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Evaluation of Sound Touch Elastography in Diagnosing Nonalcoholic Fatty Liver Disease

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Abstract

[Objective] We aimed to evaluate the effectiveness of sound touch elastography (STE) in diagnosing nonalcoholic fatty liver disease (NAFLD). **[Methods]** A total of 58 patients with nonalcoholic fatty liver (NAFL) and 37 with nonalcoholic steatohepatitis (NASH) were enrolled between January 2018 and January 2023. These patients were assigned to the NAFL and NASH groups, respectively. Additionally, 39 healthy volunteers were selected as the control group. All participants underwent liver STE and sound touch quantification (STQ) examinations. Receiver operating characteristic (ROC) curves were used to compare diagnostic performance among the three groups.**[Results]** There were significant differences in STE and STQ values among the three groups ($P < 0.001$). The areas under the ROC curve (AUC) for STE and STQ were 0.833 and 0.710, respectively, between the control and NASH groups; 0.725 and 0.668 between the NASH and NAFL groups; and 0.607 and 0.534 between the control and NAFL groups.**[Conclusions]** STE and STQ values were significantly higher in the NASH group than in the NAFL and control groups. Additionally, STE values in the NAFL group were higher than those in the control group. STE showed good diagnostic performance in identifying both NAFL and NASH and in distinguishing between the two. The combination of STE with two-dimensional ultrasonography offers significant value in the differential diagnosis across the NAFLD spectrum and is worthy of clinical application and further promotion.

Keywords nonalcoholic fatty liver disease; sound touch elastography; sound touch quantify
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1 Introduction

In recent years, the incidence of nonalcoholic fatty liver disease (NAFLD) has increased, contributing to a rising prevalence of diffuse liver diseases[1 3]. The NAFLD spectrum includes nonalcoholic fatty liver (NAFL), nonalcoholic steatohepatitis (NASH), and their related complications, such as cirrhosis and hepatocellular carcinoma[4]. NASH is closely associated with significant hepatic inflammation and fibrosis, thereby increasing the risk of progression to end-stage liver disease[5,6]. Accurate and early diagnosis of conditions within the NAFLD spectrum is crucial for improving patient outcomes.

In this study, clinical data, ultrasound images, and liver stiffness measurements (LSM) were collected and analyzed using sound touch elastography (STE) and sound touch quantification (STQ). We aimed to evaluate the clinical utility of STE in patients with NAFLD and to offer new insights for clinical application.

2 Data and Methods

2.1 Clinical Data

A total of 168 patients who attended Shenzhen Third People's Hospital between January 2018 and January 2023 were initially considered for inclusion. Ultimately, 134 participants were enrolled in the study: 58 patients with nonalcoholic fatty liver (NAFL), 37 patients with nonalcoholic steatohepatitis (NASH), and 39 healthy volunteers.

The inclusion criteria for NAFLD patients were as follows[7]: (1) age between 18 and 65 years; (2) no history of alcohol consumption; (3) ultrasonographic findings indicative of fatty liver, including increased liver volume, enhanced liver parenchymal echogenicity, posterior echo attenuation, and positive liver kidney contrast.

Patients with normal alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels were assigned to the NAFL group, while those with elevated ALT levels persisting for more than four weeks were assigned to the NASH group.

The exclusion criteria included: (1) patients diagnosed with other liver diseases such as viral hepatitis (24 cases) or autoimmune liver disease (8 cases); (2) failure in STE detection (2 cases).

Healthy volunteers met the following criteria: (1) age between 18 and 65 years; (2) no history of alcohol consumption or liver disease; (3) normal liver function tests and liver ultrasound findings.

The study protocol was approved by the Ethics Committee of the Third People's Hospital of Shenzhen Municipality (approval numbers: [2018]02-202-01 and [2022-042]). Written informed consent was obtained from all participants.

2.2 Instruments and Methods

(1) Instruments: A Mindray Resona7 color Doppler diagnostic system equipped with a convex probe (model SC6U-1, frequency range: 1.0 6.0 MHz) was used.

(2) Two-dimensional abdominal ultrasound examination: Participants were instructed to fast and lie in the supine position. Both arms were abducted and placed above the head to fully expose the abdomen and intercostal spaces. A senior sonographer performed scans of the liver and spleen

using the convex array probe. The following parameters were measured: the maximum oblique diameter of the right hepatic lobe, the inner diameter of the main portal vein, spleen thickness, inner diameter of the splenic vein, and subcutaneous soft tissue thickness of the anterior liver.

(3) Ultrasound elastography examination: Ultrasound elastography was performed using the same Mindray Resona7 system and conducted by the same sonographer in STE mode, with pre-defined system parameters. The STE sampling box was placed in the right anterior or posterior lobe of the liver through a right intercostal approach. The leading edge of the sampling frame was positioned 1 2 cm below the liver capsule, avoiding intrahepatic vascular structures. Patients were instructed to hold their breath calmly during image acquisition. When the confidence level exceeded 90% and the motion stability index displayed more than four green pentagrams, the measurement was recorded. The procedure was repeated five times, and the average value was calculated. The mode was then switched to STQ, and the same process was used to obtain another set of five measurements, from which the mean was derived.

2.3 Statistical Methods

Data were analyzed using SPSS 25.0 statistical software. Normally distributed data were expressed as the mean ± standard deviation and analyzed using one-way analysis of variance (ANOVA). Non-normally distributed data were presented as the median (25th percentile, 75th percentile) and analyzed using the Kruskal Wallis H test. Receiver operating characteristic (ROC) curves were used to evaluate the diagnostic efficacy of liver STE and STQ in distinguishing among the control, NAFL, and NASH groups. A P value < 0.05 was considered statistically significant.

3 Results

3.1 Basic Characteristics, Liver STE, and Liver STQ

Compared with the control group, the NASH group showed significant differences in body weight, body mass index (BMI), platelet count, alanine aminotransferase (ALT), aspartate aminotransferase (AST), subcutaneous soft tissue thickness, maximum oblique diameter of the right hepatic lobe, portal vein diameter, and splenic thickness ($P < 0.05$).

Compared with the NAFL group, the NASH group also demonstrated statistically significant differences in body weight, BMI, platelet count, ALT, AST, subcutaneous soft tissue thickness, and the oblique diameter of the right hepatic lobe ($P < 0.05$).

In the NAFL group, body weight, BMI, subcutaneous soft tissue thickness, right hepatic lobe oblique diameter, and portal vein diameter were significantly different from those in the control group ($P < 0.05$).

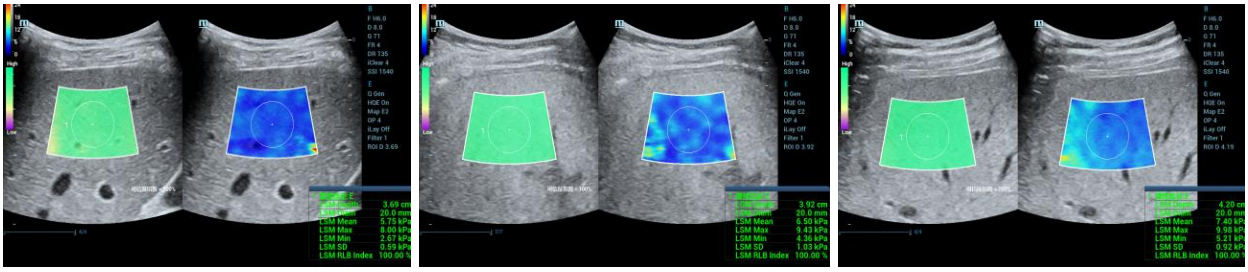
Liver stiffness measurements (LSM) were as follows:

NASH group: STE 7.44 ± 1.68 kPa, STQ 7.45 ± 1.68 kPa;

NAFL group: STE 6.36 ± 1.45 kPa, STQ 6.38 ± 1.44 kPa;

Control group: STE 5.84 ± 1.29 kPa, STQ 5.85 ± 1.31 kPa.

There were significant differences in liver STE and STQ values among the three groups ($P < 0.001$) (Figure 1, Table 1).



A B C

Figure 1. Schematic diagram of LSM measured by STE in different groups. A: control group, liver STE = 5.75 kpa; B: NAFL group, liver STE = 6.50 kpa; C: NASH group, liver STE = 7.40 kpa.

Table 1: Basic clinical data of the subjects

Group	control group(n=39)	NAFL group(n=58)	NASH group(n=37)	*F* value
Age(year)	37.64±10.91	37.55±10.67	33.24±8.40	2.44
Height(cm)	165.26±8.59	167.22±7.57	169.35±7.15	2.63
Weight(kg)	60.53±9.72	74.00±10.82[a]	79.82±11.99[ab]	32.31
BMI(kg/m^2)	22.14±3.14	26.45±3.39[a]	37.35±9.60[ab]	83.41
PLT(×10^9/L)	223.00(203.00,265.00)	263.00(223.75,288.50)	254.00(205.50,293.50)[ab]	3.31
direct Bilirubin(μmol)	13.90(11.20,17.10)	11.80(9.90,14.95)	13.10(11.18,17.75)	0.05
ALT(U/L)	17.00(12.00,29.00)	28.50(20.75,39.00)	102.00(59.00,121.00)[ab]	67.86
AST(U/L)	22.00(17.00,27.00)	23.50(19.00,26.00)	46.00(34.00,58.00)[ab]	53.33
soft tissue Thickness(mm)	14.13±2.66	18.35±3.76[a]	19.96±3.45[ab]	30.91
The oblique diameter of the right lobe of the liver(mm)	127.89±8.49	146.74±8.60[a]	153.30±9.55[ab]	87.19
internal diameter of portal vein(mm)	10.84±1.20	11.47±0.91[a]	11.35±1.12[ab]	6.63
The spleen thickness(mm)	31.92±4.15	33.54±3.96	35.16±3.98[ab]	6.14
Internal diameter of the splenic vein(mm)	6.02±1.51	5.74±1.02	6.41±1.46	1.20
Liver STE(kPa)	5.84±0.94	6.36±1.33[a]	7.44±1.46[ab]	15.80
Liver STQ(kPa)	6.34±1.27	6.59±1.56	7.45±1.68[ab]	5.64
Spleen STE(kPa)	16.04±2.52	15.78±3.79	14.38±2.37	3.14

Note: [a]Compared with the control group, $p<0.05$; [b]Compared with the NAFL group, $p<0.05$.

3.2 Diagnostic Efficacy of Liver STE and STQ in Differentiating the Control, NAFL, and NASH Groups

Liver STE and STQ demonstrated good diagnostic performance in distinguishing the control group from the NASH group, with areas under the curve (AUC) of 0.833 and 0.710, respectively. In differentiating NASH from NAFL, the diagnostic performance was moderate (AUC: 0.725 for STE, 0.668 for STQ). However, the diagnostic efficacy of both STE and STQ in distinguishing the control group from the NAFL group was limited (AUC: 0.607 and 0.534, respectively) (Figure 2; Tables 2 4).

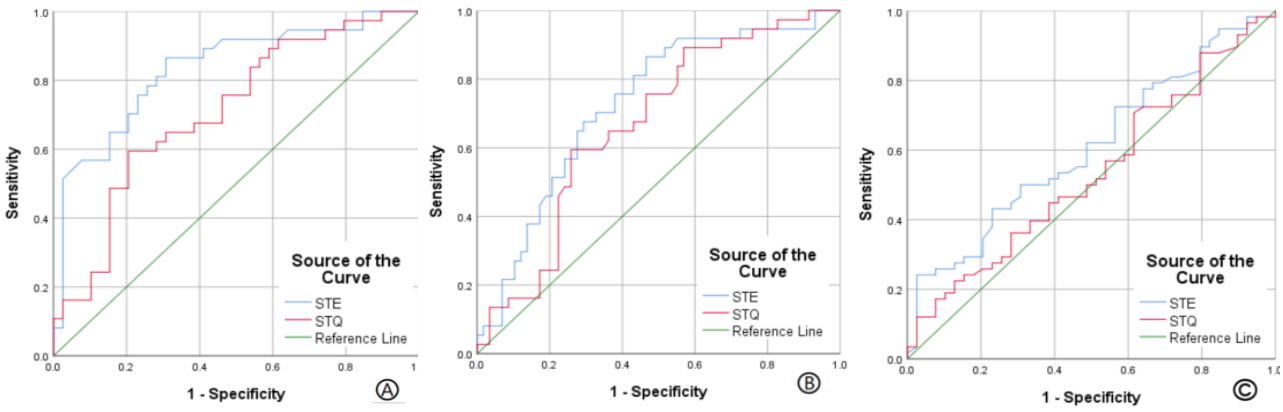


Figure 2. Liver STE and liver STQ distinguished the ROC curves of the control, NAFL, and NASH groups. A: Liver STE and liver STQ distinguish the ROC curve between the control group and the NASH group; B: Liver STE and liver STQ distinguish the ROC curves between the NASH and NAFL groups; C: Liver STE and liver STQ distinguish between the control and NAFL groups.

Table 2: Diagnostic efficacy of liver STE and liver STQ in distinguishing between control and NASH groups

	AUC	sensibility	specificity	95% *CI*
Liver STE	0.833	0.865	0.692	0.740–0.926
Liver STQ	0.710	0.594	0.769	0.593–0.826

Table 3: Diagnostic efficacy of liver STE and liver STQ in distinguishing between NASH and NAFL groups

	AUC	sensibility	specificity	95% *CI*
Liver STE	0.725	0.865	0.534	0.621–0.829
Liver STQ	0.668	0.892	0.431	0.558–0.777

Table 4: Diagnostic efficacy of liver STE and liver STQ in distinguishing between control and NAFL groups

	AUC	sensibility	specificity	95% *CI*
Liver STE	0.607	0.241	0.974	0.494–0.720
Liver STQ	0.534	0.224	0.872	0.418–0.651

4 Discussion

With the improvement of living standards, the incidence of nonalcoholic fatty liver disease (NAFLD) has been increasing year by year, and NAFLD can lead to progressive liver fibrosis[8]. Although NAFL alone is not considered high-risk, nonalcoholic steatohepatitis (NASH) represents a critical turning point in disease progression[9,10].

Liver biopsy remains the gold standard for the diagnosis and staging of NAFLD. However, due to its invasiveness, risk of complications, and sampling variability, it is not suitable for routine screening or dynamic monitoring in clinical practice. Therefore, there is a pressing need to explore noninvasive and accurate alternatives for diagnosing the NAFLD spectrum.

Conventional ultrasound can detect hepatic steatosis based on a "bright liver" appearance and increased liver kidney contrast, but it lacks the ability to differentiate between NAFL and NASH. Magnetic resonance imaging (MRI) can quantitatively assess liver steatosis and fibrosis; however, its long scanning time, high cost, and contraindications in patients with metal implants limit its clinical utility[11,12].

FibroScan transient elastography enables simultaneous assessment of liver fibrosis and steatosis but lacks real-time visual guidance, which may compromise its diagnostic accuracy[13].

Sound touch elastography (STE) and sound touch quantification (STQ) represent a new gen-

eration of ultrasound elastography techniques. In particular, STE enables real-time liver stiffness measurement (LSM) under two-dimensional image guidance, with a large sampling area, high data throughput, a high success rate, and good diagnostic performance in staging liver fibrosis[14].

However, whether STE can effectively differentiate NAFL from NASH remains uncertain. In this study, liver ultrasound elastography was performed in the control, NAFL, and NASH groups. Significant differences in LSM values were observed among the three groups, and the diagnostic efficacy of STE and STQ was evaluated.

The results showed that body weight, body mass index (BMI), platelet count (PLT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), subcutaneous soft tissue thickness, right hepatic lobe oblique diameter, portal vein diameter, and splenic thickness were significantly higher in the NASH group compared with the control group ($P < 0.05$). However, no significant differences were observed in age, height, direct bilirubin levels, or splenic vein diameter ($P > 0.05$).

When comparing the NASH and NAFL groups, significant differences were found in body weight, BMI, PLT, ALT, AST, subcutaneous soft tissue thickness, and right hepatic lobe diameter ($P < 0.05$). No significant differences were noted in age, height, direct bilirubin, portal vein diameter, splenic thickness, or splenic vein diameter ($P > 0.05$).

These findings may be associated with obesity, as individuals with excessive body weight and NAFLD are more likely to develop NASH. Higher body weight and BMI are often accompanied by increased subcutaneous fat deposition, which contributes to more severe hepatic steatosis and greater fluctuations in liver function indicators. These changes may reflect varying degrees of active hepatic inflammation and fibrosis, thereby accelerating the progression from NAFL to NASH.

The results showed that liver stiffness measurements (LSM) differed significantly among the three groups ($P < 0.001$), with values highest in the NASH group, followed by the NAFL group, and lowest in the control group.

Patients in the NASH group exhibited extensive hepatocyte steatosis and ballooning degeneration, along with increased liver volume and tension, mixed inflammatory cell infiltration, and varying degrees of liver fibrosis. Additionally, collagen fiber deposition in the portal area or hepatic lobules further contributed to increased liver stiffness, resulting in the highest LSM values.

In the NAFL group, LSM values were lower than those in the NASH group but higher than in the control group. This may be attributed to extensive hepatocellular fat accumulation without significant ballooning or presinusoidal fibrosis. As a result, liver stiffness was elevated but remained lower than that observed in NASH.

The control group comprised individuals with normal livers—without hepatocyte steatosis, ballooning, inflammatory infiltration, or fibrosis. Consequently, liver tissue remained soft, with the lowest LSM values observed.

In this study, liver STE and STQ both demonstrated good diagnostic efficacy in differentiating NASH, NAFL, and normal liver tissue. They also effectively distinguished NAFL from normal liver. These differences likely reflect the underlying pathological features—fatty changes, hepatocyte ballooning, inflammatory responses, and fibrosis—which lead to increased liver stiffness.

However, the pathological distinction between NAFL and normal liver lies primarily in the presence of steatosis without significant inflammation or fibrosis, resulting in only modest differ-

ences in LSM.

Notably, liver STE exhibited higher diagnostic accuracy than STQ in identifying both NAFL and NASH. This may be due to the technical advantages of STE, a real-time two-dimensional ultrasound elastography method with a larger sampling area, higher data acquisition volume, and more stable and accurate measurements. It also shows stronger correlation with key pathological features, including steatosis, ballooning degeneration, inflammatory cell infiltration, and fibrosis[15].

The accurate diagnosis of diseases within the NAFLD spectrum—such as NAFL, NASH, and NASH-related cirrhosis—has long been a clinical challenge. Differential diagnosis remains both a research focus and a practical difficulty, as liver function biochemical indicators are influenced by numerous factors and often lack sufficient specificity.

In terms of imaging, the NAFLD spectrum presents with overlapping features, leading to low diagnostic sensitivity. Due to ethical constraints and the limitations of routine diagnostic approaches, clinical identification and classification of NAFLD-related diseases have largely relied on physicians' subjective experience. Consequently, standardized, quantitative, and objective diagnostic criteria have been lacking.

This study introduced liver STE and STQ as new, noninvasive imaging techniques providing objective and quantifiable indicators for the diagnosis and differentiation of NAFLD spectrum diseases, with promising results. In particular, liver STE—a new generation of ultrasound elastography—demonstrated excellent performance in distinguishing among normal liver, NAFL, and NASH, especially in the differential diagnosis of NASH.

Future diagnostic strategies should aim to integrate imaging modalities, such as ultrasound-based elastography, with liver function and biochemical test results. This combined approach may significantly enhance diagnostic accuracy and effectiveness and warrants further investigation and broader clinical application.

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