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TO CORRELATE FAT QUANTIFICATION ON ULTRASOUND GUIDED ATTENUATION PARAMETER WITH MR SPECTROSCOPY AND MDIXON IN THE EVALUATION OF NON-ALCOHOLIC FATTY LIVER DISEASE: A PILOT STUDY

Radio-Diagnosis

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ABSTRACT

Background: Nonalcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders worldwide, with increasing prevalence linked to obesity, diabetes, and metabolic syndrome. Accurate quantification of hepatic fat is crucial for diagnosis, staging, and monitoring of the disease. While MR spectroscopy (^{1}H-MRS) and mDIXON are established non-invasive reference standards for liver fat quantification, they are expensive and not widely accessible. The ultrasound-guided attenuation parameter (UGAP) offers a promising, affordable alternative by quantifying liver fat through tissue attenuation analysis. However, its diagnostic performance and correlation with established MRI-based techniques require further validation. This is the first study that compares two modalities and three techniques: MR Spectroscopy (^{1}H-MRS) and mDIXON on MRI and UGAP on ultrasound. **Objective:** To correlate the hepatic fat quantification on ultrasound-guided attenuation parameter with MR Spectroscopy (^{1}H-MRS) and mDIXON in patients with NAFLD. **Material And Method:** A total of 30 adult patients were evaluated with NAFLD that had been discovered by incidentally on ultrasound. Hepatic fat fraction was measured on (^{1}H-MRS) and mDIXON using 3.0T MRI Philips scanner. After MRI study, UGAP measurements were obtained using GE LOGIQ FORTIS ultrasound. Twelve valid measurements were averaged. Data were collected to assess the correlation between UGAP fat quantification and MR-based fat quantification techniques. **Results:** Pearson correlation was used to assess the association between UGAP grading, MR Spectroscopy fat fraction and mDIXON fat fraction. Correlation is significant at the 0.01 level. The ultrasound-guided attenuation parameter showed a strong positive correlation with both MR Spectroscopy and mDIXON results, with a correlation coefficient of 0.869 and 0.897 respectively. Notably, the mDIXON method demonstrated a higher level of agreement with MR Spectroscopy, with a correlation coefficient of 0.892. **Conclusions:** UGAP shows high degree of correlation with MR spectroscopy and mDIXON imaging as a non-invasive method for the evaluation of non-alcoholic fatty liver disease. UGAP has an acceptable accuracy for liver fat quantification. This study highlights that UGAP can be used in isolation, potentially providing a cost-effective and accessible alternative technique to MRI-based techniques in the assessment and monitoring of hepatic steatosis.

KEYWORDS

Nonalcoholic fatty liver disease (NAFLD), MR spectroscopy (^{1}H-MRS), Modified DIXON method (mDIXON), Ultrasound guided attenuation parameter (UGAP), Magnetic resonance imaging (MRI), (PRESS) Point resolved spectroscopy

INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) has become the most common chronic liver condition globally, affecting nearly one-third of the adult population. NAFLD ranges from simple steatosis and steatohepatitis to fibrosis and cirrhosis, and even up to hepatocellular carcinoma and liver failure (2). Accurate and reliable fat quantification is essential for diagnosis, follow up and monitoring of NAFLD. Traditionally, liver biopsy has been considered the gold standard for fat assessment, but being invasive, associated risks limit its routine use. Imaging tests such as UGAP, MR Spectroscopy and mDIXON are becoming the best non-invasive method of diagnosing hepatic steatosis (3). This study aims to evaluate the correlation of UGAP with MRS and mDIXON in quantifying hepatic fat, with the goal of validating UGAP as a reliable alternative for clinical and screening applications.

MATERIAL AND METHOD

This hospital-based prospective study was conducted at a tertiary care hospital. Thirty patients diagnosed with non-alcoholic fatty liver disease (NAFLD) based on clinical, biochemical, and imaging criteria after getting an approval from the institutional ethic committee were included in our study. Patients of either sex and any age with diffuse hepatic steatosis diagnosed on ultrasound were included, while those with chronic alcoholism, chronic viral hepatitis, hepatocellular carcinoma (HCC), or known liver malignancies were excluded. A written informed consent was obtained from all patients before enrolling them into this study. Fat quantification was performed using an GE LOGIQ FORTIS ultrasound machine equipped with elastography and attenuation imaging capabilities, with the attenuation coefficient measured in decibels per centimeter (dB/cm) and steatosis grading estimated accordingly. Magnetic resonance spectroscopy (^{1}H-MRS) was performed using ELITION 3T Philips MRI scanner with a body coil, and the hepatic fat fraction was calculated using the lipid-to-water peak ratio. For standardization purposes a single voxel of 30 x 30 x 30 mm^3 was placed in segment VII and VIII of the liver with TR 2000ms, TE 50ms and flip angle 90 degree. The spectral resolution used was 1.95 and spectral bandwidth 2000 Hz. Respiratory gating for also used for acquisition of optimal images. The mDIXON technique was employed on the same MRI scanner, using a multi-echo gradient-echo sequence to generate water and fat images for liver fat fraction quantification. The parameters used for acquisition of mDIXON images were; voxel size of 2.5 x 2.5 x 6 mm, FOV of 400 x 350, TR 5.7s, TE 0.97s and delta TE 0.7s. Descriptive statistics were used to summarize demographic and clinical data, and correlations between ultrasound-guided attenuation parameters, MR spectroscopy (^{1}H-MRS), and mDIXON were assessed using Pearson's correlation coefficient, with a p-value <0.05 considered statistically significant.

RESULTS

A total of 30 patients (22 males and 8 females) with a mean age of 45.6 ± 13.2 years (range: 31–72 years) were enrolled in the study. Among them, seven patients had a history of hypertension and diabetes mellitus, while elevated levels of total bilirubin, AST, ALT, and ALP were noted in 4, 6, 6, and 3 patients, respectively. A strong positive correlation was found between ultrasound-guided attenuation parameter (UGAP) fat quantification and (^{1}H-MRS) fat fraction grading (Pearson's $r = 0.869$, $p < 0.001$), and a similarly good correlation was observed between UGAP and mDIXON fat fraction grading (Pearson's $r = 0.897$, $p < 0.001$). Additionally, (^{1}H-MRS) and mDIXON fat fraction grading showed a high degree of correlation (Pearson's $r = 0.892$, $p < 0.001$). For diagnosing significant hepatic fat content (≥5%), the sensitivity and specificity of UGAP were 78% and 82%, respectively, whereas (^{1}H-MRS) demonstrated the highest diagnostic performance with a sensitivity of 90% and specificity of 88%.

DISCUSSION

Of the 30 patients diagnosed with (NAFLD) majority of the cohort were males (n=22, 73.3%), reflecting the higher incidence of NAFLD in men, as reported in several studies. The mean age of the study population was 45.6 ± 13.2 years. A striking finding of this study was the strong positive correlation between UGAP and ^{1}H-MRS ($r = 0.869$, $p < 0.001$), as well as between UGAP and mDIXON ($r = 0.897$, $p <$

0.001). This suggests that findings on UGAP show a strong correlation with both MR-based modalities, highlighting its potential as an effective, non-invasive tool for assessing hepatic fat content in clinical settings. Furthermore, the high degree of correlation between ^{1}H-MRS and mDIXON ($r = 0.892$, $p < 0.001$) reinforces the reliability of these MR-based techniques in evaluating hepatic steatosis. Interestingly, a subset of patients in this cohort had comorbid conditions, including hypertension and diabetes mellitus, with liver function tests showing elevated AST, ALT, and bilirubin levels, which are commonly associated with more severe forms of NAFLD. These findings suggest that UGAP, when combined with clinical markers, could be a valuable adjunct in the early detection and monitoring of liver disease progression, particularly in populations with metabolic risk factors.

Imajo et al., 2022 (9) In their study of 1010 patients demonstrated that UGAP values significantly correlated with MRI-PDFF, with an interclass correlation coefficient of 0.768, indicating a strong agreement between the two modalities. Bland-Altman analysis in their study further supported this correlation, revealing a minimal mean bias of 0.0002 percent and narrow 95% limits of agreement (-0.015 to 0.015). Moreover, UGAP showed excellent diagnostic performance for detecting hepatic steatosis Grades 1, 2 and 3 with AUROCs of 0.910, 0.912 and 0.894, respectively.

Study conducted by Tada et al., 2019 (14) also evaluated 126 patients that the performance of UGAP in the assessment of fatty infiltration of liver, comparing it with MRI-PDFF. Their study demonstrated a positive correlation between UGAP and MRI-PDFF values ($r=0.73$), supporting the validity of UGAP as a non-invasive tool for hepatic fat quantification. The correlation between UGAP and MRI-PDFF values was 0.559 ($p<0.001$) in patients with no or mild steatosis (grade ≤ 1). In addition, the r between the UGAP and MRI-PDFF values in obese patients was 0.773 ($p<0.001$).

Another study conducted by Yin et al., 2024 (15) reported the use of quantitative UGAP in the noninvasive evaluation of patients with suspected metabolic-associated hepatic steatosis. In their study of 113 patients, UGAP values showed a strong linear correlation with MRS ($r = 0.76$), which was better than the correlation between CAP and MRS ($r = 0.61$). The diagnostic performance of UGAP was also high, with AUROC values ranging from 0.84 to 0.98 for different steatosis grades. Additionally, they established cut-off values of 12%, 19%, and 22% for steatosis Grade 1, 2 and 3 respectively.

Kukuk et al., 2015 (16) compared various mDIXON MRI sequences with MR spectroscopy and histological fat quantifications in 59 patients, 33 of whom had MRS-determined hepatic fat fraction >5% (mean 17%, max 45%). They found that six-echo mDIXON correlated well with MRS, histological fat quantifications with correlation coefficients of $R = 0.984$ and 0.967 respectively (all $p < 0.001$). Six-echo mDIXON and MRS demonstrated the strongest correlation with histological fat quantifications results, reinforcing their accuracy in quantitative hepatic fat assessment.

Zhao et al., 2019 (17) assessed hepatic fat content using both multi-echo DIXON MRI and MR spectroscopy (MRS) in a pediatric and adolescent Chinese population. They reported that MRS-PDFF yielded a mean of 9.1% ± 10.0%, and hepatic steatosis was detected in 46.5% of participants, all of whom were overweight. Spearman's analysis demonstrated excellent correlation between multi-echo DIXON and MRS ($r>0.9$, $p<0.01$), and Bland-Altman plots confirmed good agreement between these two modalities.

Kang et al., 2017 (18) his study demonstrated that whole liver MRI-PDFF using modified Dixon techniques correlates strongly with both MR Spectroscopy fat fraction ($r=0.961$) and the histological grading of hepatic steatosis ($r=0.809$), validating its accuracy for noninvasive fat quantification. These findings reinforce MRI-PDFF as a reliable alternative to more invasive or limited-scope methods like liver biopsy and single-voxel MRS.

Idilman et al., 2016 (19) conducted a comparative analysis of MRI-PDFF and MR Spectroscopy (MRS) against histology in patients with non-alcoholic fatty liver disease (NAFLD). Both MRI-PDFF and MR Spectroscopy (MRS) showed good correlations with histological grading of steatosis ($r=0.743$ and $r=0.712$, respectively) with no statistically significant superiority between the two modalities. Additionally, MRI-PDFF and MR Spectroscopy were highly correlated with each other ($r=0.986$, $p<0.001$) and both accurately differentiated severe steatosis from mild to moderate steatosis.

Kim et al., 2022 (20) compared multiple techniques for hepatic fat quantification, including MRI-PDFF, MR spectroscopy (MRS), traditional histopathology, and artificial intelligence (AI)-based analysis. MRI-PDFF and MR Spectroscopy (MRS) showed significant correlation ($r=0.983$, $p<0.001$), with a Bland-Altman bias of 2.06%, indicating close agreement. Histologically measured fat fractions (FFpathologist) and AI-estimated values (FFAI) also correlated strongly ($r=0.872$, $p<0.001$). Additionally, both MRI-PDFF and MR Spectroscopy (MRS) showed good correlation with FFpathologist ($r=0.701$ and 0.709) and FFAI ($r=0.700$ and 0.690, all $p < 0.001$).

Limitations:

Histological confirmation was not included in this study as a standard method for evaluating hepatic steatosis. Since the MR Spectroscopy fat fraction method is advised for measuring hepatic steatosis in a clinical context, it was utilized as a reference instead. Only Indian patients with NAFLD were included. As a result, our findings might not apply to other demographics. Only GE scanners are compatible with the UGAP used in this study. Larger prospective studies are needed to validate these findings and further define the clinical utility of UGAP across diverse patient populations.

CONCLUSION

This study demonstrates a high degree of agreement between MRI-based techniques for liver fat quantification and ultrasound-guided attenuation parameters (UGAP) as an effective, accessible, and non-invasive tool for assessing hepatic steatosis. This study shows that there is good correlation between ^{1}H-MRS, mDIXON and UGAP with a correlation coefficient of >0.8, suggesting that these studies can be used in isolation for liver fat quantification.

Table 1. Correlation Between UGAP With MR Spectroscopy And mDIXON In Patients With NAFLD

Correlations				
			(^{1}H-MRS) ff grading	mDIXON ff grading
Spearman's rho	UGAP ff grading	r	0.869	0.897
		P-value	<0.001	<0.001
		n	30	30
**. Correlation is significant at the 0.01 level (2-tailed).				

Abbreviations: ^{1}H-MRS = magnetic resonance spectroscopy; UGAP = ultrasound-guided attenuation parameter; mDIXON = modified Dixon method; NAFLD = non-alcoholic fatty liver disease.

Table 2. Correlation between MR spectroscopy and mDIXON in patients with NAFLD

Correlation			
			mDIXON ff grading
Spearman's rho	(^{1}H-MRS) ff grading	r	0.892
		P-value	<0.001
		n	30
**. Correlation is significant at the 0.01 level (2-tailed).			

Abbreviations: ^{1}H-MRS = magnetic resonance spectroscopy; mDIXON = modified Dixon method; NAFLD = non-alcoholic fatty liver disease.

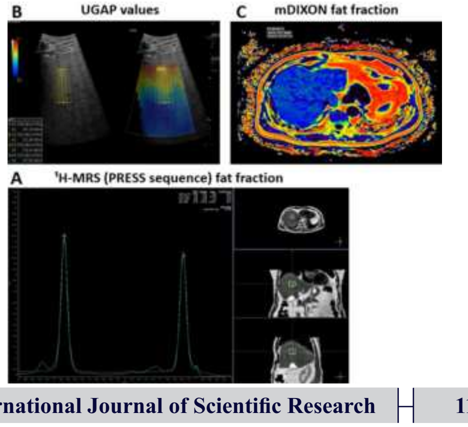

Figure 1: A) MR spectroscopy demonstrating hepatic fat fraction of 47.9%, consistent with severe steatosis. **B)** Ultrasound-guided attenuation parameter showing high attenuation coefficient indicative of grade 3 hepatic steatosis. **C)** mDIXON fat quantification map showing fat fraction of 31%, also indicative of severe hepatic steatosis.

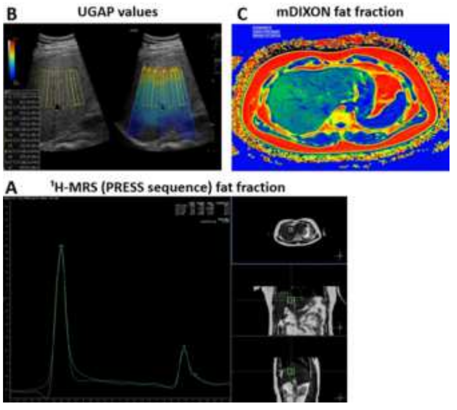

Figure 2: A) MR spectroscopy demonstrating hepatic fat fraction of 16.8%, indicative of moderate steatosis. **B)** Ultrasound-guided attenuation parameter showing high attenuation coefficient suggestive of grade 2 hepatic steatosis. **C)** mDIXON fat quantification map showing fat fraction of 17%, also consistent with moderate hepatic steatosis.

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