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ORIGINAL RESEARCH

# Interplatform Agreement Between Liver Steatosis Analysis and Ultrasound-Guided Attenuation Parameter in the Evaluation of Hepatic Steatosis

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**Objective:** Liver steatosis analysis (LiSA) and the ultrasound-guided attenuation parameter (UGAP) are recently introduced commercially available techniques for the non-invasive evaluation of hepatic steatosis. This study aimed to assess the interplatform agreement between LiSA and UGAP in quantifying hepatic fat content.

**Methods:** Individuals diagnosed with or suspected of having fatty liver disease were included in the study. The overall interplatform agreement between LiSA and UGAP was assessed. The cohort was classified into 8 groups: 4 groups based on steatosis severity (S0-S3) and 4 groups based on predominant etiologies including non-alcoholic fatty liver disease, alcoholic liver disease, drug-induced fatty liver disease, and other causes. Paired-sample *t*-tests were used to compare LiSA and UGAP values. Interplatform agreement was evaluated using Bland–Altman analysis with 95% limits of agreement (LOAs) and intraclass correlation coefficients (ICCs). The Pearson's correlation coefficient was calculated to assess the relationship between LiSA and UGAP.

**Results:** A cohort of 357 patients with available LiSA, UGAP, and controlled attenuation parameter measurements were included in the study. No significant differences were observed between LiSA and UGAP values ($p > 0.05$). Pearson's correlation coefficients ranged from ranged from 0.89 to 0.94 across all groups, while ICCs exceeded 0.80. Bland–Altman analysis demonstrated slight biases between LiSA and UGAP, ranging from −6.17 to 1.97 dB/m for all groups, with 95% LOAs for mean attenuation coefficient values ranging from −40.55 to 36.09 dB/m.

**Conclusion:** LiSA and UGAP exhibited excellent interplatform agreement and can be used interchangeably for longitudinal monitoring of patients with hepatic steatosis.

**Keywords:** attenuation, fatty liver, interplatform, liver steatosis analysis, ultrasonography, ultrasound-guided attenuation parameter

## Introduction

Hepatic steatosis is a prevalent histological finding in individuals with obesity, metabolic syndrome, hepatitis C virus (HCV) infection, excessive alcohol consumption, and exposure to certain medications. It is estimated to affect approximately 25% of the global population and may soon surpass viral hepatitis as the leading indication for liver transplantation.[1–4] Hepatic steatosis is associated with an increased risk of type 2 diabetes mellitus and cardiovascular disease and has also been linked to hepatocellular carcinoma.[5] Furthermore, liver lipid content influences the progression of chronic liver disease, highlighting the clinical importance of accurate evaluation and quantification of hepatic fat.

Liver biopsy remains the gold standard for assessing hepatic steatosis; however, its clinical utility is limited due to its invasiveness, high cost, and susceptibility to sampling bias.[6] Therefore, there is a growing need for accurate, reproducible, and non-invasive diagnostic methods for detecting and quantifying hepatic steatosis.

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Several ultrasound-based techniques have been developed for the non-invasive assessment of hepatic steatosis. The controlled attenuation parameter (CAP), integrated into the FibroScan device (Echosens, France), was the first method approved for quantifying hepatic fat content based on ultrasound attenuation. CAP has been widely used and its diagnostic accuracy has been extensively validated.[7–9] The World Federation for Ultrasound in Medicine and Biology guidelines endorse it as a standardized and reproducible point-of-care tool for detecting hepatic steatosis.[10] However, a key limitation of CAP is its inability to precisely localize the region of interest, contributing to high measurement failure rates.[11]

Recently, several ultrasound manufacturers have introduced B-mode ultrasound-guided attenuation examination techniques for hepatic steatosis assessment. Liver steatosis analysis (LiSA) and the ultrasound-guided attenuation parameter (UGAP) have become commercially available as non-invasive tools that utilize real-time B-mode ultrasound imaging. LiSA, integrated into the Hepatus visual quantitative measuring platform (Mindray), employs real-time grayscale image guidance and is based on physical principles similar to those of CAP. UGAP, developed for the LOGIQ E11 ultrasound system (GE Healthcare), is another ultrasound-based parameter designed for hepatic steatosis detection and quantification.

Previous studies have evaluated the diagnostic performance of UGAP and LiSA in grading hepatic steatosis.[12–15] However, no prior study has assessed the agreement between these two ultrasound-based methods. Establishing interplatform agreement is essential for ensuring the generalizability of results across different manufacturers. High interplatform agreement enhances the clinical applicability of ultrasound attenuation techniques for detecting, quantifying, and monitoring hepatic steatosis over time.

This study aimed to evaluate the interplatform agreement between two ultrasound imaging platforms, LiSA and UGAP, for the assessment of fatty liver disease.

## Materials and Methods

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki and was approved by the Ethics Committee of the First Hospital of Shanxi Medical University (No. KYLL-2023-132). Written informed consent was obtained from all participants.

### Study Population

Patients were prospectively recruited from The First Affiliated Hospital of Shanxi Medical University between September 2022 and March 2023. A cohort of 468 patients were enrolled. The inclusion criteria were as follows: (1) age $\geq$ 18 years; (2) a diagnosis or clinical suspicion of fatty liver disease; (3) completion of three measurements, including LiSA, UGAP and CAP; and (4) the ability and willingness to provide informed consent. The exclusion criteria were as follows: (1) age < 18 years; (2) pregnancy; (3) a history of liver surgery; (4) the presence of focal liver lesions exceeding 5 cm in diameter; (5) ascites; and (6) serum alanine aminotransferase (ALT) or aspartate aminotransferase (AST) levels exceeding five times the upper limit of normal. All enrolled participants, including elderly individuals, successfully met the functional requirements for protocol completion. Post-hoc age-stratified analyses confirmed consistent measurement reliability across age groups (Supplemental Table 1).

### Participant Preparation

Participants fasted ≥8 hours and abstained from physical activity for 24 hours pre-examination. After 10-minute supine rest in a 22±1°C environment, a single sonographer performed three consecutive ultrasound scans within 30 minutes. Standardized positioning (supine with elevated right arm) optimized intercostal windows while participants maintained normal respiration. This protocol ensured hemodynamic stability and minimized metabolic variability across measurements.[16]

### Ultrasound Attenuation Assessment

Each subject underwent comprehensive evaluation including conventional B-mode ultrasonography (Figure 1A) and three quantitative attenuation measurements performed sequentially within 30 minutes: 1) Ultrasound-guided attenuation parameter (UGAP) was acquired using a LOGIQ E11 system (GE Healthcare) equipped with a C1-6-D convex array

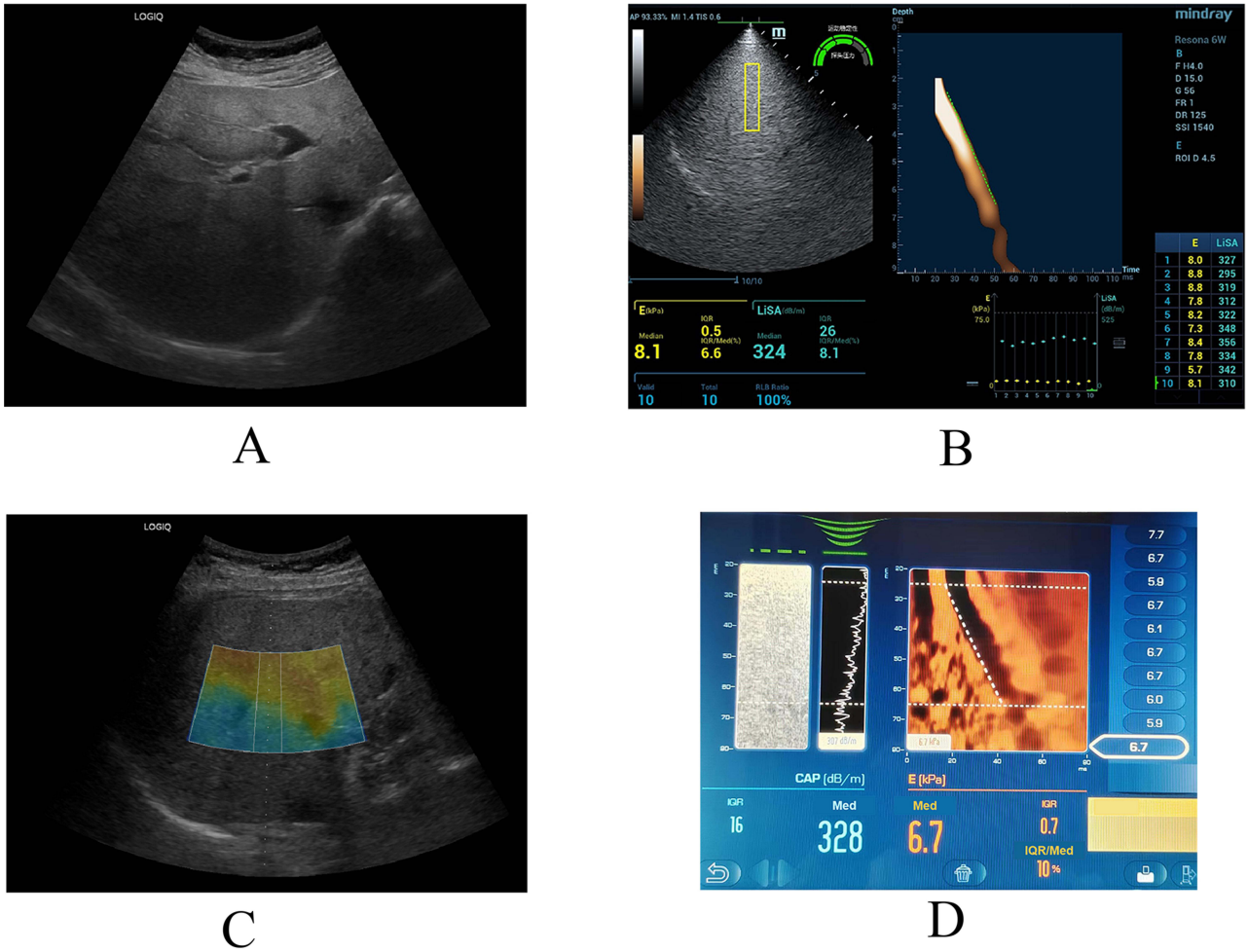


**Figure 1** Examples of liver imaging results in a 63-year-old man with coronary heart disease. (**A**) B-mode ultrasound examination indicating severe hepatic steatosis. (**B**) LiSA measurement using the Mindray Resona 6w with a value of 324 dB/m. (**C**) UGAP measurement using the GE LOGIQ E11 with a value of 327.58 dB/m. (**D**) CAP measurement using FibroScan with a value of 328 dB/m.
**Abbreviations**: LiSA, Liver steatosis analysis; UGAP, Ultrasound-guided attenuation parameter; CAP, controlled attenuation parameter.

transducer. 2) Liver steatosis analysis (LiSA) was performed using a Resona 6w platform (Mindray) with an LFP5-1U probe. 3) Controlled attenuation parameter (CAP) was measured using a FibroScan device (Echosens) with the M probe.

All examinations were conducted through the intercostal space targeting liver segment V, with careful avoidance of vascular structures, biliary tracts, and focal lesions. The transducer was maintained perpendicular to the skin surface throughout image acquisition.

For LiSA measurements, the operator positioned the standardized ViTE region of interest (ROI) within homogeneous liver parenchyma, obtaining ≥10 valid measurements per subject (Figure 1B). UGAP acquisition required brief breath-holding (5–7 seconds), with 10 frames recorded per examination (Figure 1C). Measurements were considered technically adequate when meeting the following quality criteria: interquartile range (IQR) ≤30 dB/m and IQR/median ratio ≤15%.

CAP measurements were obtained following manufacturer protocols, with 10 valid acquisitions required per subject (Figure 1D). Steatosis severity was classified according to established CAP thresholds: S0 (none): <230 dB/m; S1 (mild): 230–274 dB/m; S2 (moderate): 275–299 dB/m; S3 (severe): ≥300 dB/m.

## Interobserver and Intraobserver Reproducibility

Interobserver reproducibility was assessed in a randomly selected subset of the participants (n = 50) by comparing measurements obtained by two radiologists (Radiologists A and B). Radiologists A and B had 10 and 20 years of

experience in abdominal ultrasound, respectively. Both radiologists underwent training and had performed over 300 LiSA and UGAP measurements prior to the study. Intraobserver reproducibility was evaluated in a separate randomly selected subset of participants (n = 50), in which radiologist A performed repeated LiSA and UGAP measurements. To minimize potential measurement bias, participants took a 60-minute break between examinations.

## Statistical Analysis

All statistical analyses were performed using SPSS version 26.0. Continuous variables are expressed as mean ± standard deviation (SD). Differences between measurements obtained from two platforms or two sessions were analyzed using the paired sample *t*-test. The Pearson's correlation coefficient was used to assess associations, categorized as follows: < 0.20-minimal correlation; 0.20–0.39-weak correlation; 0.40–0.70- moderate correlation; and ≥ 0.70-strong correlation.[17] Interplatform agreement was evaluated using intraclass correlation coefficients (ICCs) and Bland–Altman analysis.[18] The 95% confidence intervals (CIs) and 95% limits of agreements (LOAs) were calculated accordingly. The ICC values were interpreted based on the following classification. 0–0.20: slight agreement; 0.21–0.40:fair agreement; 0.41–0.60: moderate agreement; 0.61–0.80: substantial agreement; and 0.81–1.00: almost perfect agreement.[19] All statistical tests were two-sided, and *p*-values less than 0.05 were considered statistically significant.

# Results

## Baseline Characteristics

A cohort of 468 patients were initially recruited for the study. Exclusion criteria led to the removal of 8 patients with a history of liver surgery, 7 patients with focal liver lesions larger than 5 cm, 10 patients with ascites, and 8 patients with ALT or AST levels exceeding five times the upper limit of normal. As a result, 435 patients met the eligibility criteria. Of these, 380 patients underwent all three measurements (LiSA, UGAP and CAP). Further exclusions included 12 patients due to unsuccessful measurements, and 10 patients due to unqualified imaging. Ultimately, 357 patients (mean age: 46.73 ±13.25 years; 186 males/171 females) were included in the final analysis (Figure 2). Table 1 summarizes the demographic and imaging characteristics.

The study population had an average BMI of 25.20±3.85 kg/m$^2$ and a mean skin-to-liver capsule distance of 1.84 ±0.39 cm. Based on CAP measurements, the distribution of hepatic steatosis was as follows: 71 (19.89%) patients had no liver steatosis (S0), 47 (14.7%) patients had mild steatosis (S1), 43 (13.5%) patients had moderate steatosis (S2), and 79 (24.8%) patients had severe steatosis (S3). Among patients with ≥ S1 steatosis (n = 286), the most common underlying causes were: non-alcoholic fatty liver disease (NAFLD): 234 patients (81.81%), alcoholic liver disease (ALD): 30 patients (10.49%), drug-induced fatty liver disease (DIFLD): 10 patients (3.50%), and other aetiologies: 12 patients (4.20%).

## Overall Interplatform Agreement Between LiSA and UGAP

In the cohort, the mean LiSA and UGAP values were 257.29±49.04 dB/m and 257.17±49.80 dB/m, respectively. No significant difference was observed between the LiSA and UGAP measurements ($t = 0.15$, $p = 0.88$; Figure 3A). A strong linear correlation between LiSA and UGAP (r = 0.96, $p < 0.001$; Figure 3B). Bland–Altman analysis (Figure 3C) indicated a slight bias between the two platforms, with a mean difference of 0.12 dB/m and 95% limits of agreement ranging from −29.08 to 29.32 dB/m. For absolute agreement, the interplatform ICC was 0.96 (95% CI 0.95–0.96), indicating excellent agreements between LiSA and UGAP.

## Interplatform Agreement Between LiSA and UGAP Across Steatosis Stages

The cohort was classified into 4 groups (S0-3) based on CAP as the reference standard for liver steatosis quantification. Table 2 summarizes the mean LiSA and UGAP values for each stage. No significant differences were observed between the LiSA and UGAP measurement methods across any steatosis stage (all $p > 0.05$). Bland–Altman analysis indicated that there was no statistically significant bias between the LiSA and UGAP values, with mean differences of 3.00 dB/m for S0, −0.64 dB/m for S1, −0.58 dB/m for S2, and −0.15 dB/m for S3. The 95% LOAs for mean AC values were −23.10 to 25.16 dB/m for S0, −25.81 to 26.45 dB/m for S1, −31.45 to 29.35 dB/m for S2, and −35.53 to 36.09 dB/m for S3.

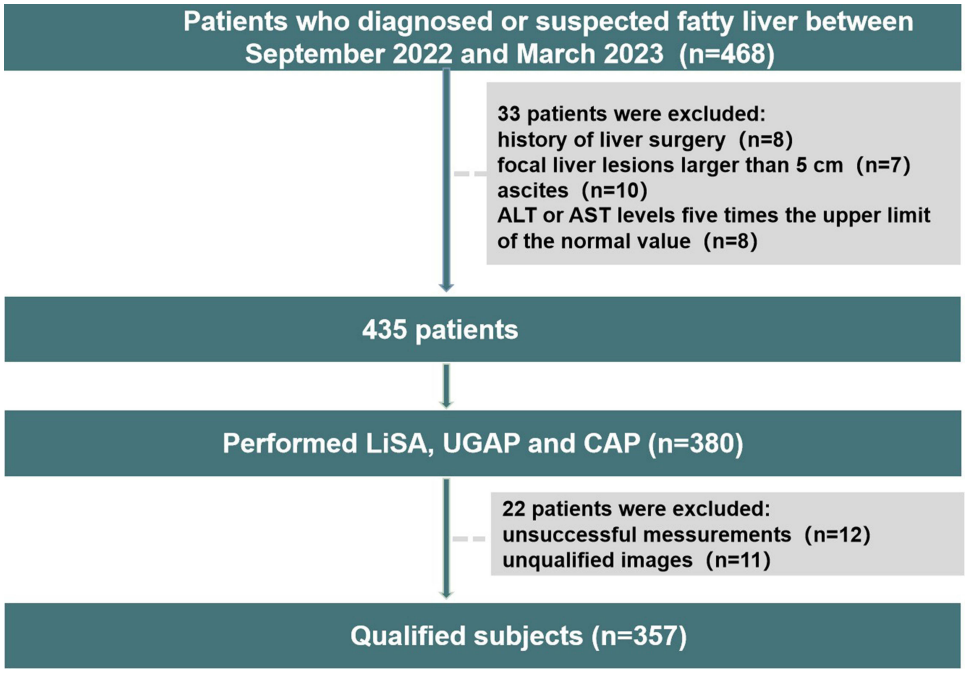


**Figure 2** Flowchart of the study participants.
**Abbreviations**: ALT, alanine aminotransferase; AST, aspartate aminotransferase; LiSA, liver steatosis analysis; UGAP, ultrasound-guided attenuation parameter; CAP, controlled attenuation parameter.

ICCs demonstrated strong interplatform agreement: S0 (0.87), S1 (0.89), S2 (0.81) and S3 (0.91). Additionally, a statistically significant positive correlation was found between LiSA and UGAP across all steatosis stages (S0, r = 0.87, $p < 0.01$; S1, r = 0.89, $p < 0.01$; S2, r = 0.82, $p < 0.01$; S3, r = 0.91, $p < 0.01$).

**Table 1** Characteristics of the Enrolled Patients

| Variable | Summary Statistics |
|---|---|
| **Demographics** | |
| Gender (male/female) | 186/171 (52.1%/47.9%) |
| Age (years) | 46.73±13.25 (18–81) |
| BMI (kg/m$^2$) | 25.20±3.85 (18.19–40.06) |
| **Imaging** | |
| SCD (cm) | 1.84±0.39 (0.80–3.41) |
| LiSA (dB/m) | 257.29±49.04 (153.00–386.00) |
| UGAP (dB/m) | 257.17±49.80 (146.50–392.14) |
| **Steatosis stage using CAP** | |
| S0 | 71 (19.89%) |
| S1 | 118 (33.05%) |
| S2 | 87 (24.37%) |
| S3 | 81 (22.69%) |
| **Aetiology** | |
| NAFLD | 234 (81.81%) |
| ALD | 30 (10.49%) |
| DIFLD | 10 (3.50%) |
| Others | 12 (4.20%) |

**Notes**: Values are presented as mean±standard deviation (range) or number (%).
**Abbreviations**: BMI, body mass index; SCD, skin-capsule distance; LiSA, liver steatosis analysis; UGAP, ultrasound-guided attenuation parameter; CAP, controlled attenuation parameter; NAFLD, non-alcoholic fatty liver disease; ALD, alcoholic liver disease; DIFLD, drug-induced fatty liver disease.

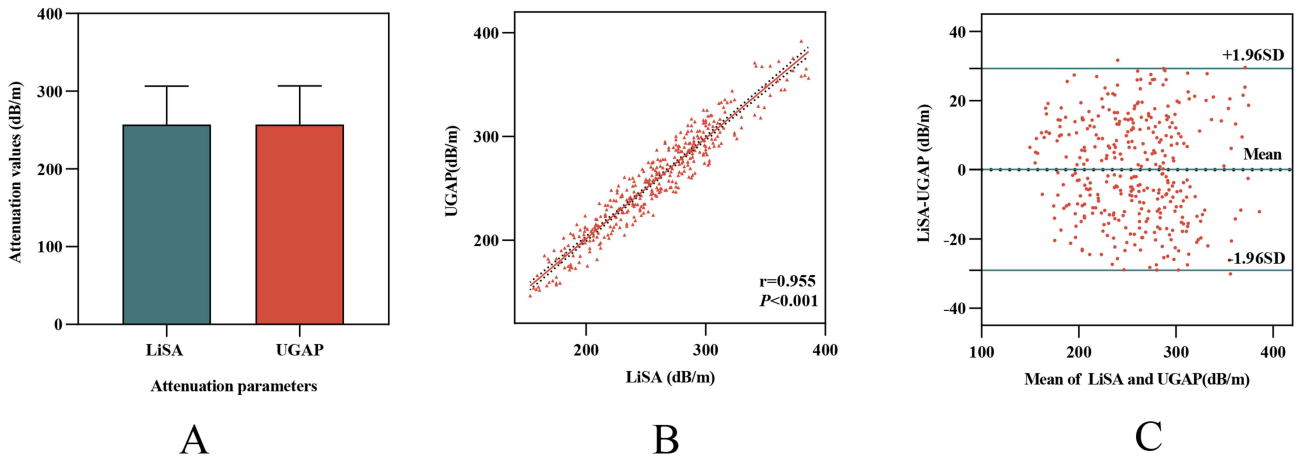


**Figure 3** Overall interplatform agreement of attenuation values between LiSA and UGAP. (**A**) Distribution of LiSA and UGAP measurements. (**B**) Scatter plot illustrating the linear correlation between LiSA and UGAP (r=0.955). (**C**) Bland–Altman plots depicting the bias between LiSA and UGAP. The mean bias was 0.12 dB/m, with 95% LOAs ranging from −29.08 to 29.32 dB/m. The solid blue line in the middle represents the mean bias obtained from the two platforms, while the upper and lower blue lines indicate ±1.96 standard deviations.
**Abbreviations**: LiSA, Liver steatosis analysis; UGAP, Ultrasound-guided attenuation parameter; LOAs, limits of agreement.

## Interplatform Agreement Between LiSA and UGAP Across Different Aetiologies

Patients with steatosis (≥ S1, n = 286) were classified into four groups based on the predominant aetiology of liver disease: NAFLD, ALD, DIFLD and other causes. The mean LiSA and UGAP values for each group are presented in Table 3. No significant differences were observed between the two measurements across any aetiology (all $P>0.05$). Bland–Altman analysis showed slight biases between LiSA and UGAP, ranging from −6.17 to 1.97 dB/m, with 95% LOAs of the mean AC values spanning −40.55 to 32.19 dB/m. The ICCs for interplatform agreement across aetiology groups ranged from 0.88 to 0.93. Similarly, Pearson correlation coefficients between LiSA and UGAP demonstrated a strong correlation between LiSA and UGAP across all groups (r = 0.89 to 0.94).

## Interplatform Agreement and Potential Confounding Factors

The absolute differences between LiSA and UGAP values were not correlated with age (r = 0.01, $p = 0.80$), BMI (r = 0.06, $p = 0.26$), or SCD (r = 0.09, $p = 0.10$).

## Interobserver and Intraobserver Reproducibility of LiSA and UGAP Measurements

LiSA values measured by radiologists A and B were 247.94±57.79 dB/m and 248.06±58.28 dB/m, respectively. There was no significant difference in LiSA values between the radiologists ($t = -0.05$, $p = 0.96$), and the ICC was 0.97 ($p < 0.001$). There was a significant correlation between the attenuation values measured during the two sessions (Pearson's

**Table 2** Interplatform Agreement Between LiSA and UGAP Across Different Hepatic Steatosis Stages

| Steatosis Stage | Prevalence | AC Value (dB/m) | | T (P)[a] | Mean Bias (dB/m) | 95% LOAs (dB/m) | ICC[b] (95% CI) | Pearson r |
|---|---|---|---|---|---|---|---|---|
| | | LiSA | UGAP | | | | | |
| S0 | 71 (19.89%) | 194.88±22.55 | 193.84±25.34 | 0.71 (0.48) | 1.03 | −23.10 to 25.16 | 0.87 (0.80–0.92) | 0.87 |
| S1 | 118 (33.05%) | 244.95±27.58 | 244.62±28.03 | 0.26 (0.79) | 0.32 | −25.81 to 26.45 | 0.89 (0.84–0.92) | 0.89 |
| S2 | 87 (24.37%) | 278.09±23.90 | 280.05±26.60 | −0.64 (0.53) | −1.05 | −31.45 to 29.35 | 0.81 (0.73–0.87) | 0.82 |
| S3 | 81 (22.69%) | 306.68±43.21 | 306.40±41.85 | 0.14 (0.89) | 0.28 | −35.53 to 36.09 | 0.91 (0.86–0.94) | 0.91 |

**Notes**: [a]P-values were calculated using the paired sample *t*-test (two-tailed). [b] ICC was calculated based on a single-unit, absolute agreement, two-way mixed effect analysis of variance (ANOVA) model.
**Abbreviations**: LiSA, liver steatosis analysis; UGAP, ultrasound-guided attenuation parameter; AC, attenuation coefficient; LOAs, 95% limits of agreement; ICC, intraclass correlation coefficient; CI, confidence interval.

**Table 3** Interplatform Agreement Between LiSA and UGAP Across Different Aetiologies

| Aetiology | Prevalence | AC Value (dB/m) | | t (*P*)[a)] | Mean Bias (dB/m) | 95% LOAs (dB/m) | ICC [b)] (95% CI) | Pearson r |
|---|---|---|---|---|---|---|---|---|
| | | LiSA | UGAP | | | | | |
| NAFLD | 234 (81.81%) | 270.26±39.71 | 270.11±40.29 | 0.16 (0.87) | 0.16 | −29.85 to 30.17 | 0.93 (0.91–0.943) | 0.93 |
| ALD | 30 (10.49%) | 288.67±40.80 | 286.69±39.10 | 0.70 (0.49) | 1.97 | −28.25 to 32.19 | 0.93 (0.85–0.96) | 0.93 |
| DIFLD | 10 (3.50%) | 307.80±47.63 | 313.18±44.12 | −1.01 (0.34) | −5.38 | −38.31 to 27.55 | 0.93 (0.77–0.98) | 0.94 |
| Others | 12 (4.20%) | 253.08±34.67 | 259.25±38.67 | −1.22 (0.25) | −6.17 | −40.55 to 28.21 | 0.88 (0.66–0.96) | 0.89 |

**Notes**: [a)] *P*-values were calculated using the paired sample *t*-test (two-tailed). [b)] ICC was calculated based on a single-unit, absolute agreement, two-way mixed effect analysis of variance (ANOVA) model.

**Abbreviations**: LiSA, liver steatosis analysis; UGAP, ultrasound-guided attenuation parameter; AC, attenuation coefficient; LOAs, 95% limits of agreements; ICC, intraclass correlation coefficient; CI, confidence interval; NAFLD, non-alcoholic fatty liver disease; ALD, alcoholic liver disease; DIFLD, drug-induced fatty liver disease.

**Table 4** Interobserver and Intraobserver Reproducibility of UGAP and LiSA Measurements

| | AC Value (dB/m) | | t (*P*)[a)] | Mean bias (dB/m) | 95% LOAs (dB/m) | ICC[b)] (95% CI) | Pearson r |
|---|---|---|---|---|---|---|---|
| | 1st Session | 2nd Session | | | | | |
| Interobserver reproducibility of LiSA | 247.94 ±57.79 | 248.06± 58.28 | −0.05 (0.96) | −0.11 | −29.37 to 29.15 | 0.97 (0.94 to 0.98) | 0.97 |
| Intraobserver reproducibility of LiSA | 265.19±65.99 | 263.74±62.49 | 0.71 (0.48) | 1.45 | −27.95 to 30.85 | 0.97 (0.95 to 0.98) | 0.97 |
| Interobserver reproducibility of UGAP | 225.93±41.34 | 225.94±40.93 | −0.01 (0.99) | −0.02 | −17.05 to 17.01 | 0.98 (0.96 to 0.99) | 0.98 |
| Intraobserver reproducibility of UGAP | 225.96±40.41 | 225.38±42.02 | 0.51 (0.62) | 0.57 | −13.27 to 14.40 | 0.99 (0.97 to 0.99) | 0.99 |

**Notes**: [a)] *P*-values were calculated using the paired sample *t*-test (two-tailed). [b)] ICC was calculated based on a single-unit, absolute agreement, two-way mixed effect analysis of variance (ANOVA) model.

**Abbreviations**: LiSA, liver steatosis analysis; UGAP, ultrasound-guided attenuation parameter; AC, attenuation coefficient; LOAs, 95% limits of agreement; ICC, intraclass correlation coefficient; CI, confidence interval.

r = 0.97). Bland–Altman plots showed a slight bias between the two sessions, with a −0.11 dB/m mean difference and 95% LOAs ranging from −29.37 to 29.15 dB/m.

The intraobserver reproducibility of LiSA and the interobserver reproducibility and intraobserver reproducibility of UGAP were evaluated using the same methodology. Detailed results are presented in Table 4.

## Discussion

Numerous studies have demonstrated the diagnostic accuracy of LiSA and UGAP in assessing liver steatosis, establishing both as valid imaging biomarkers for the detection and quantification of hepatic fat accumulation.[12–15] However, despite these findings, the degree of agreement between these two ultrasound-based platforms remains an area of interest. In this study, an excellent interplatform agreement was observed between LiSA and UGAP.

First, overall interplatform agreement was assessed in the entire cohort (n = 357). Second, Interplatform agreement across different steatosis stages was evaluated by classifying patients into 4 groups based on steatosis severity (S0, n = 71; S1, n = 118; S2, n = 87; and S3, n = 81). Subsequently, interplatform agreement across different aetiologies was examined in patients with any degree of steatosis (≥ S1, n = 286), who were further categorized into four groups based on the predominant liver disease aetiology: (NAFLD, n = 234; ALD, n = 30; DIFLD, n = 10 and other causes, n = 12).

Across all analyses, no significant differences were observed between LiSA and UGAP measurements (all $p > 0.05$). A strong correlation was demonstrated across all groups, with Pearson correlation coefficients ranging from 0.89 to 0.94. When the ICCs of all groups were greater than 0.80, the agreement was excellent.

Until recently, only correlation analyses and ICC analyses were the primary statistical methods used to assess agreement between different measurement techniques. However, as Bland and Altman have highlighted, these methods have certain limitations.[18] To address this, the present study incorporated Bland–Altman analysis to this study. Bland–Altman plots showed slight biases between LiSA and UGAP, with the bias ranging from −6.17 to 1.97 dB/m. The 95% LOAs of the mean AC values ranged from −40.55 to 36.09 dB/m. According to Bland and Altman, when differences within the 95% LOAs are not clinically meaningful, the two measurement methods can be considered interchangeable.

The Bland-Altman analysis revealed minimal systematic bias between measurement methods, with mean differences ranging from −6.17 to 1.97 dB/m. While the 95% limits of agreement (LOAs) spanned −40.55 to 36.09 dB/m, this magnitude of variation falls within clinically acceptable limits for hepatic attenuation coefficient quantification. Consistent with Bland and Altman's principle, interchangeability requires that differences within LOAs lack clinical significance—a criterion satisfied in this context.

Critically, our observed LOA range (−40.55 to 36.09 dB/m; 76.64 dB/m total spread) is substantially narrower than the tolerance threshold (−73.5 to 45.5 dB/m; 119 dB/m spread) established by Lin et al in their multi-platform NAFLD study,[20] where such variation was explicitly deemed "small" given biological heterogeneity and technical factors inherent in ultrasound methodologies. Moreover, clinical relevance must be judged against pathological ranges: attenuation values in advanced steatosis (S3) typically exceed 300 dB/m, rendering differences within ±40 dB/m (<15% variation) diagnostically insignificant. This variation is smaller than the 40–50 dB/m transitions required for inter-grade reclassification (eg, S1 to S2).

Thus, despite the absolute LOA width, the observed differences are unlikely to impact clinical decision-making in steatosis grading or etiological assessment. Future standardization of ROI placement and operator training may further reduce technical variability.

The interplatform agreement was found to be very high across the overall cohort, all steatosis severity groups, and all aetiology groups. Additionally, interplatform agreement remained unaffected by BMI or SCD, aligning with findings from Han[20] and Jeon.[21] These results support the interchangeable use if LiSA and UGAP in the general population.

The agreement of ultrasound attenuation measurements was comparable to that of other imaging modalities for liver steatosis assessment. MRI-PDFF is considered the leading non-invasive quantitative imaging biomarker for hepatic steatosis.[22,23] A study by Kumada et al assessed the agreement between UGAP and MRI-PDFF for hepatic steatosis quantification, demonstrating interchangeability within a clinically acceptable range, with a bias of −0.01 and upper and lower LOAs of 0.12 and −0.13, respectively.[24] Similarly, Serai et al evaluated MRI-PDFF reproducibility across different MRI platforms, including Philips 3-T, 1.5-T, and GE 3-T MR systems.[25] The study involved 24 adult volunteers and reported excellent interplatform agreement with ICC values ranging from 0.91 to 0.95. A meta-analysis of 34 studies involving 2104 patients further confirmed the excellent reproducibility of MRI–PDFF across different imaging manufacturers, with a slight mean Bland–Altman bias of −0.13%.[26]

As newly introduced parameters, the test-retest reproducibility of UGAP and LiSA require validation before widespread clinical implementation. In the present study, excellent interobserver and intraobserver reliability was observed for both UGAP and LiSA. These findings are consistent with previous studies reporting excellent intraobserver and interobserver reproducibility for each ultrasound attenuation examination platform. Jeon et al reported excellent intersession reproducibility for UGAP, with an ICC of 0.96 (95% CI, 0.93–0.98).[21] Similarly, Zhao et al demonstrated good interobserver and intraobserver reproducibility of UGAP, with ICCs of 0.86 (95% CI, 0.78–0.91) and 0.91 (95% CI, 0.78–0.97), respectively.[27] Ren et al reported good interoperator and intraoperator reproducibility for LiSA, with ICCs of 0.88 (95% CI, 0.82–0.94) and 0.91 (95% CI, 0.83–0.95), respectively.[15] Given the high interobserver and intraobserver reproducibility, LiSA and UGAP appear to be clinically applicable screening tools for hepatic steatosis.

This study had several distinctive aspects. First, the interplatform agreement between LiSA and UGAP—both of which have only recently become commercially available—was assessed. Second, the cohort was classified by hepatic steatosis stage and aetiology. Third, a prospective enrolment of 357 participants was conducted, representing the largest sample size to date for assessing interplatform agreement.

Several limitations should be acknowledged. First, this was a single-site study that evaluated only two platforms highlighting the need for multicentre and multiplatform studies. Second, the interobserver and intraobserver reproducibility of LiSA and UGAP was evaluated in different study populations, as conducting multiple measurements with three operators for a single patient posed practical challenges. Third, the study exclusively included Chinese patients, which may limit the generalizability of the findings to broader populations. Fourth, while our sample size was relatively large, it remains insufficient to completely eliminate potential selection bias. Fifth, the lack of validation in other ethnic groups represents an important limitation for clinical application.

## Conclusion

In summary, LiSA and UGAP exhibited excellent interplatform agreement, supporting their interchangeable use for the longitudinal follow-up of patients with hepatic steatosis. Additionally, both modalities demonstrated excellent inter-observer and intraobserver reproducibility.

## Abbreviations

AC, Attenuation Coefficient; ALD, Alcoholic liver disease; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; ATI, Attenuation imaging; AUROC, Area under the receiver operating characteristic curve; CAP, Controlled attenuation parameter; CI, Confidence intervals; CVD, Cardiovascular disease; DIFLD, Drug-induced fatty liver disease; EFSUMB, Ultrasound in Medicine and Biology; HCC, Hepatocellular carcinoma; HCV, Hepatitis C virus; ICC, Intraclass correlation coefficients; IQR, Interquartile range interval; LiSA, Liver steatosis analysis; LOA, Limits of agreements; MRI-PDFF, Magnetic resonance imaging proton density fat fraction; NAFLD, Nonalcoholic fatty liver disease; SCD, Skin-capsule distance; SD, Standard deviation; T2DM, Type 2 diabetes mellitus; TAI, Tissue Attenuation Imaging; UGAP, Ultrasound-guided attenuation parameter.

## Data Sharing Statement

All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

## Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and received approval from the Ethics Committee of the First Hospital of Shanxi Medical University (No. KYLL-2023-132). Written informed consent was obtained from all participants prior to their involvement in the study.

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## Disclosure

The authors declare that they have no conflicts of interest relevant to this study.

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