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Mri Fat Quantography in Fattly Liver Patients

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Abstract

Background: Non-Alcoholic Fatty Liver Disease (NAFLD) is a growing health concern globally, necessitating accurate, non-invasive tools for diagnosis and grading. This study aimed to evaluate hepatic fat accumulation using Magnetic Resonance Imaging-Proton Density Fat Fraction (MRI-PDFF) and correlate it with biochemical markers and ultrasonography (USG) findings in patients suspected of fatty liver disease.

Methods: This cross-sectional observational study included 80 patients with suspected hepatic steatosis. Each patient underwent detailed clinical evaluation, BMI assessment, liver function tests, lipid profile, and abdominal ultrasonography. MRI-PDFF was performed for quantitative assessment of liver fat content. Data were statistically analyzed using SPSS version 23, and significance was set at $p < 0.05$.

Results: The mean age of patients was 42.65 ± 14.85 years, with a male predominance (61.25%). Overweight individuals (BMI >25) comprised 60% of cases. Grade 2 steatosis was the most common USG finding (73.75%), while MRI revealed Grade 1 fat deposition in 48.75% and Grade 3 in only 6.25%. The mean PDFF increased with steatosis severity: $19.4 \pm 7.0\%$ in Grade 2 and $25.4 \pm 4.0\%$ in Grade 3 ($p \leq 0.03$). Elevated liver enzymes (SGPT 59.82 ± 50.86 IU/L) and dyslipidemia (mean triglycerides 187.68 ± 109.73 mg/dL) were significantly associated with hepatic fat accumulation. MRI findings correlated significantly with USG grades and segmental liver involvement, confirming its diagnostic superiority. Conclusion: MRI-PDFF is a reliable, quantitative, and non-invasive tool for assessing hepatic fat content, offering better accuracy than USG in detecting and grading fatty liver disease. Integration of biochemical and imaging findings enhances the diagnostic yield in NAFLD.

Keywords: MRI-PDFF, hepatic steatosis, fatty liver, ultrasonography, liver fat quantification, NAFLD, liver enzymes, lipid profile.

Introduction

Hepatic steatosis is a commonly observed imaging result that may signify chronic liver disease, with non-alcoholic fatty liver disease being the most prevalent kind (1). Non-alcoholic fatty liver disease (NAFLD) is a spectrum of conditions defined by hepatic steatosis without identifiable aetiologies such as viral hepatitis, alcohol consumption, steatogenic pharmaceuticals, or genetic lipodystrophies. This is presently the most widespread chronic liver disease globally, with an estimated prevalence of 25% worldwide. NAFLD varies in severity from non-alcoholic fatty liver (NAFL) (2), characterised by isolated steatosis,

to non-alcoholic steatohepatitis (NASH), fibrosis, and NASH-related cirrhosis, which represent the most severe manifestations of the condition. In addition to steatosis, NASH entails necro-inflammatory changes in hepatocytes, highlighting the progressive aspect of the illness. Approximately 33% of people with NAFL and NASH develop to inflammation, hepatocyte damage (3), and fibrosis, whereas approximately 20% may demonstrate some reversal of the condition. Hepatic decompensation and cirrhosis manifest over an average of 7.6 years in around 3% of individuals with NAFLD. Moreover, individuals with decompensated NASH have an average life expectancy of about 2 years (4). Furthermore, a recent meta-analysis indicated that moderate to severe hepatic steatosis in NAFLD patients is strongly associated with clinically significant coronary artery disease. Hepatic steatosis serves as the histological marker of NAFLD, however it may also be present in various other conditions. Individuals with hepatic steatosis are at risk for adverse consequences, including fibrosis (4), steatohepatitis, end-stage liver disease, and hepatocellular cancer. A recent extensive cohort research indicated that hepatic steatosis may serve as an independent predictor of death at the population level, alongside hepatic fibrosis. A 30% reduction in liver fat deposition, as measured by magnetic resonance imaging proton density fat fraction (MRI-PDFF), can predict the likelihood of fibrosis regression in NAFLD (5). Nonetheless, a considerable proportion of patients with early-stage NAFLD exceeds the threshold that warrants medical intervention for all individuals. The significant occurrence of serious later consequences underscores the need for preventative treatments in patients with advanced NAFLD (6,7).

The prevalence throughout the general population in India ranges from 9% to 35%. The prevalence varies according on geographical distribution within the country and the assessment modality employed. The methods for non-invasive quantification of liver fat include ultrasonography (USG), controlled attenuation parameter (CAP), computed tomography, hydrogen-1 magnetic resonance spectroscopy (MRS), and magnetic resonance imaging (MRI) (8). A recently refined MRI approach, magnetic resonance imaging–estimated proton density fat fraction (PDFF), has demonstrated a robust correlation and comparable performance to MRS Elevated liver fat content assessed by MRI-PDFF correlates with the advancement of fibrosis, and the risk of mortality escalates exponentially as fibrosis progresses from Stage 0 (9).

The definitive method for diagnosing non-alcoholic fatty liver is a liver imaging-guided biopsy. This option is deemed intrusive and has risks of discomfort, haemorrhage, infection, and potentially fatal outcomes. Moreover, there may be sampling error and observer variability in liver biopsies. Consequently, it is advisable to employ non-invasive methods for the diagnosis of NAFLD (10). Recent improvements have significantly improved the techniques for assessing hepatic fat. Magnetic resonance spectroscopy is widely acknowledged as the most accurate non-invasive technique for detecting hepatic fat (11).

Nontargeted liver biopsy is presently the definitive standard for diagnosing NAFLD. Histologically, hepatic steatosis is classified according to the percentage of hepatocytes carrying intracellular lipid vacuoles and is categorised into four classes (normal, mild, moderate, and severe) based on its impact on hepatocytes. According to the research conducted, grade zero (66% of hepatocytes damaged, S3) is classified as severe. The typical threshold for mild steatosis is 30% (12). A liver biopsy is conducted to ascertain the presence of inflammation and substantial fibrosis. Liver biopsy is essential for the definitive diagnosis of NASH , and NAFLD-risk stratification necessitates differentiating patients with inflammation and/or fibrosis, specifically distinguishing those with NASH from those with isolated steatosis. A significant restriction of liver biopsy is its impracticality for routine and recurrent assessment of steatosis, attributable to high costs, sampling inaccuracies, and complications associated with its invasiveness (13), including discomfort, infection, or haemorrhage. Moreover, restricted patient acceptance and diminished

intra- and inter-observer repeatability have also been highlighted. The histopathologic characteristics of NAFLD are irregular at the spatial scale of a biopsy. The uneven distribution of fat in the liver sometimes leads to variability caused by sampling error (14,15).

The evaluation of liver steatosis in living donors is crucial, as most living-donor liver transplant programs restrict liver donation to a steatosis range of 10 to 20% to ensure donor safety. The objective of this study is to quantify liver fat using MRI Fat Quantography in patients with proven fatty liver via ultrasound.

Methodology

The present study was a cross-sectional observational study conducted to evaluate patients suffering from fatty liver disease. The study was carried out in the Department of Medicine at CSS Hospital, Subharti Medical College, Meerut, over a period from July 2023 to February 2025. All patients diagnosed with fatty liver disease via ultrasonography (USG), irrespective of gender, were included as the study unit. A total of 80 USG-proven fatty liver patients were recruited sequentially, based on eligibility criteria. Prior to inclusion, informed written consent was obtained from all participants after explaining the purpose and procedures of the study. Ethical approval to conduct the research was granted by the Institutional Ethical Committee of CSS Hospital, Subharti Medical College, Meerut.

The sample size was determined using G*Power software (Version 3.1) as per Faul et al., 2009. The calculation was based on prevalence data obtained from a pilot survey. A power analysis using chi-square testing indicated that a minimum of 80 participants would be required to achieve a statistical power of 0.8 at an alpha level of 0.05 with an effect size of 0.577.

Inclusion criteria for the study were USG-proven cases of fatty liver. Exclusion criteria included individuals with malignancies or severe comorbidities such as end-stage renal disease or chronic obstructive pulmonary disease, a history of blood transfusion within the last three months, known HIV positivity, acute liver failure, pregnancy, and those who declined to provide written informed consent.

The subjects were scanned using a 1.5 T scanner (Aera, Siemens Medical Systems), which was outfitted with an 18-channel body matrix coil and a 32-channel spine matrix coil, of which only 8 was utilized. After obtaining sequences in the standard liver MRI protocol (coronal T2-weighted HASTE, transverse T2-weighted BLADE, transverse T2-weighted fat-suppressed BLADE, diffusion-weighted imaging with echo-planar imaging and b values of 50, 400, and 800 s/mm2, and T1 volumetric interpolated breath-hold examination [VIBE] e-Dixon), the sequences that provide parametric maps for the quantification of hepatic fat, iron, stiffness, and T1 and T2 relaxation times was acquired. We are going to make use of the package that was provided by the vendor (LiverLab), which provides analysis and quantification of both fat and iron. The LiverLab procedure included three different sequences that were performed after the abdomen protocol. In addition to a standard examination of the liver, T1 VIBE e-Dixon, VIBE q-Dixon (a single breath-hold multiecho Dixon sequence with six echoes that provides volumetric FF and R2* maps), and HISTO (15-second breath-hold single-voxel STEAM spectroscopy with a 333 cm3 voxel size) sequences was carried out. With the help of the scanner's software, the R2* values was adjusted to account for the effects of fat, and the fat percentage was adjusted to account for the T2* effects.

Statistical analysis

SYSTAT 13.2 was utilized throughout each and every statistical analysis that is conducted. In order to determine whether or not the assumption of normality is valid, a Shapiro–Wilk test was performed. The mean and standard deviation was used to express continuously distributed variables that have a normal distribution (only age), whereas the median was used to express continuously distributed variables that do

not have a normal distribution (minimum-maximum). A count-based summary was provided for the categorical variables (for example, sex) (percentages). For the MRE, T1 MOLLI mapping schemes, T2 mapping, and B1-corrected VFA T1 mapping, a Mann-Whitney U-test was used to compare the groups and determine whether or not there is a significant difference between them. A Pearson chi-square analysis was used to determine the associations between the groups (patients-control) and sex. A Spearman's correlation coefficient was used to determine the associations between the PDFF values and MRE, T1 mapping, and T2 mapping.

Result

A total of 80 patients with ultrasound-proven fatty liver disease and grade II & III fatty Liver were enrolled in this cross-sectional study conducted in the Department of General Medicine at Subharti Medical College, Associated Chhatarpti Shivaji Subharti Hospital. Meerut, between July 2023 and February 2025. Each participant underwent MRI fat quantography using a 3.0 Tesla United imaging MRI with an 18-channel body matrix coil and a 32-channel spine matrix coil. Quantitative imaging was performed using sequences from the LiverLab software package, including T1 VIBE e-Dixon, VIBE q-Dixon, and HISTO spectroscopy to generate fat fraction and R2* maps. The quantified hepatic fat percentages were corrected for T2* and R2* effects.

Table 1: Demographic Profile of Study Subjects

Variable	**Category**	Mean±SD/ Percentage
Age (years)		42.65 ± 14.85
Gender	Male	49 (61.25%)
	Female	31 (38.75%)
Total		80 (100.0%)
BMI (kg/m²)	Mean±SD	25.75 ± 1.63

The demographic profile of the 80 study participants reveals a predominance of middle-aged adults, with a mean age of 42.65 ± 14.85 years. Males constituted the majority of the cohort at 61.25% (n=49), compared to females at 38.75% (n=31), indicating a male predominance in the occurrence of fatty liver disease in this population. The average Body Mass Index (BMI) was 25.75 ± 1.63 kg/m², placing most participants in the overweight category. These findings suggest that middle-aged, overweight males are more commonly affected by fatty liver, aligning with known risk patterns for non-alcoholic fatty liver disease (NAFLD).

Table 2: Lipid Profile and Biochemical Parameters of Study Participants

Parameter	**Mean**	**SD**	**p-value**
Lipid Profile			
Triglycerides (TGs) (mg/dL)	187.68	109.734	0.001
Serum Cholesterol (S. CHL) (mg/dL)	166.21	47.814	0.001
Low-Density Lipoprotein (LDL) (mg/dL)	96.421	39.0745	0.001
Very Low-Density Lipoprotein (VLDL) (mg/dL)	33.403	14.8146	0.001
High-Density Lipoprotein (HDL) (mg/dL)	37.339	9.7072	0.001

Biochemical Markers			
SGOT (AST – IU/L)	48.08	35.021	0.001
SGPT (ALT – IU/L)	59.82	50.862	0.001
Alkaline Phosphatase (ALP – IU/L)	114.90	36.801	0.001
Albumin (ALB – g/dL)	4.104	0.6553	0.05
Total Protein (g/dL)	7.40	0.71	0.01
Bilirubin (mg/dL)	0.69	0.50	0.01

The biochemical and lipid profile parameters of the study participants reveal significant metabolic derangements associated with fatty liver disease. Among lipid markers, triglycerides had the highest mean value at 187.68 ± 109.73 mg/dL, followed by serum cholesterol at 166.21 ± 47.81 mg/dL. In contrast, HDL—the protective lipid fraction—was notably low at 37.34 ± 9.71 mg/dL, reflecting an atherogenic lipid pattern. These differences were statistically significant ($p = 0.001$), indicating a strong association between dyslipidemia and fatty liver disease. Similarly, liver enzymes showed elevated values, with SGPT (ALT) averaging 59.82 ± 50.86 IU/L and SGOT (AST) at 48.08 ± 35.02 IU/L, reflecting ongoing hepatocellular injury. Alkaline phosphatase (114.90 ± 36.80 IU/L) was also elevated. Among protein markers, albumin was within normal limits (4.10 ± 0.66 g/dL), while total protein was 7.40 ± 0.71 g/dL and bilirubin 0.69 ± 0.50 mg/dL—both statistically significant. Collectively, these findings underscore the presence of metabolic dysfunction and hepatic stress in fatty liver patients.

Table 3: Comparison of USG Findings and MRI Grading among Study Participants

Modality	**Grading**	**Frequency**	**Percentage (%)**	**p-value**
USG	Grade 1	0	0.00	
	Grade 2	59	73.75	
	Grade 2*	17	21.25	
	Grade 3	4	5.00	**0.001**
	Total	**80**	**100.00**	
MRI	Normal	11	13.75	
	Grade 1	39	48.75	
	Grade 2	25	31.25	
	Grade 3	5	6.25	**0.045**
	Total	**80**	**100.00**	

The comparison between USG and MRI findings in the evaluation of fatty liver disease reveals notable differences in grading sensitivity and distribution patterns. Ultrasonography (USG) categorized the majority of patients as Grade 2 (73.75%) and Grade 2* (21.25%), with only 5% falling into Grade 3 and none in Grade 1, indicating a clustering of patients in moderate steatosis grades. In contrast, MRI, which offers more precise fat quantification, showed a broader distribution: 13.75% had normal liver fat, 48.75% were classified as Grade 1 (mild steatosis), 31.25% as Grade 2 (moderate), and 6.25% as Grade 3 (severe). The absence of Grade 1 detection in USG highlights its limitation in identifying early-stage steatosis, which was frequently captured on MRI. Both modalities showed statistically significant distributions

(USG p = 0.001; MRI p = 0.045), affirming that MRI provides a more nuanced and sensitive assessment of hepatic fat content, particularly in lower grades that USG may miss.

Table 4: Correlation Matrix Between Ultrasound and MRI-Based Steatosis Grades

The correlation between USG and MRI grading of hepatic steatosis revealed notable variability, underscoring the superior sensitivity of MRI for fat quantification. Among the USG Grade 2 cases, 35 patients were reclassified as MRI Grade 1, 24 as MRI Grade 2, 4 as MRI Grade 3, and 10 showed no detectable fat content on MRI (normal). This re-distribution highlights a significant downgrading tendency by MRI, suggesting potential overestimation by USG. In contrast, among USG Grade 3 patients, only 1 each matched MRI Grades 1 and 2, while 2 retained MRI Grade 3 status. The tree chart clearly illustrates that MRI grading offers refined stratification, identifying both under- and over-estimations inherent in ultrasound-based assessment, particularly for Grade 2 steatosis.

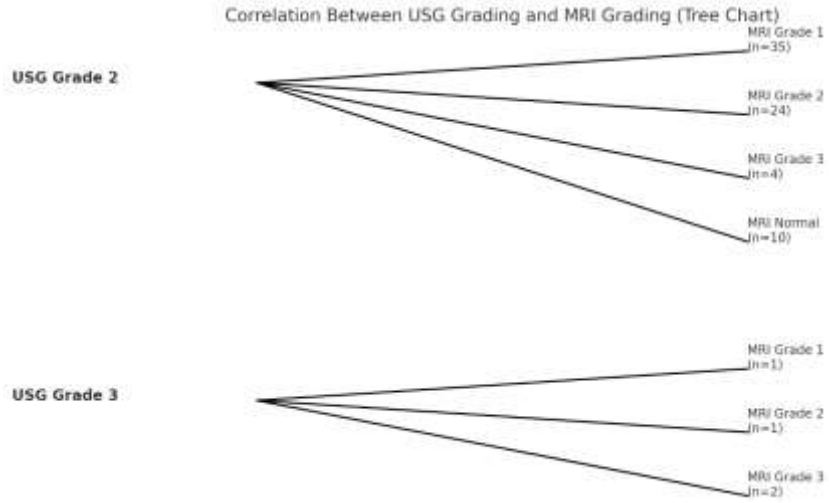

TABLE 12: MEAN PDFF VALUES WITH STANDARD DEVIATION AND RANGE ACROSS STEATOSIS GRADES BASED ON MRI QUANTIFICATION

Category	Mean	SD (%)	Min (%)	Max (%)	P-value
Overall (all grades)	12.0	8.5	2.6	30.0	0.001
Grade 2 (Moderate steatosis)	19.4	7.0	14.7	22.1	0.03
Grade 3 (Severe steatosis)	25.4	4.0	21.7	30.0	0.01

Mean Proton Density Fat Fraction (PDFF) values across different grades of hepatic steatosis, as quantified by MRI. The overall mean PDFF across all patients was 12.0 ± 8.5%, with values ranging from 2.6% to 30.0%, indicating a wide spectrum of hepatic fat accumulation in the study cohort (p = 0.001). Patients with Grade 2 (moderate) steatosis had a mean PDFF of 19.4 ± 7.0% (range: 14.7–22.1%, p = 0.03), while those with Grade 3 (severe) steatosis demonstrated significantly higher fat content, with a mean PDFF of 25.4 ± 4.0% (range: 21.7–30.0%, p = 0.01).

Discussion

In this cross-sectional study, 80 patients with ultrasound-proven fatty liver disease and grade II were enrolled at CSS Hospital, Subharti Medical College, Meerut, from July 2023 to February 2025. Each participant had 3.0 Tesla United imaging MRI fat quantography with an 18-channel body matrix coil and 32-channel spine matrix coil. Fat fraction and R2* maps were generated using LiverLab software sequences, comprising T1 VIBE e-Dixon, VIBE q-Dixon, and HISTO spectroscopy. Hepatic fat percentages were corrected for T2* and R2*.

In this study, the mean age of participants was 42.65 ± 14.85 years, indicating that fatty liver disease is increasingly prevalent among younger adults, aligning with studies by Rodge et al. [16], Beyer et al. [17], and Zhang et al. [18]. A significant male predominance was observed (61.25%), consistent with findings from Rodge et al. [16], Beyer et al. [17], and Erden et al. [19], though Park et al. [20] reported a more balanced gender distribution. Additionally, 60% of participants were overweight (BMI >25 kg/m²), supporting the established link between elevated BMI and hepatic steatosis as reported in studies by Rodge et al. [16], Caussy et al. [21], and Zhang et al. [18]. In this study, dyslipidemia was prominently observed, with triglycerides showing the highest mean (187.68 ± 109.73 mg/dL) and HDL the lowest (37.34 ± 9.71 mg/dL), consistent with findings by Rodge et al. [16], Beyer et al. [17], and Caussy et al. [21], who emphasized the association of hypertriglyceridemia and low HDL with hepatic steatosis. Among biochemical markers, SGPT (ALT) had the highest mean (59.82 ± 50.86 IU/L), while bilirubin was the lowest (0.69 ± 0.50 mg/dL), aligning with studies by Rodge et al. [16], Starekova et al. [22], and Erden et al. [19], highlighting ALT as a more sensitive marker of hepatic fat accumulation compared to bilirubin.

In this study, ultrasound revealed that Grade 2 steatosis was most common (73.75%), with no cases of Grade 1, suggesting diagnosis typically occurred at moderate stages; this aligns with Rodge et al. [16] and Beyer et al. [17], who also noted ultrasound's limited sensitivity for detecting mild steatosis. Conversely, MRI identified Grade 1 steatosis as most prevalent (48.75%), followed by Grade 2 (31.25%) and Grade 3 (6.25%), with 13.75% showing normal fat content. These results mirror findings by Rodge et al. [16] and Caussy et al. [21], highlighting MRI's superior sensitivity for early fat quantification and its ability to detect hepatic steatosis even in cases missed by ultrasound.

In our study, the mean Proton Density Fat Fraction (PDFF) value for the overall cohort was 12.0 ± 8.5%, with a significant rise in steatosis severity: 19.4 ± 7.0% in Grade 2 and 25.4 ± 4.0% in Grade 3 cases. These differences were statistically significant ($p \leq 0.03$), reinforcing the utility of MRI-PDFF as a reliable, non-invasive biomarker for quantifying hepatic fat content. These findings are consistent with the results of Caussy et al. [21], who highlighted that MRI-PDFF accurately reflects histologic grades of steatosis and is highly sensitive in detecting even minor fat accumulation. Likewise, Rodge et al. [16] reported mean PDFF values of 10.5% in Grade 1, 22.4% in Grade 2, and 29.7% in Grade 3 NAFLD patients, closely aligning with our values. Erden et al. [19] also demonstrated that PDFF provides consistent correlation with histopathological fat grading, showing excellent reproducibility across liver regions. Moreover, Starekova and Reeder [22] emphasized that PDFF has superior diagnostic performance compared to USG or CT in evaluating hepatic steatosis, especially in early or moderate disease. The narrow standard deviation in higher grades in our study also supports the precision of MRI in quantifying advanced steatosis.

Conclusion

This cross-sectional study demonstrated that the majority of ultrasound-proven fatty liver cases were found

in younger, overweight males, with Grade 2 steatosis being the most prevalent. MRI fat quantography provided a more precise and objective assessment of hepatic fat content, often revealing lower grades of steatosis than suggested by ultrasound, highlighting its superior diagnostic sensitivity. Significant derangements in lipid profiles and liver enzymes were observed, reinforcing the metabolic basis of fatty liver disease. Segmental analysis confirmed a predominance of mild to moderate steatosis across liver regions. Additionally, MRI-derived PDFF values showed clear correlation with histological grading. Overall, MRI fat quantography emerges as a valuable, non-invasive modality for accurate detection, grading, and monitoring of hepatic steatosis, especially in cases where ultrasound may overestimate disease severity.

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