features further emphasized that, while direct MRI OL visualization is paramount, secondary factors such as coexisting loose bodies and chronic symptom duration significantly elevate the clinical probability of arthroscopically confirmed chondral lesions. Incorporating these clinical and radiological parameters into preoperative risk stratification algorithms can optimize surgical planning and patient counseling.

This study has some limitations. A small subset of patients underwent both preoperative MRI and CT, which limited the statistical power necessary to evaluate the potential synergistic benefit of combined multimodal imaging. Additionally, this investigation was conducted within a single hospital network.

Conclusion

Preoperative MRI provides excellent accuracy and unbiased diagnostic agreement for OLs and synovitis and serves as an indispensable tool for surgical planning. However, clinicians should recognize the potential for discordance between MRI and arthroscopic findings in the assessment of ligamentous injury as well as the limited sensitivity of MRI for detecting small intra-articular loose bodies. The ML-driven detection of OLs, interpreted alongside chronic symptom duration and coexisting loose bodies, provides key predictive utility for optimizing arthroscopic surgical planning. Future multicenter prospective trials with larger cohorts are required to validate our predictive models.

Abbreviations

MRI, magnetic resonance imaging; OL, osteochondral lesion; ML, machine learning; LOOCV, leave-one-out cross-validation; CT, computed tomography; vs., versus; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval; SVM, Support Vector Machine; CFL, calcaneofibular ligament; ATFL, anterior talofibular ligament; HFUS, high-frequency ultrasonography

Declarations

All patients provided informed consent to participate in the study, although the requirement for informed consent had been waived by the institutional ethics committee because of the retrospective study design.

References

1. Friemert B, Oberländer Y, Schwarz W et al (2004) Diagnosis of chondral lesions of the knee joint: can MRI replace arthroscopy? A prospective study. *Knee Surg Sports Traumatol Arthrosc* 12:58–64. <https://doi.org/10.1007/s00167-003-0393-4>
2. Kuikka PI, Kiuru MJ, Niva MH, Kröger H, Pihlajamäki HK (2006) Sensitivity of routine 1.0-Tesla magnetic resonance imaging versus arthroscopy as gold standard in fresh traumatic chondral lesions of the knee in young adults. *Arthroscopy* 22:1033–1039. <https://doi.org/10.1016/j.arthro.2006.06.021>
3. Munk B, Madsen F, Lundorf E et al (1998) Clinical magnetic resonance imaging and arthroscopic findings in knees: a comparative prospective study of meniscus anterior cruciate ligament and cartilage lesions. *Arthroscopy* 14:171–175. [https://doi.org/10.1016/s0749-8063\(98\)70036-2](https://doi.org/10.1016/s0749-8063(98)70036-2)
4. Ochi M, Sumen Y, Kanda T, Ikuta Y, Itoh K (1994) The diagnostic value and limitation of magnetic resonance imaging on chondral lesions in the knee joint. *Arthroscopy* 10:176–183. [https://doi.org/10.1016/s0749-8063\(05\)80090-8](https://doi.org/10.1016/s0749-8063(05)80090-8)
5. Potter HG, Linklater JM, Allen AA, Hannafin JA, Haas SB (1998) Magnetic resonance imaging of articular cartilage in the knee: an evaluation with use of fast-spin-echo imaging. *J Bone Joint Surg* 80:1276–1284. <https://doi.org/10.2106/00004623-199809000-00005>
6. Recht MP, Kramer J, Marcelis S et al (1993) Abnormalities of articular cartilage in the knee: analysis of available MR techniques. *Radiology* 187:473–478. <https://doi.org/10.1148/radiology.187.2.8475293>
7. Speer KP, Spritzer CE, Goldner JL, Garrett WE Jr (1991) Magnetic resonance imaging of traumatic knee articular cartilage injuries. *Am J Sports Med* 19:396–402. <https://doi.org/10.1177/036354659101900414>
8. Tan TC, Wilcox DM, Frank L et al (1996) MR imaging of articular cartilage in the ankle: comparison of available imaging sequences and methods of measurement in cadavers. *Skelet Radiol* 25:749–755. <https://doi.org/10.1007/s002560050173>
9. Verhaven EF, Shahabpour M, Handelberg FW, Vaes PH, Opdecam PJ (1991) The accuracy of three-dimensional magnetic resonance imaging in the diagnosis of ruptures of the lateral ligaments of the ankle. *Am J Sports Med* 19:583–587. <https://doi.org/10.1177/036354659101900605>
10. Rolf CG, Barclay C, Riyami M, George J (2006) The importance of early arthroscopy in athletes with painful cartilage lesions of the ankle: a prospective study of 61 consecutive cases. *J Orthop Surg Res* 1:4. <https://doi.org/10.1186/1749-799X-1-4>
11. Takao M, Uchio Y, Naito K, Fukazawa I, Ochi M (2005) Arthroscopic assessment for intra-articular disorders in residual ankle disability after sprain. *Am J Sports Med* 33:686–692. <https://doi.org/10.1177/0363546504270566>
12. DiGiovanni BF, Fraga CJ, Cohen BE, Shereff MJ (2000) Associated injuries found in chronic lateral ankle instability. *Foot Ankle Int* 21:809–815. <https://doi.org/10.1177/107110070002101003>

13. Hintermann B, Boss A, Schäfer D (2002) Arthroscopic findings in patients with chronic ankle instability. *Am J Sports Med* 30:402–409. <https://doi.org/10.1177/03635465020300031601>
14. Ben Kibler WB (1996) Arthroscopic findings in ankle ligament reconstruction. *Clin Sports Med* 15:799–804. [https://doi.org/10.1016/S0278-5919\(20\)30088-0](https://doi.org/10.1016/S0278-5919(20)30088-0)
15. Okuda R, Kinoshita M, Morikawa J, Yasuda T, Abe M (2005) Arthroscopic findings in chronic lateral ankle instability: do focal chondral lesions influence the results of ligament reconstruction? *Am J Sports Med* 33:35–42. <https://doi.org/10.1177/0363546504271058>
16. Taga I, Shino K, Inoue M, Nakata K, Maeda A (1993) Articular cartilage lesions in ankles with lateral ligament injury: an arthroscopic study. *Am J Sports Med* 21:120–127. <https://doi.org/10.1177/036354659302100120>
17. Bonnin M, Tavernier T, Bouysset M (1997) Split lesions of the peroneus brevis tendon in chronic ankle laxity. *Am J Sports Med* 25:699–703. <https://doi.org/10.1177/036354659702500520>
18. Ferkel RD, Chams RN (2007) Chronic lateral instability: arthroscopic findings and long-term results. *Foot Ankle Int* 28:24–31. <https://doi.org/10.3113/FAI.2007.0005>
19. Schäfer D, Hintermann B (1996) Arthroscopic assessment of the chronic unstable ankle joint. *Knee Surg Sports Traumatol Arthrosc* 4:48–52. <https://doi.org/10.1007/BF01565998>
20. Al Adal S, Pourkazemi F, Mackey M, Hiller CE (2019) The prevalence of pain in people with chronic ankle instability: a systematic review. *J Athl Train* 54:662–670. <https://doi.org/10.4085/1062-6050-531-17>
21. Breulmann F, Mehl J, Otto A, Lappen S, Siebenlist S, Rab P (2024) Therapie der Osteochondrosis dissecans. *Orthopädie* 53:69–82. <https://doi.org/10.1007/s00132-023-04461-8>
22. Tang B, Wang L, Zheng Y, Gong S, Wang Y (2026) A head-to-head comparison of high-frequency ultrasound and magnetic resonance imaging for preoperative assessment of ATFL tears and concomitant CFL injuries. *Front Surg* 13:1863972. <https://doi.org/10.3389/fsurg.2026.1863972>
23. Evans BT, Tepolt FA, Niu E, Kramer DE, Kocher MS (2018) Intra-articular findings during the modified Brostrom procedure for lateral instability of the pediatric ankle. *J Pediatr Orthop B* 27:73–76. <https://doi.org/10.1097/BPB.0000000000000498>

Table

Table 1: Overall Diagnostic Performance (n=54)

Lesion	TP	FP	TN	FN	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Kappa (95% CI)	Accuracy (95
Osteochondral lesion	23	5	21	5	82.1% (63.1–93.9)	80.8% (60.6–93.4)	82.1% (63.1–93.9)	80.8% (60.6–93.4)	0.629 (0.422–0.837)	81.5% (68.6–
Synovitis	50	0	1	3	94.3% (84.3–98.8)	100.0% (2.5–100.0)	100.0% (92.9–100.0)	25.0% (0.6–80.6)	0.382 (-0.153–0.916)	94.4% (84.6–
Loose body	6	4	38	6	50.0% (21.1–78.9)	90.5% (77.4–97.3)	60.0% (26.2–87.8)	86.4% (72.6–94.8)	0.430 (0.136–0.725)	81.5% (68.6–
Ligamentous injury	42	9	3	0	100.0% (91.6–100.0)	25.0% (5.5–57.2)	82.4% (69.1–91.6)	100.0% (29.2–100.0)	0.341 (0.046–0.637)	83.3% (70.7–

* Statistically significant ($p < 0.05$). Abbreviations: TP, True Positive; FP, False Positive; TN, True Negative; FN, False Negative; PPV, Positive Predictive Value; NPV, Negative Predictive Value, CI, Confidence Interval.