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Original Article

A Comparative Study on Role of MR Chemical Shift Imaging (mDIXON) and Ultrasound Elastography with CT Hounsfield Unit in Assessment of Early Stages of Non-Alcoholic Fatty Liver Disease

Chakradhar Ravipati*, Swaran Kumar Murthy, Yuvaraj Muralidharan, Karthik Krishna Ramakrishnan, Sukumar Ramaswamy, Paarthipan Natarajan

Department of Radiodiagnosis, Saveetha Medical College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India

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ABSTRACT

Introduction: Non-alcoholic steatohepatitis (NASH), which is more severe than moderate fatty liver disease (NAFL) and is associated with an increased risk of liver cirrhosis and consequences, is a common disorder characterised by the build-up of triglycerides in liver cells. NAFLD frequently presents symptom-free until complications emerge, makes early detection difficult. The most invasive and limited diagnostic method is liver biopsy. Promising solutions for NAFLD screening and early diagnosis are non-invasive imaging methods. This study assessed the precision of CT Hounsfield units, ultrasound elastography, and MR chemical shift imaging (mDIXON) in determining early NAFLD stages.

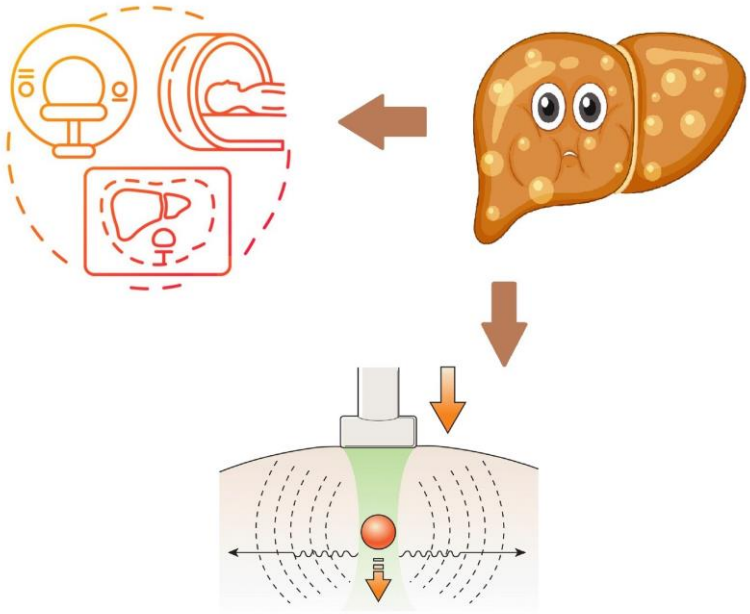
Methods: At a tertiary care facility in India, we did a prospective cross-sectional study with 80 patients who had NAFLD that had been discovered by incidentally. To measure hepatic steatosis and fibrosis, the study compared m-DIXON, ultrasound grayscale imaging, CT Hounsfield unit, and ultrasound point shear wave elastography (US- pSWE). Descriptive statistics, chi-square tests, ANOVA, and regression analysis were used in the data analysis.

Results: Our findings revealed that the majority (56.25%) of participants had grade I fatty liver, with hepatomegaly observed in 72.5% of participants. Strong correlations were identified between CT attenuation values and ultrasound greyscale imaging for fatty liver grading and between CT values and MRI chemical shift imaging for fat percentage determination. However, the CT's relation with US- pSWE for hepatic fibrosis evaluation was inconsistent. Remarkably, MRI's proton-density fat fraction emerged as a precise non-invasive biomarker for steatosis measurement.

Conclusion: In conclusion, non-invasive imaging modalities like mDIXON, CT Hounsfield units, and MRI chemical shift imaging contribute to NAFLD screening and early diagnosis. They offer precise assessments of hepatic steatosis and fibrosis, facilitating timely management and enhanced patient care.

* Corresponding author: Chakradhar Ravipati
✉ E-mail: chakradharravipati5298@gmail.com

GRAPHICALABSTRACT



Introduction

Triglycerides (TG) that accumulate excessively in liver cells can lead to hepatic steatosis [1]. Hepatic steatosis is associated with chronic liver disease, particularly non-alcoholic fatty liver disease (NAFLD), which can range from a mild condition to a more severe form known as non-alcoholic steatohepatitis (NASH). NASH has a higher risk of progressing to liver cirrhosis and other complications, while non-alcoholic fatty liver (NAFL) tends to have slower histological progression [2]. NAFLD encompasses non-alcoholic steatohepatitis, non-alcoholic hepato-steatosis, and hepatic fibrosis.

The prevalence of obesity, metabolic syndrome, and insulin resistance, which are major risk factors for NASH, is increasing worldwide [3, 4], with a global prevalence of NAFLD of 25.24% (95% CI: 22.10-28.65) as of 2016 with the highest prevalence in the Middle East and South America and the lowest in Africa [5]. Global burden of disease (GBD) 2017 estimated the annual incidence of NASH cirrhosis to be 367,780 in 2017, which has almost doubled from that in 1990 [6]. In India, NASH is present in approximately 9-32% of the population, while the global prevalence of NASH in NAFLD patients ranges from 6-26% [6-9].

Roughly 15 to 25 percent of NASH patients may develop irreversible consequences such as hepatic fibrosis, liver cirrhosis, or hepatocellular carcinoma [10]. Unfortunately, these conditions are often asymptomatic until complications arise, earning them the label of "silent liver diseases"[11].

Currently, NAFLD often goes undetected as liver biopsy, the gold standard diagnostic procedure, is typically performed only on symptomatic patients or those with elevated aminotransferase levels. However, liver biopsy has limitations, including invasiveness, discomfort, risk of complications, inability to determine cirrhosis severity, and sampling errors [7].

In contrast, non-invasive imaging modalities could serve as reliable screening tools for NAFLD, offering advantages such as non-invasiveness, reduced variability, comprehensive evaluation of liver tissue, minimal sampling errors, and better patient compliance.

Implementing such modalities would enable the screening and early diagnosis of NAFLD, even in asymptomatic individuals, facilitating timely management. In this study, MR chemical shift imaging (mDIXON) with ultrasound elastography and CT Hounsfield unit are considered as imaging modalities to investigate their findings and assess the accuracy of m-DIXON in detecting early stages of non-alcoholic fatty liver disease.

Aims and objectives

(1) To compare the diagnostic accuracy of MR chemical shift imaging (mDIXON), USG grey scale imaging with CT HFU in hepatic steatosis, and US-pSWE in hepatic fibrosis in early assessment of NAFLD.
(2) To quantify the degree of fatty infiltration of the liver in patients with NAFLD with MR chemical shift imaging m-DIXON magnetic resonance chemical shift imaging.
(3) Hypothesis being tested are,
Hypothesis for Imaging Modalities' Accuracy: Non-invasive imaging modalities, such as MR chemical shift imaging (mDIXON), ultrasound elastography, and CT Hounsfield units, can accurately detect and quantify hepatic steatosis and fibrosis in early stages of NAFLD.
This contrasts with the current gold standard of liver biopsy, which is invasive.
Hypothesis for mDIXON's Precision: The mDIXON (MRI chemical shift imaging) technique can precisely and non-invasively quantify the degree of fatty infiltration in the liver in patients with NAFLD.
Correlation Hypothesis: There are significant correlations between CT attenuation values and ultrasound grayscale imaging for fatty liver grading, as well as between CT values and MRI chemical shift imaging for fat percentage determination.
These hypotheses aim to determine if these imaging techniques are effective and reliable alternatives to the invasive liver biopsy in diagnosing and assessing the NAFLD progression.

Martials and Methods

This prospective cross-sectional study was conducted in 80 patients in a tertiary care centre in India to compare the accuracy of MR-chemical shift imaging (m-DIXON) against CT- Hounsfield Unit, Ultrasound grey scale imaging with CT-Hounsfield Unit in the assessment of hepatic steatosis and Ultrasound with point shear wave elastography with CT-Hounsfield Unit in the assessment of hepatic fibrosis in early stages of Non -Alcoholic Fatty Liver Disease. Patients who are referred to the radiology department for abdominal imaging with incidental findings of NAFLD were included for the study. These patients were subjected to:

- US grey scale imaging for liver size and echotexture.
- US point shear wave elastography to evaluate hepatic fibrosis.
- CT imaging for Hounsfield unit of liver attenuation.
- MR Chemical shift imaging (mDIXON) for liver fat quantification.

Inclusion criteria

(1) Patients who are referred to the radiology department for
(2) Abdominal imaging with incidental findings of NAFLD has been selected for the study.
(3) Patients who show features of early stages of fatty liver are selected for the study.
(4) Patients who are willing to participate in the study with their informed consent signed will be included in the study.

Exclusion criteria

(1) Patients showing severe fibrosis in US-pSWE have been excluded from the study.
(2) Pregnant females and children less than 18 years old.
(3) Patient with claustrophobia, metallic implants, and pacemaker.
(4) Patients not willing to participate in the study.

US grey scale imaging

Specifications of equipment used: Phillips affinity 70G Ultrasound Equipment
All patients underwent real-time- 2D- B mode ultrasound just before point shear wave elastography assessment. A single operator conducted all the examinations following a

defined scanning protocol. Liver measurements were done by sagittal section in the midclavicular line, a liver that is longer than 15.5-16 cm in the midclavicular line is considered enlarged [12]. Liver fat content was graded into grade 0 to III as represented in Figure 1a-d , grade 0 (No steatosis): Normal echogenicity of liver parenchyma; Normal visualization of the diaphragm and intrahepatic blood vessels; grade I (Mild steatosis): Slightly increased echogenicity of liver parenchyma; Normal visualization of the diaphragm and intrahepatic blood vessels; grade II (Moderate steatosis): Markedly increased echogenicity of liver parenchyma; Slightly impaired visualization of the diaphragm and intrahepatic vessels; grade III (severe steatosis): Severely increased echogenicity of liver parenchyma, with poor or no visualization of the diaphragm and intrahepatic blood vessels and posterior part of the right liver lobe.

Ultra-sound Point shear wave elastography

Specifications of equipment used: Phillips affinity 70G ultrasound equipment

Ultrasound Shear Wave Elastography (US- pSWE) is a non-invasive imaging technique used to assess tissue stiffness by measuring the speed of shear waves propagating through the tissue. It employs ultrasound to generate and monitor these waves, providing quantitative information about tissue elasticity. This helps in diagnosing liver fibrosis, tumours, and other conditions without the need for invasive procedures. The ultrasound machine tracks the shear wave's progression and gauge's its velocity in kilograms per square inch (kPa). In real-time -2D- B mode imaging, the vessel-free area at least 1.5 cm from the Glisson's capsule is chosen, and then with the use of a trackball a region of interest is fixed that was 1.5 cm by 0.5 cm in size, as depicted in Figure 2, the patient was taught to hold their breath while data capture. Ten accurate measurements in kPa were taken, the mean value was taken for each subject, and a value below 1 kPa was ignored. Table 1 presents the staging of liver fibrosis utilizing kPa values obtained from shear wave elastography, specifically the ElastPQ point shear wave elastography method, which is based on the Metavir scoring system.

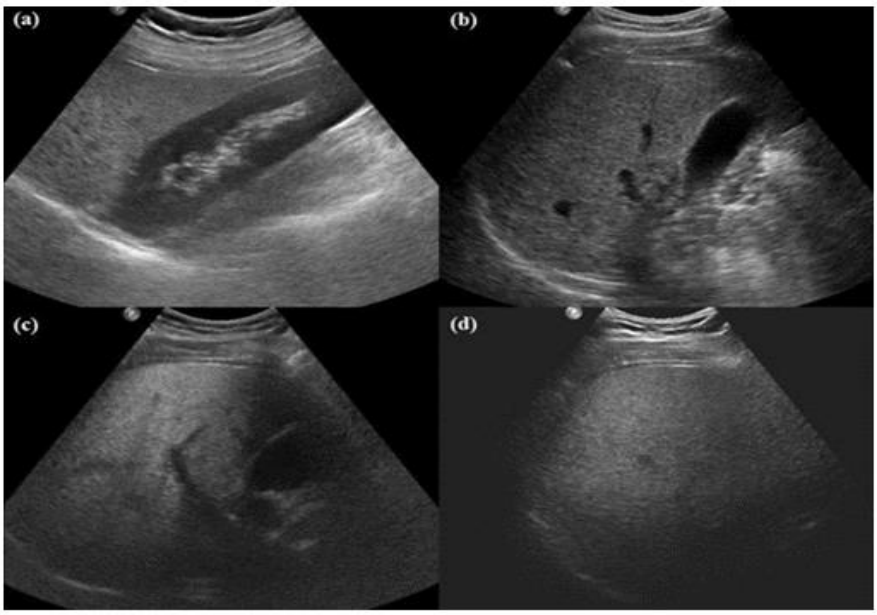


Figure 1: Four grades of hepatic steatosis (a) grade 0 (No steatosis): Normal echogenicity of liver parenchyma; Normal visualization of the diaphragm and intrahepatic blood vessels; (b) grade I (Mild steatosis): Slightly increased echogenicity of liver parenchyma; Normal visualization of the diaphragm and intrahepatic blood vessels;(c) grade II (Moderate steatosis): Markedly increased echogenicity of liver parenchyma; Slightly impaired visualization of the diaphragm and intrahepatic vessels; and (d) grade III (severe steatosis): Severely increased echogenicity of liver parenchyma, with poor or no visualization of the diaphragm and intrahepatic blood vessels and posterior part of the right liver lobe (Photograph courtesy of Dr. Swaran Kumar. © 2023 Dr. Swaran Kumar, Saveetha Medical college and Hospital. Chennai All Rights Reserved)

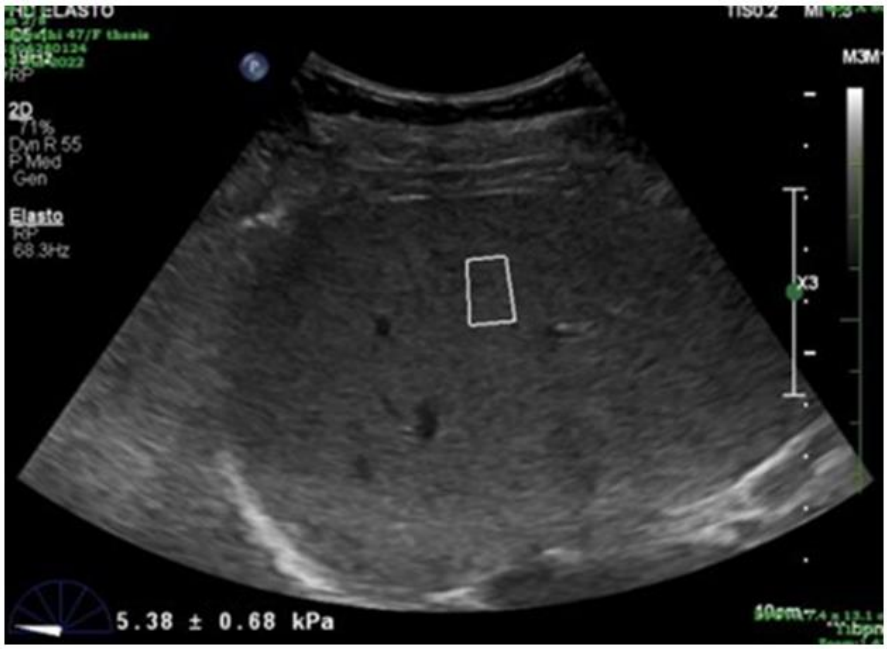


Figure 2: US-pSWE imaging shows a value of 5.38 +/- 0.68 kPa in a sample at the right lobe of the liver, the vessel-free area well away from the Glisson's capsule is chosen, and then with the use of a trackball a region of interest is fixed (Photograph courtesy of Dr. Swaran Kumar. © 2023 Dr. Swaran Kumar, Saveetha Medical college and Hospital,Chennai . All Rights Reserved)

Table 1: Staging of liver fibrosis based on ElastPQ point shear wave elastography method, which is based on the Metavir scoring system

Liver fibrosis staging	kPa
Normal F0	2.0-4.5
Normal - Mild F0 - F1	4.5-5.7
Mild - Moderate F2 - F3	5.7-12.0
Moderate - Severe F3 - F4	12.0-21.0+

CT imaging for liver attenuation

Specifications of equipment used: Siemens Somatom definition 128-slice ct scanner

With the support of a single energy 128 slice CT scanner. Imaging data were collected while holding the breath in the supine position at 120 kVp, 1.25 mm slice thickness. Post-acquisition the slice with the ability to visualize the right lobe of the liver and spleen was selected, and round ROI (region of interest) was drawn in the right lobe of the liver avoiding regions with vessels, ducts, and motion artifact and mean attenuation of liver and spleen are obtained. To diagnose a fatty liver on non-contrast CT, moderate to severe steatosis (at least 30% fat fraction) is predicted by: Relative hypoattenuation: liver attenuation more than 10 HU less than that of spleen [13]. Absolute low attenuation: liver attenuation lower than 40 HU [14]. An example of estimation of liver fat by CT Hounsfield units is demonstrated in Figure 3.

MR chemical shift imaging

Specifications of equipment used: Phillips Multiva 1.5T magnetic resonance imaging system

This MRI technique takes advantage of the proton's different resonance on fat and water molecules. The signal from water and fat protons is cumulative if images acquired are taken in phase and destructive if taken out of phase. MRI chemical shift imaging (mDIXON) was conducted with a matrix of 384 × 320, slice thickness of 5 mm and FOV of 350 mm. In-phase and out of phase breath holding T1 gradient echo images were acquired in the axial plane. It was seen how much of the hepatic parenchymal signal was lost in out-of-phase images similar to fatty infiltration. To measure the signal strength, an

area of interest (ROI) was marked on the liver using a movable ellipse cursor. The hepatic parenchyma ROI was drawn to omit blood vessels, motion artifact, and partial volume effect. A lower ratio corresponded to bigger signal drops and thus higher fat content. IP and OP images are obtained, the ROI ellipse was marked in the same size and location in both IP and OP imaging (Figures 4 and 5), and a histogram was taken from which the mean value of IP and OP image was obtained respectively for each subject.

Fat percentage is calculated from m-DIXON, In-phase (IP), and Out-of-Phase (OP) values using the following formula:

Fat percentage = [(IP - OP)/ (IP × 2)] × 100. FAT % = [(IP-OP)/ (IP × 2)] × 100

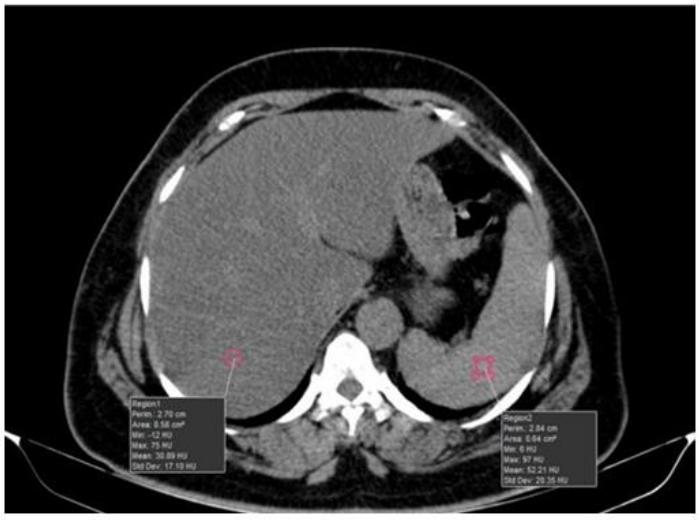


Figure 3: Mean liver parenchymal attenuation of ROI in the right lobe of liver and spleen being 30.89 HU (SD: 17.10 HU) and 52.21 HU (SD: 20.35 HU), respectively, with liver showing relative hypoattenuation of more than10 HU less than that of spleen andabsolute low attenuation: liver attenuation lower than 40 HU. Hence diagnosis of Fatty liver can be made (Photograph courtesy of Dr. Swaran Kumar. © 2023 Dr. Swaran Kumar, Saveetha Medical college and Hospital, Chennail. All Rights Reserved)

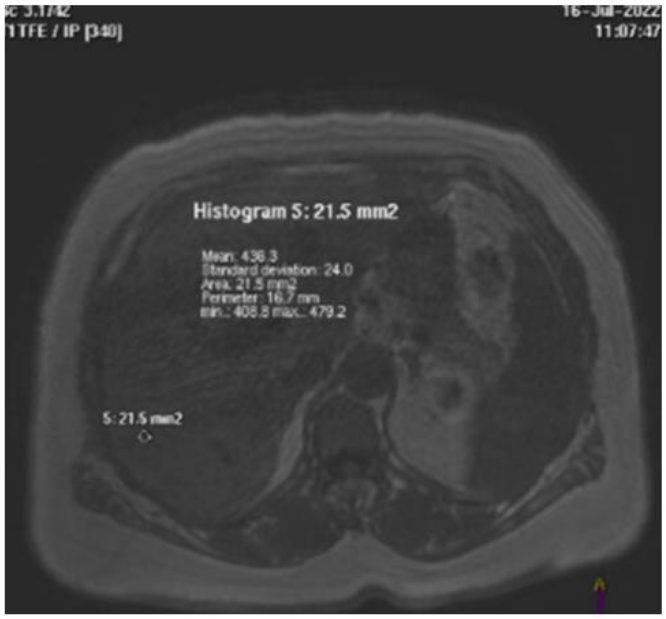


Figure 4: Phase mean of 436.3 in fixed ROI at the right lobe of the liver (Photograph courtesy of Dr. Dr. Chakradhar Ravipati. © 2023 Dr. Chakradhar Ravipat, Saveetha Medical college and Hospital, Chennai. All Rights Reserved)

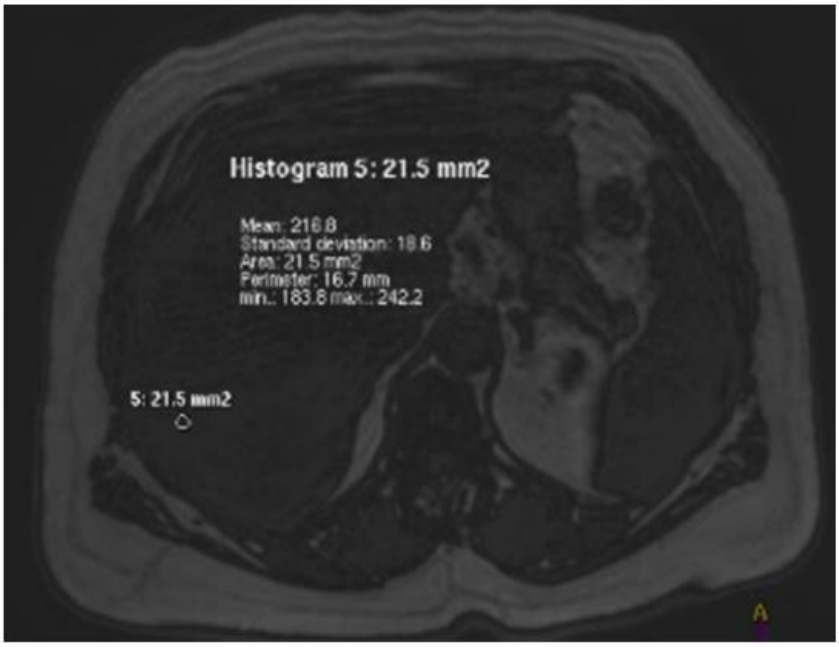


Figure 5: Out-of-phase means of 216.8 in fixed ROI at the right lobe of the liver. (Photograph courtesy of Dr. Chakradhar Ravipati. © 2023 Dr. Chakradhar Ravipati, Saveetha Medical College and Hospital, Chennai. All Rights Reserved)

Using mean values obtained from same location in both IP and OP imaging, as illustrated in Figures 4 and 5, the fat percentage of liver is calculated using the formula, as mentioned above.

IP: Mean- 436.3
OP: Mean- 216.8
Fat %= (IP - OP)/ (IP × 2) × 100.
Fat % = 25.15171011

Ethical approval

This study was conducted in full accordance with the principles set forth in the Declaration of Helsinki and its subsequent amendments. Before the initiation of the research, the study protocol, including the objectives, methods, and potential risks and benefits to participants, was reviewed and approved by SMCH-IEC-Institutional Review Board (Approval Number: SMC/IEC/2020/09/037).

All participants were provided with comprehensive information about the study's objectives, methods, potential risks, and benefits. Written informed consent was obtained from each participant before any study-related procedure was performed. Participants were made aware that their participation was entirely voluntary, and they had the right to withdraw from the study at any point without facing any repercussions. Confidentiality of all personal and medical data was maintained throughout the study, and data were anonymized to ensure the privacy of the participants.

Specific statistical test used for data analysis

A Chi-square test was done to assess the association of the outcomes like hepatomegaly, fibrosis stages, and stages of fatty liver with demographic variables like age, gender, BMI, and history of DM, and HTN. ANOVA test was done to compare the mean difference of US-p SWE, size of liver, CT mean HFU, and percentage of FAT by MRI with age, BMI, and fatty liver grading. Student t-test was done to compare the mean difference in size of the liver, US-p SWE, CT mean HFU, and % FAT of liver between the age groups. P-value was considered significant if $P < 0.05$.

Data analysis

Data was entered in Microsoft excel. Descriptive analysis was represented in Charts and graphs as proportions. A statistical significance test was done using SPSS Software (Statistical Packages for Social Sciences) version 20.0. Mean, median, and SD was calculated for the continuous

variables like age, BMI, size of the liver, US-pSWE of liver and CT mean HFU and % Fat of liver in MR chemical shift imaging.

Quality control measures for image analysis

(1) Observer Training: Prior to analysis, all human observers underwent a training session to familiarize themselves with the standard operating procedures and criteria for image interpretation, ensuring consistency in image assessment across different observers.

(2) Standardized Image Acquisition Protocols: Implementing consistent and standardized protocols for capturing images, thus ensuring that all images presented to the observers are of consistent quality and taken from standardized angles, eliminating biases due to variations in image quality.

(3) Consensus Meetings: In cases of significant discrepancies between observers, consensus meetings were held to discuss and resolve disagreements.

By implementing these measures, the reliability and accuracy of human observers in the image analysis process can be ensured.

Results and Discussion

The study population was selected based on incidental findings of fatty liver in ultrasound imaging over a period of 18 months by random sampling method.

Table 2: Characteristics of study participants and distribution of parameters

Parameter	Total no. of patients n=80 (%)
Age < 40 years ≥ 40 years	37 (46.25) 43 (53.75)
Gender Male Female	48 (60) 32 (40)
BMI 18.5- 24.9 25-29.9 ≥30	34 (42.5) 27 (33.7) 19 (23.7)
HTN Yes No	74 (92.5) 6 (7.5)
DM Yes No	13 (16.2) 67 (83.7)
USG grey scale	
Size of liver ≤ 16 cms > 16 cms	 22 (27.5) 58 (72.5)
Steatosis Grade I Grade II Grade III	45 (56.25) 27 (33.75) 8 (10)
US – pSWE	
Liver fibrosis staging Normal (F0) Normal -Mild (F0-F1) Mild- Moderate (F2-F3) Moderate - severe (F3-F4)	14 (17.5) 28 (35) 38 (47.5) 0 (0)

Note: Percentages are calculated based on the total number of study participants (n=80)

Table 3: Association between various patient parameters and liver status with P-values

Parameter	USG-fatty liver grading	Stages of Fibrosis
Age	0.384	0.0009
Gender	0.544	0.216
BMI	0.324	0.014
HTN	0.548	0.440
DM	0.001	0.045

Note: p-value <0.05 is considered statistically significant

A total of 80 participants were included in the study out of which 48 participants were male and 32 were female. 37 participants were below the age of 40 years. On visualizing the size of liver on Ultrasonographic imaging it was observed that only 22 participants had a liver size of less than 16 cm while the rest of 58 participants had more than 16 cm showing that a majority of the study population had also hepatomegaly. On studying the pattern of grades of fatty liver among the study population, it was observed that 45 participants showed features suggestive of grade I fatty liver, 27 were grade II and 8 were grade III, suggesting majority of the study population belonged to the initial stage (grade I) of steatosis. The extent of fibrosis observed on USG point Shear Wave Elastography (ElastPQ) was classified into stages of fibrosis with the help of Metavir score, for values falling between respective ranges. It was observed that 14 participants had the normal architecture of liver or no fibrosis, 28 participants had normal to mild fibrosis, and 38 participants had mild to moderate fibrosis, but none fell into the category of moderate to severe fibrosis.

It was found that there was a statistically significant association seen between age, BMI and stage of fibrosis. DM had a significant association between both fatty liver grading and stage of fibrosis, as listed in Table 3. On analysing the extent of fibrosis in different grades of fatty liver, it is observed that the grade I fatty liver patients majority fell into the group of normal (85.7% of normal) and normal to mild fibrosis (67.9 % of normal to mild fibrosis); as the graph incline towards grade II there is increase the incidence of normal (14.3 % of normal), normal to mild (32.1 % of normal to mild fibrosis), and mild-moderate fibrosis (42.1% in mild to moderate); in grade III fatty liver shows the highest incidence of mild to moderate fibrosis (21.15 of mild to moderate). Signifying that extent of fibrosis has a strong correlation with a higher grade of fatty liver.

Based on the results, the data suggests that age, BMI, diabetes, and hypertension have varying associations with liver status. Age and BMI are more strongly associated with the extent of fibrosis, while diabetes is associated with both higher grades of fatty liver and more advanced fibrosis. Hypertension, on the other hand, does not appear to have a significant association with liver status in this dataset. These findings can be valuable for understanding risk factors and potentially guiding interventions for patients with non-alcoholic fatty liver disease.

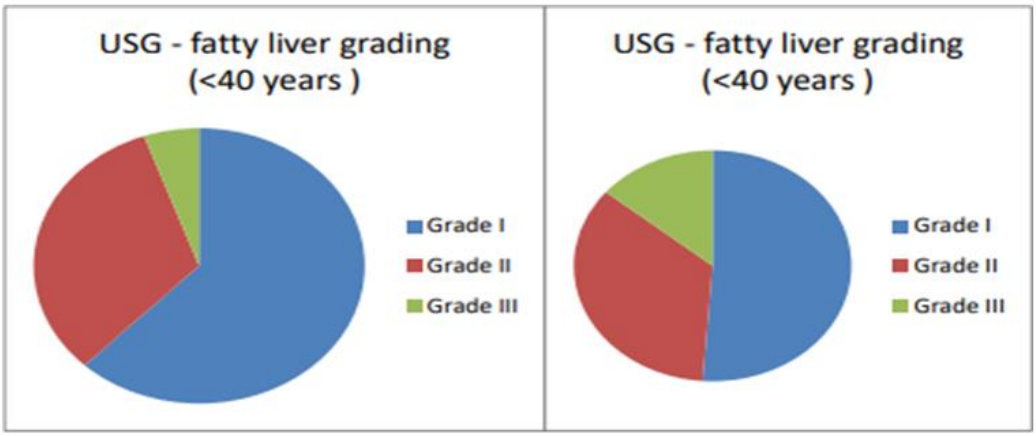


Figure 6: Pie chart of relations of age with USG grey scale fatty liver grading

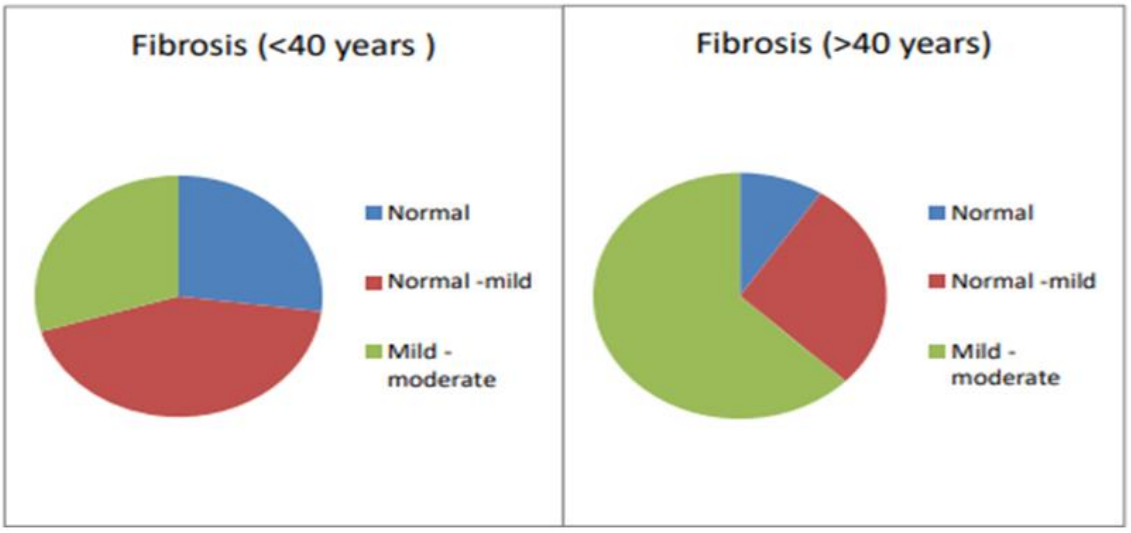


Figure 7: Pie chart of relations of age with stage of liver fibrosis

Our prospective study enrolled 80 patients with fatty liver, consisting of 48 males (60%) and 32 females (40%). In terms of age, 43 participants (53.75%) were over 40 years old, while 37 participants (46.25%) were under 40 years old. Among the 80 participants, the majority (45 participants, 56.25%) were classified as grade I fatty liver, aligning with our goal of early diagnosis. Using ultrasound grayscale imaging, the mean liver size was determined to be 16.496 cm with a standard deviation of 1.9962. A liver size exceeding 15 cm indicates hepatomegaly, which was observed in approximately 72.5% of participants with fatty liver disease. It is worth noting that none of the asymptomatic and incidentally diagnosed patients in our study fell into the moderate to severe fibrosis category. Instead, the majority (47.5%) exhibited mild to moderate fibrosis, followed by 35% with normal to mild fibrosis. These findings suggest a strong association between fatty liver and the occurrence of fibrosis, although it is unlikely for asymptomatic patients to develop severe fibrosis beyond the mild-moderate range.

According to Zeb I. and Li D. *et al.* [3], non-enhanced CT scans can reliably diagnose fatty liver, making CT attenuation value a non-invasive gold standard modality in our study. Regression analysis between CT attenuation value and ultrasound grayscale imaging for fatty liver grading revealed a good correlation, with a slope of -11.7678, intercept of 55.5817, and R2 of 0.5088. Similarly, the linear regression analysis between CT attenuation value and MRI chemical shift imaging for fat percentage analysis showed an excellent correlation, with a slope of -0.507, intercept of 36.365, and R2 of 0.6576. Therefore, it is reasonable to conclude that MRI chemical shift imaging is a reliable modality for qualitatively assessing fatty liver and accurately determining the percentage of fat in liver tissue. This aligns with a study by Bhat V. *et al.* [11], which demonstrates a linear correlation between mDIXON fat estimation and non-invasive CT attenuation as well as histopathological analysis.

A study conducted by Gasim GI., Elshehri FM., Kheidr M., Alshubaily FK., ElZaki EM., and Musa IR. *et al.* reported unreliable use of CT in diagnosing mild steatosis, contradicting our study. However, their research also indicated increased accuracy in moderate to severe fatty liver disease. When comparing CT attenuation value with ultrasound point shear wave elastography (US-pSWE) through linear regression, no reliable correlation was found, with a slope of -2.9481, intercept of 54.7978, and R2 of 0.1292. Thus, CT attenuation value is not a reliable modality for assessing hepatic fibrosis. These findings are consistent with studies by Kramer H., Pickhardt PJ., Kliewer MA., Hernando D., Chen G-H, Zagzebski JA., *et al.* [1], which demonstrate excellent linear correlations between MRI proton-density fat fraction and SECT fat attenuation with MRS measurements, indicating their accuracy as non-invasive biomarkers for quantifying steatosis.

US-pSWE was found to have poor accuracy in liver fat quantification, which aligns with a study by AliyariGhasabeh M., Shaghaghi M., Khoshpouri P., Pan L., Pandya A., Pandya P., *et al.* [4]. This study concluded that mDIXON (Multi-echo Dixon) in the liver has high accuracy in distinguishing between individuals with normal liver fat and those with mildly elevated liver fat. Multi-echo Dixon can be used to screen for early fat deposition in the liver and pancreas. Furthermore, Hamer OW, Aguirre DA., Casola G., Lavine JE., Woenckhaus M., Sirlin CB. *et al.* argue that chemical shift GRE imaging is more reliable than ultrasound or CT for assessing intralesional fat, which is consistent with the findings of our study [13].

The occurrence of all grades of fatty liver was not found to be associated with the age and gender of the patients. However, hepatic fibrosis was statistically significant with older age (>40 years), while there was no statistical significance with gender in relation to hepatic fibrosis. Body mass index (BMI) showed no statistical significance with hepatic steatosis, but was statistically significant in relation to hepatic fibrosis, suggesting that overweight and obesity are more likely to be associated with the incidence of hepatic fibrosis. Higher blood pressure did not show statistical significance in all grades of hepatic steatosis and hepatic fibrosis. However, diabetes was highly statistically significant in the incidence and prevalence of both hepatic steatosis and fibrosis.

Analysing the extent of fibrosis, the majority of grade I fatty liver patients had normal fibrosis grading (85.7% normal) or normal to mild fibrosis (67.9% normal to mild fibrosis). As the grade of fatty liver increased, grade II fatty liver had the majority of mild-moderate fibrosis (42.1% mild to moderate), followed by normal to mild fibrosis (32.1% normal to mild fibrosis) and normal (14.3% normal). Grade III fatty liver showed the highest incidence of mild to moderate fibrosis (21.15% mild to moderate), indicating a strong correlation between the extent of fibrosis and higher grades of fatty liver.

Limitations of the study

This study has several limitations. Firstly, the relatively small sample size of 80 participants may limit the generalizability of the findings to broader populations. Selection bias may be present since participants were chosen based on incidental findings, which could introduce a bias towards more severe cases of non-alcoholic fatty liver disease (NAFLD). In addition, the study's cross-sectional design prevents the establishment of causality or the assessment of long-term trends. Moreover, the study did not consider certain potential confounding factors, such as dietary habits and physical activity, which could impact the results. Further research with larger and more diverse samples, prospective designs, and comprehensive consideration of confounders is needed for robust conclusions.

Conclusion

Our study concludes that patients with non-alcoholic fatty liver disease with the presence of overweight, obesity, and diabetes mellitus as risk factors, have sequelae of presentation from non-alcoholic steatosis to hepatic fibrosis over a period of time. Current imaging modalities such as ultrasound, CT, and MRI have demonstrated their role as non-invasive biomarkers to evaluate and even quantitative the fatty infiltration in the liver, especially by MRI in non-alcoholic fatty liver disease and its progression.

Clinical significance of the study

The ability to non-invasively evaluate and quantify fatty infiltration has pivotal clinical implications. Early identification of NAFLD and its transition to non-alcoholic steatohepatitis (NASH) can guide clinicians in timely intervention, thus potentially arresting or even reversing disease progression. Given the potential complications of unchecked NASH, including hepatic fibrosis and hepatocellular carcinoma, these imaging modalities may play an essential role in reducing morbidity and mortality associated with NAFLD.

Future directions

As we advance our understanding of NAFLD and its imaging biomarkers, there is an impetus to

refine these imaging techniques for greater specificity and sensitivity. Potential areas of research could delve into developing MRI sequences tailored specifically for NAFLD assessment or combining modalities for a more comprehensive liver evaluation. Moreover, longitudinal studies tracking patients over extended periods, using these imaging tools, can offer insights into disease progression and the long-term impact of interventions.

Abbreviations

NAFLD	Non-alcoholic fatty liver disease
NASH	Non-alcoholic steatohepatitis
MRI	Magnetic Resonance Imaging
CT	Computed Tomography
USG	Ultrasound Grayscale Imaging
HFU	Hounsfield Unit
BMI	Body Mass Index
DM	Diabetes Mellitus
HTN	Hypertension
IP	In-Phase
OP	Out-of-Phase
TG	Triglycerides
FOV	Field of View
US-pSWE	Ultrasound Point Shear Wave Elastography

Consent for Publication

We, the undersigned authors of this research paper, entitled: "Comparison of MR Chemical Shift Imaging (mDIXON) and Ultrasound Elastography with CT Hounsfield Unit in Assessment of Early Stages of Non-Alcoholic Fatty Liver Disease", hereby grant consent for the publication of this manuscript in the Journal of medicinal and chemical sciences. We confirm that all authors have reviewed and approved the final version of the manuscript and agree to its submission for peer review and potential publication.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

ORCID

Chakradhar Ravipati
https://orcid.org/0000-0002-3871-6181
Swaran Kumar Murthy
https://orcid.org/0000-0003-2343-6846
Yuvaraj Muralidharan
https://orcid.org/0000-0002-9895-2717
Karthik Krishna Ramakrishnan
https://orcid.org/0000-0002-1690-769X

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