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Correlation between Ultrasonography and Mri in Evaluating Fatty Liver

Dr. Harippraradh. K.S[1], Dr. Nivya Mary.A[2], Dr S Sundararajan[3], Dr. S. Jaiganesh[4]

[1]Post Graduate, Department of Radio Diagnosis, Meenakshi Medical College Hospital and Research Institute, Meenakshi Academy of Higher Education and Research(Deemed to be University), Kanchipuram

[2]Assistant Professor, Department of Radio Diagnosis, Meenakshi Medical College Hospital and Research Institute,Meenakshi Academy of Higher Education and Research (Deemed to be University), Kanchipuram

[3]Professor & Head, Department of Radio Diagnosis,Meenakshi Medical College Hospital and Research Institute, Meenakshi Academy of Higher Education and Research (Deemed to be University), Kanchipuram,

[4]Professor, Department of Radio Diagnosis,,Meenakshi Medical College Hospital and Research Institute, Meenakshi Academy of Higher Education and Research (Deemed to be University), Kanchipuram,

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KEYWORDS

Fatty liver, NAFLD, MRI-PDFF, Ultrasonography, Hepatic steatosis, Diagnostic accuracy, Imaging correlation.

ABSTRACT:

Introduction:

Non-alcoholic fatty liver disease (NAFLD) is a growing global health concern associated with obesity and metabolic syndrome. While magnetic resonance imaging–proton density fat fraction (MRI-PDFF) is considered the gold standard for hepatic fat quantification, ultrasonography (USG) remains a widely used screening tool due to its accessibility and cost-effectiveness. This study is aimed to evaluate the role USG and MRI in assessing fatty liver severity and to correlate between their diagnostic accuracy.

METHODS:

A retrospective observational study was conducted at Meenakshi Medical College Hospital from January 2024 to March 2025. Fifty patients who underwent USG for suspected fatty liver were included. MRI upper abdomen screening was performed for all the patients who underwent USG. USG grading was based on liver echogenicity and MRI grading based on MRI-PDFF quantified hepatic fat fraction using the mDIXON-Quant sequence. The agreement and correlation between modalities were assessed using chi-square analysis and Kendall's Taub.

Results:

USG and MRI demonstrated substantial agreement, especially for grade 0 (80%) and grade I (70.8%) steatosis. A strong positive correlation was observed (Kendall's Tau-b = 0.776, $p < 0.001$). MRI-PDFF showed excellent diagnostic performance with 97.5% sensitivity and 100% specificity (AUC = 1.00), while USG demonstrated 92.31% sensitivity and 72.73% specificity (AUC = 0.906). Also MRI showed superior diagnostic efficacy especially in identifying early or subtle steatotic changes.

Conclusion:

Though USG remains a valuable initial screening tool, MRI is a superior modality for accurately quantifying hepatic steatosis and should be considered the reference standard, particularly for early-stage disease.

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INTRODUCTION:

Non-alcoholic fatty liver disease (NAFLD) is a leading cause of chronic liver disease globally, characterized by the accumulation of fat in hepatocytes in the absence of significant alcohol consumption. Its prevalence has increased in parallel with obesity and metabolic syndrome, affecting up to 25% of the global population [1]. Its strong association with rising rates of **obesity, metabolic syndrome, and type 2 diabetes** makes it a major target for early detection and longitudinal monitoring. Accurate quantification of hepatic steatosis is essential for diagnosis, monitoring, and therapeutic decision-making in NAFLD.

Although alcoholic fatty liver disease (AFLD) shares similar imaging characteristics with non-alcoholic fatty liver disease (NAFLD)—such as increased echogenicity on ultrasonography and elevated fat fraction on MRI—it poses distinct challenges in clinical research. One major difficulty is the subjectivity and inconsistency in self-reported alcohol consumption, which can complicate accurate diagnosis [2]. Additionally, AFLD exhibits greater variability in disease progression due to fluctuating alcohol intake, and social stigma surrounding alcohol use may limit patient disclosure and participation in studies [3].

Traditionally, **magnetic resonance imaging-proton density fat fraction (MRI-PDFF)** has been considered the gold standard for non-invasive hepatic fat quantification due to its high accuracy and reproducibility [2,3]. MRI allows for precise volumetric assessment of liver fat content and has demonstrated strong correlations with histological steatosis grading [4]. However, the high cost, limited availability, and complexity of MRI limit its widespread clinical use.

In contrast, **ultrasonography (US)** remains the most commonly used imaging modality for initial NAFLD screening due to its low cost, accessibility, and non-invasiveness. Though limited in sensitivity for detecting mild steatosis, ultrasonographic techniques, including the ultrasound-guided attenuation parameter (UGAP) and advanced quantitative ultrasound (QUS) parameters, have shown promising results in assessing steatosis severity [5,6].

Recent studies have aimed to compare the diagnostic performance of ultrasonographic techniques with MRI in order to validate ultrasound as a reliable alternative. Notably, Cantero et al. reported that ultrasonography and blood markers combined achieved predictive accuracy close to that of MRI in detecting liver fat content [7]. Similarly, Pirmoazen et al. demonstrated that specific QUS parameters showed strong correlations with MRI-PDFF, suggesting the potential for quantitative ultrasound to serve as an accurate and cost-effective diagnostic tool [6].

This study aims to explore the correlation between ultrasonographic findings and MRI in the evaluation of fatty liver, contributing to the growing evidence supporting the role of advanced ultrasound techniques in NAFLD assessment. By elucidating the strengths and limitations of both modalities, this study seeks to inform clinical decision-making and promote the optimal use of imaging technologies in managing hepatic steatosis.

METHODOLOGY:

This retrospective observational study was conducted in the Department of Radiodiagnosis at Meenakshi Medical College Hospital and Research Institute (MMCHRI), Enathur, Kanchipuram. The study spanned a 12-month period from January 2024 to March 2025 and aimed to evaluate the correlation between ultrasonography and MRI in the assessment of fatty liver disease.

The study population included patients referred for abdominal imaging during the study period. Using time-period sampling, 50 patients who had undergone both abdominal ultrasonography and magnetic resonance imaging (MRI) were selected for inclusion. Patients with chronic liver diseases such as viral or autoimmune hepatitis were excluded. Cases with incomplete imaging records or degraded image quality were also omitted.

Ultrasound examinations were carried out using a high-resolution B-mode ultrasound machine equipped with a 3.5 MHz convex transducer. Patients fasted for at least 8 hours prior to the examination and were positioned supine or in left lateral decubitus as required, with brief breath-holding to optimize image quality. Liver echogenicity was assessed, classified using a semi-quantitative grading system: grade 0 for normal echotexture, grade 1 for mild diffuse echogenicity with preserved portal vein and diaphragm visibility, grade 2 for moderate echogenicity with reduced visualization, and grade 3 for severe echogenicity with poor visibility.

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In cases of diagnostic uncertainty, consensus readings were made in consultation with a senior radiologist.

Magnetic resonance imaging was performed using a 1.5 Tesla Siemens magnetom spectra with an mDIXON-Quant sequence, a chemical shift-based water-fat separation technique. Imaging parameters included a repetition time (TR) of 6.9 milliseconds, a 10° flip angle. A 3 cm² region of interest (ROI) was placed in the right hepatic lobe in segment V and VI , avoiding large vessels. Fat content was quantified using the proton density fat fraction (PDFF) technique, which is considered a reliable, non-invasive biomarker for hepatic steatosis. Based on established PDFF thresholds, liver fat content was categorized as follows: grade 0 for fat fraction <6.4%, grade 1 for 6.5–17.4%, grade 2 for 17.5–22.1%, and grade 3 for >22.2%.

All imaging and clinical data were extracted from the institutional database, anonymized, and compiled for analysis. Statistical analysis was performed using JAMOVI version 2.6. The correlation between ultrasonographic grading and MRI-measured fat fraction was assessed using Pearson's correlation coefficient. Cross-tabulations were used to compare the grading classifications between the two imaging modalities. Statistical significance was defined as a p-value less than 0.05.

RESULTS:

The table 1 presents the baseline characteristics of patients diagnosed with fatty liver disease, comprising a total sample size of 50 individuals. The data include demographic parameters, anthropometric measurements, and lipid profile values, summarized using means, standard deviations (SD), and range values.

The mean age of the study population was 40.5 years with a standard deviation of 12.05 years, indicating a relatively wide age distribution among participants, ranging from 21 to 69 years. In terms of gender distribution, females constituted the majority with 32 participants (64%), while males accounted for 18 (36%).

Anthropometric assessment revealed a mean body mass index (BMI) of 29.21 kg/m² (SD = 12.28), suggesting that a significant proportion of the cohort fell within the overweight or obese category, consistent with common associations observed in fatty liver disease. The MRI-proton density fat fraction (MRI-PDFF), which serves as a quantitative measure of hepatic steatosis, had a mean value of 13.8% with a substantial standard deviation of 11.3%, indicating considerable variability in hepatic fat content among participants. The minimum and maximum values ranged from 1.56% to 37.2%, reflecting diverse degrees of liver fat infiltration.

Lipid profile analysis showed elevated mean levels of low-density lipoprotein (LDL) at 124 mg/dL (SD = 41.2), with values spanning from 55 to 253 mg/dL. High-density lipoprotein (HDL), considered protective against cardiovascular disease, had a mean value of 50.1 mg/dL with relatively low variability (SD = 6.9), and a narrower range of 38 to 48 mg/dL. Very low-density lipoprotein (VLDL) levels averaged 27.32 mg/dL (SD = 8.8), with a range between 11 and 56 mg/dL. Additionally, triglyceride (TGL) levels were noted to be elevated, with a mean of 142 mg/dL (SD = 46.2) and a wide range of 48 to 266 mg/dL, further highlighting metabolic disturbances frequently encountered in fatty liver disease.

Table 1: Baseline characteristics of Fatty liver disease (n = 50)

S.NO	Variable	Mean	SD	Minimum and maximum values
1	Age in years	40.5	12.05	21 - 69
2	Gender	Females – 32 (64%), Males – 18 (36%)		
3	BMI	29.21	12.28	21.20 – 36.28
4	MRI-PDFF Fat Fraction (%)	13.8	11.3	1.56 – 37.2
5	LDL	124	41.2	55 – 253

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6	HDL	50.1	6.9	38 – 48
7	VLDL	27.32	8.8	11 – 56
8	TGL	142	46.2	48 – 266

SD: Standard deviation; **BMI:** Body mass index**;** **AST:** Aspartate aminotransferase; **ALT:** Alanine aminotransferase; **LDL:** Low density lipoprotein; **HDL:** High density lipoprotein; **VLDL:** Very low density lipoprotein; **TGL:** Triglycerides.

Table 2 illustrates the distribution of fatty liver disease severity among the study population (n = 50) based on ultrasonography (USG) and magnetic resonance imaging (MRI) grading. According to USG, 22% of participants exhibited no evidence of fatty liver (grade 0), while 40% had grade I steatosis, 28% had grade II, and 10% were classified as grade III. Conversely, MRI classified 20% as grade 0, 48% as grade I, 20% as grade II, and 12% as grade III. These findings suggest a higher sensitivity of MRI in detecting mild hepatic steatosis (grade I), as it identified more patients in this category compared to USG.

Table 3 presents a cross-tabulation evaluating the level of agreement between USG and MRI in grading the severity of fatty liver. Among patients categorized as grade 0 by USG, 80% were similarly graded by MRI, reflecting good agreement in identifying the absence of steatosis. In grade I, 70.8% of patients classified by USG were likewise confirmed by MRI. In grade II, 70% of patients classified by USG were likewise confirmed by MRI, while for grade III, half the cases (50%) showed concordant grading between the two modalities.

The Chi-square test yielded a statistically significant result ($\chi^2 = 56.4, p < 0.001$), indicating a strong association between the grading outcomes of USG and MRI. Despite some discrepancies in individual classifications, particularly in borderline or transitional grades (e.g., some USG grade II being labelled grade III on MRI), the overall level of agreement between the two modalities was statistically significant. This underscores the reliability of both imaging techniques in assessing fatty liver disease, while also highlighting MRI's greater precision, particularly in early-stage steatosis.

Table 2: Classifying the severity of fatty liver (n = 50)

Severity of fatty liver	**USG**	**MRI**
0	11 (22%)	10 (20%)
I	20 (40%)	24 (48%)
II	14 (28%)	10 (20%)
III	5 (10%)	6 (12%)

Table 3: Level of agreement between ultrasonography and MRI in classifying the severity of fatty liver (n = 50)

USG grading	**MRI grading**				
	0	**I**	**II**	**III**	**Total**
0	8 (80%)	3 (12.5%)	0	0	11
I	2 (20%)	17 (70.8%)	1 (10%)	0	20
II	0	4 (16.7%)	7 (70%)	3 (50%)	14
III	0	0	2 (20%)	3 (50%)	5

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Total	10	24	10	6	50

Chi square (x^2) = 56.4, p < 0.001

Table 4 presents the correlation matrix assessing the relationship between ultrasonographic (USG) grading and magnetic resonance imaging (MRI) grading in the classification of fatty liver disease among 50 patients. Kendall's Tau-b correlation coefficient was used to measure the strength and direction of association between these two ordinal variables.

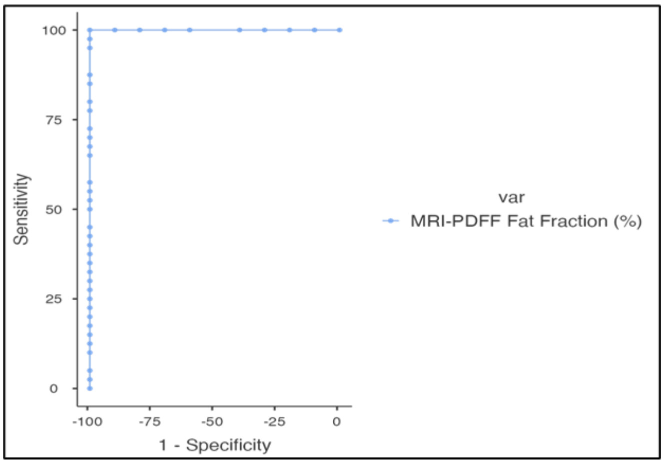
The analysis revealed a Kendall's Tau-b value of **0.776**, indicating a **strong positive correlation** between USG and MRI gradings of fatty liver severity. This suggests that as the severity of fatty liver increases as per USG grading, there is a proportionate and consistent increase in the grading as assessed by MRI. The correlation was found to be statistically significant with a **p-value < 0.001**, affirming that the observed relationship is unlikely to have occurred by chance.

These findings support the reliability of ultrasonography as a diagnostic tool in grading fatty liver disease in clinical settings, with MRI serving as a highly concordant reference standard. However, while both modalities show substantial agreement, the strong but not perfect correlation also suggests that MRI may detect subtle hepatic changes that USG might under- or overestimate in certain cases. Thus, MRI could serve as a more precise modality in equivocal or borderline cases.

Table 4: Correlation matrix (n = 50)

Correlation matrix	**MRI grading**	**USG grading**
MRI grading	-	
USG grading	Kendall's Tau B = 0.776 p < 0.001	-

Figure 1: ROC Curve - Ability of MRI to detect steatosis and



MRI-PDFF Fat Fraction (%) (n = 50)

Table 5: Validation - Ability of MRI to detect steatosis and MRI-PDFF Fat Fraction (%) (n = 50)

Cut point	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**Youden's index**	**AUC**	**Metric Score**
6.7	97.5%	100%	100%	90.91%	0.975	1.00	1.98

Figure 1 illustrates the Receiver Operating Characteristic (ROC) curve evaluating the diagnostic performance of Magnetic Resonance Imaging-Proton Density Fat Fraction (MRI-PDFF) in detecting hepatic steatosis among the study population (n = 50). The ROC curve demonstrates the trade-off between sensitivity and 1-specificity across different threshold values. In this analysis, the curve approaches the upper left corner, indicating excellent discriminatory power of MRI-PDFF in distinguishing between steatotic and non-steatotic liver states.

Complementing the ROC analysis, Table 5 provides key validation metrics at an optimal MRI-PDFF cut-off point of 6.7%. At this threshold, the **sensitivity** was **97.5%**, reflecting a high true positive rate,

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while **specificity** reached **100%**, indicating an absence of false positives. Both the **positive predictive value (PPV)** and **negative predictive value (NPV)**were notably high at **100%** and **90.91%**, respectively. These findings confirm the robust diagnostic accuracy of MRI-PDFF for the detection of fatty liver disease.

The **Youden's Index** was calculated as **0.975**, further supporting the clinical utility of the 6.7% cut-off by maximizing the sum of sensitivity and specificity. The **area under the ROC curve (AUC)** was **1.00**, representing perfect discrimination, which underscores the capability of MRI-PDFF as a highly accurate and reliable imaging biomarker for hepatic fat quantification. Additionally, the **metric score** of **1.98** reflects strong performance in overall model classification.

Figure 2: ROC Curve - Ability of USG to detect steatosis

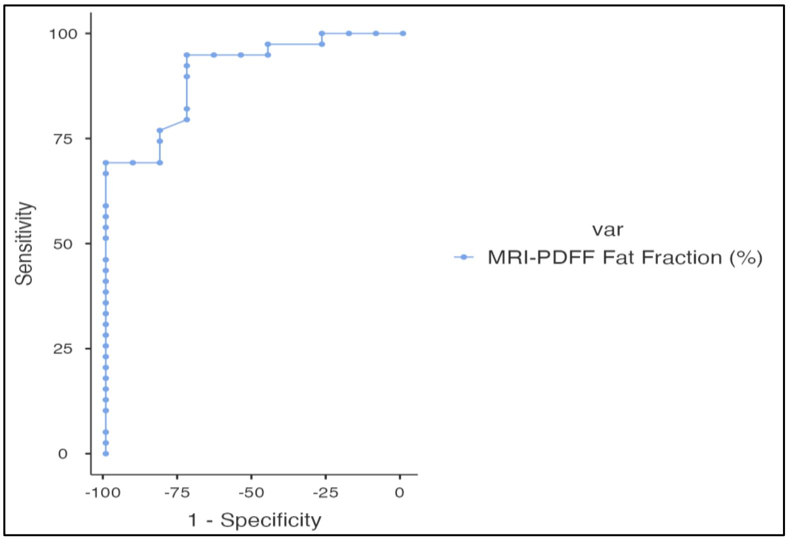

Table 5: Validation - Ability of USG to detect steatosis

Cut point	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden's index	AUC	Metric Score
6.7	92.31%	72.73%	92.31%	72.73%	0.650	0.906	1.65

Figure 2 presents the Receiver Operating Characteristic (ROC) curve assessing the ability of ultrasonography (USG) to detect hepatic steatosis, using the MRI-PDFF (Proton Density Fat Fraction) as the reference standard. The ROC curve shows a modest deviation from the ideal top-left trajectory, indicating that USG has good but not optimal discriminative capacity for identifying steatosis.

Table 5 complements this graphical representation by providing detailed diagnostic validation metrics at an optimal MRI-PDFF fat fraction cut-off of **6.7%**. At this threshold, USG demonstrated a **sensitivity of 92.31%**, indicating it correctly identified a high proportion of true positive cases. However, the **specificity was lower at 72.73%**, implying a relatively higher rate of false positives compared to MRI.

The **positive predictive value (PPV)** and **negative predictive value (NPV)** were both 92.31% and 72.73%, respectively. These values reflect USG's reasonable accuracy in both ruling in and ruling out steatosis, although its performance is more robust in confirming the presence of disease than in excluding it. The **Youden's Index**, which combines sensitivity and specificity into a single metric, was **0.650**, suggesting moderate diagnostic effectiveness.

The **area under the ROC curve (AUC)** was **0.906**, which classifies USG as having excellent diagnostic accuracy, though still inferior to MRI, which previously

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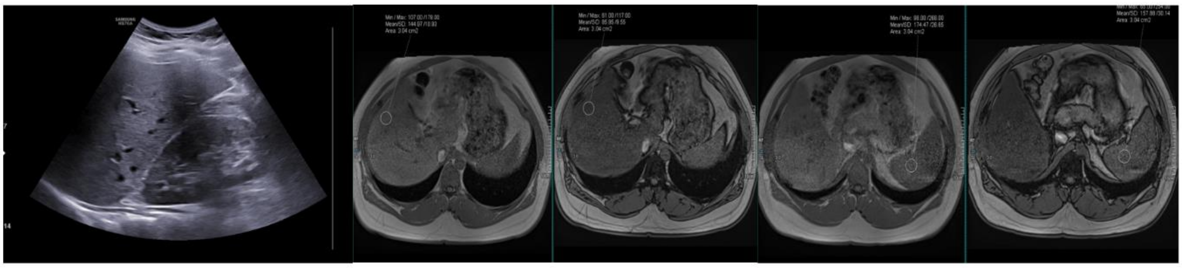
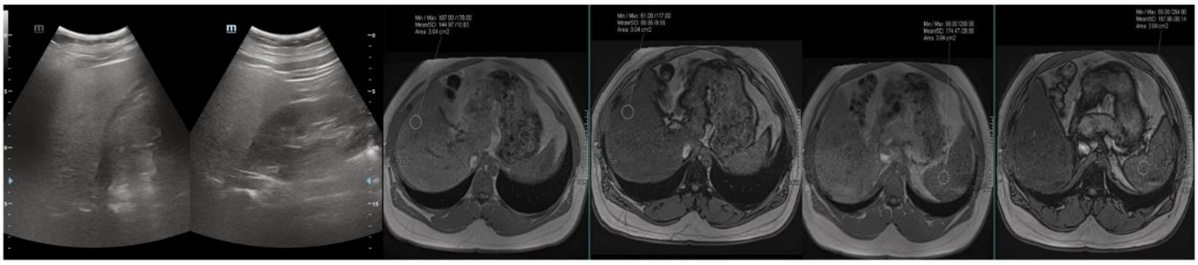
demonstrated an AUC of 1.0. The **metric score**, calculated as 1.65, also supports the conclusion that while USG is a useful screening tool, it does not match the diagnostic precision of MRI-PDFF.

Figure 3:



On B-mode ultrasound it was diagnosed as normal liver but while calculating the fat percentage using proton density fat fraction on MRI Grade 1 fatty liver was diagnosed.

Figure 4:



On B-mode ultrasound it was diagnosed as Grade 2 fatty liver and it was confirmed as Grade 2 fatty liver while calculating the fat percentage using proton density fat fraction on MRI.

DISCUSSION

The present study assessed the diagnostic utility of ultrasonography (USG) and magnetic resonance imaging–proton density fat fraction (MRI-PDFF) in evaluating hepatic steatosis among a sample of 50 individuals who were clinically suspected or diagnosed with fatty liver disease. The study population had a mean age of 40.5 years, with a female predominance of 64%. The average body mass index (BMI) was 29.21 kg/m², indicative of an overweight demographic, which is consistent with the known metabolic risk profile of fatty liver disease. The mean MRI-PDFF value was 13.8%, suggesting a wide variability in the degree of hepatic fat infiltration across the cohort. In line with the metabolic nature of the disease, the lipid profile showed elevated mean levels of LDL and triglycerides, while HDL remained within the protective range.

When grading the severity of hepatic steatosis, USG categorized 22% of the subjects as grade 0, 40% as grade I, 28% as grade II, and 10% as grade III. MRI, in comparison, classified 20% as grade 0, 48% as grade I, 20% as grade II, and 12% as grade III. These results suggest that MRI may be more sensitive in detecting early steatotic changes, particularly grade I, when compared to USG. Agreement analysis between the two modalities revealed substantial concordance, especially in grade I and grade 0 categories, where 70.8% and 80% of the USG cases were respectively confirmed by MRI. A statistically significant association was observed between the gradings provided by USG and MRI, with a chi-square value of 56.4 and a p-value less than 0.001. Furthermore, Kendall's Tau-b correlation coefficient was calculated as 0.776, indicating a strong and statistically significant positive correlation between USG and MRI gradings.

To determine the diagnostic accuracy of both imaging modalities, a receiver operating characteristic (ROC) analysis was conducted using MRI-PDFF as the reference standard. At an optimal MRI-PDFF cut-off of 6.7%, MRI demonstrated exceptional diagnostic

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performance, with a sensitivity of 97.5%, specificity of 100%, positive predictive value (PPV) of 100%, and negative predictive value (NPV) of 90.91%. The area under the ROC curve (AUC) was 1.00, and the Youden's index was 0.975, reflecting perfect discrimination between steatotic and non-steatotic cases. In contrast, USG exhibited a sensitivity of 92.31% and a specificity of 72.73% at the same threshold, with both PPV and NPV at 92.31% and 72.73%, respectively. The AUC for USG was 0.906, and the Youden's index was 0.650, suggesting moderate but not optimal diagnostic accuracy when compared to MRI.

Consistent with our results, prior studies have underscored the high diagnostic performance of MRI-PDFF. A meta-analysis by Gu et al. (2019) confirmed MRI-PDFF's excellent accuracy in detecting hepatic steatosis, with an area under the receiver operating characteristic (AUROC) curve of 0.98 for differentiating steatosis from normal liver tissue. [8] Similarly, ex vivo validation study by Bannas et al. (2015) have demonstrated MRI strong correlation with liver triglyceride content, confirming its utility as a non-invasive imaging biomarker. [9]

Our study observed a high sensitivity (97.5%) and perfect specificity (100%) for MRI-PDFF using a cut-off of 6.7%, which aligns with previously reported optimal thresholds ranging between 5.4% and 6.4% in obese and NAFLD cohorts by Cunha et al. (2019). Moreover, MRI-PDFF effectively distinguished steatosis severity grades, a finding also mirrored by Idilman et al. (2015), who reported strong correlations between MRI-PDFF, MRS, and histology-based steatosis gradings. [10, 11]

In contrast, USG demonstrated moderate diagnostic accuracy in our study, with a sensitivity of 92.3% but notably lower specificity (72.7%). While traditional B-mode USG is cost-effective and widely accessible, its performance is influenced by operator dependence and reduced sensitivity for mild steatosis as in a study conducted by Lee et al. (2022). [12] Our agreement analysis between USG and MRI grading revealed substantial concordance, especially for grade 0 and grade I steatosis, supporting findings from earlier studies that suggest USG remains a valid initial screening tool (Tada et al., 2018). [13]

Emerging ultrasound technologies such as ultrasound-derived fat fraction (UDFF) and quantitative ultrasound (QUS) have demonstrated improved accuracy in liver fat quantification. For instance, Jeon et al. (2023) reported that a multivariable QUS model showed excellent agreement with MRI-PDFF, with an AUROC of 0.943. Similarly, De Robertis et al. (2023) showed that UDFF offered significantly better diagnostic performance compared to conventional USG, emphasizing the potential of quantitative ultrasound tools in clinical settings. [14, 15]

Furthermore, ultrasound-guided attenuation parameter (UGAP) measurements have emerged as a promising method. Yagobian et al. (2025) demonstrated UGAP's high accuracy, especially in differentiating moderate and severe steatosis, with AUROC values exceeding 0.89 when compared to MRI-PDFF and histology. [16]

In summary, our findings affirm that MRI-PDFF offers superior diagnostic accuracy over USG for hepatic steatosis and should be considered the reference standard in clinical evaluation, especially for early or subtle steatotic changes. Nonetheless, USG remains a valuable screening tool.

CONCLUSION

This study demonstrates that while both ultrasonography (USG) and magnetic resonance imaging–proton density fat fraction (MRI-PDFF) are valuable in assessing hepatic steatosis, MRI offers superior diagnostic performance. MRI showed near-perfect sensitivity and specificity, making it a reliable non-invasive reference standard for liver fat quantification. USG, though less sensitive and specific, remains a useful and accessible screening tool, particularly in resource-limited settings. The strong correlation and substantial agreement between USG and MRI gradings support the clinical utility of USG in initial assessments, but MRI should be preferred for accurate grading and disease monitoring. Future research with larger cohorts and longitudinal follow-up is recommended to further validate these findings and explore the role of emerging quantitative ultrasound technologies.

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