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REAL-TIME SHEAR WAVE ELASTOGRAPHY FOR OPTIMIZING LIVER BIOPSY SITE SELECTION IN DIFFUSE LIVER DISEASE

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ABSTRACT Histopathological examination remains the gold standard for staging hepatic fibrosis and grading necroinflammatory activity in diffuse liver diseases. However, conventional percutaneous liver biopsy is limited by sampling variability, primarily due to the uneven distribution of fibrosis within the hepatic parenchyma. This heterogeneity may result in underestimation or overestimation of disease severity. Real-time shear wave elastography (SWE), a quantitative ultrasound-based imaging modality, enables non-invasive measurement and spatial mapping of liver stiffness, offering potential guidance for selecting a more representative biopsy site. This study aimed to determine whether pre-biopsy real-time SWE improves biopsy site selection and enhances concordance with histopathological staging in patients with diffuse liver disease. Patients with suspected diffuse hepatic pathology underwent SWE evaluation of the right hepatic lobe prior to biopsy. Segmental liver stiffness measurements were recorded, and intrahepatic variability was assessed. Biopsy was directed toward regions demonstrating stable and homogeneous stiffness values. Histopathological fibrosis staging served as the reference standard, and diagnostic performance was analyzed using receiver operating characteristic (ROC) curves. Intrahepatic stiffness variability ranged from 15% to 25%. SWE demonstrated strong diagnostic performance for detecting clinically significant fibrosis, with area under the ROC curve values approaching 0.90. Elastography-guided biopsy targeting showed improved agreement with histological fibrosis staging compared to conventional sampling techniques. Real-time SWE facilitates identification of representative hepatic parenchyma prior to biopsy and may reduce sampling-related inaccuracies, thereby improving diagnostic reliability in diffuse liver disease.

KEYWORDS : Shear Wave Elastography, Chronic Liver Disease, Liver Elastography

INTRODUCTION

Chronic diffuse liver diseases represent a major global health burden. Conditions such as chronic viral hepatitis, metabolic dysfunction–associated steatotic liver disease, autoimmune liver disorders, and alcohol-related liver injury progressively alter hepatic architecture through fibrosis deposition.

Despite advances in imaging, liver biopsy remains indispensable for:

- Accurate fibrosis staging
- Evaluation of inflammatory activity
- Detection of steatohepatitis
- Assessment of complex or overlapping etiologies

However, a biopsy core typically represents less than 0.002% of total liver volume. Because fibrosis may not be evenly distributed, the sampled tissue may not reflect the overall pathological stage. Published data indicate staging discordance rates approaching 20–30% in some cases.

Shear wave elastography, an ultrasound-based technique, measures liver stiffness quantitatively and displays it in real time. By mapping stiffness across multiple regions, SWE offers the opportunity to identify a biopsy site that better represents the global hepatic condition.

Technical Basis of Shear Wave Elastography

SWE operates by generating localized mechanical excitation within tissue using acoustic radiation force. This excitation produces shear waves that propagate laterally. The velocity of these waves is directly proportional to tissue stiffness. The measured velocity is converted into elastic modulus values, typically expressed in kilopascals (kPa).

Greater collagen deposition and architectural distortion in fibrotic liver increase tissue stiffness and accelerate shear wave propagation.

Elastography Techniques in Clinical Practice

Table 1: Key in Context Differences Between Different Modalities

Modality	Quantitative	Anatomical Guidance	Key Limitation
Transient Elastography	Yes	No	No imaging correlation
Point SWE	Yes	Limited	Small sampling window
2D real-time SWE	Yes	Yes	Operator dependent
MR Elastography	Yes	Yes	High cost, limited access

Among available options, real-time 2D SWE uniquely combines stiffness quantification with simultaneous ultrasound visualization.

Diagnostic Accuracy of SWE in Fibrosis Staging

Multiple clinical investigations have demonstrated strong correlation between SWE values and histological fibrosis stage.

Table 2: Range of Stiffness Values in Each Stage of Fibrosis from Early to Severe Forms.

Fibrosis category	Typical stiffness (kPa)	AUROC Range
Significant fibrosis (> F2)	7-9	0.85-0.92
Advanced fibrosis (> F3)	9-12	0.88-0.94
Cirrhosis (F4)	>12-14	0.90-0.95

Sensitivity and specificity values generally exceed 80% for clinically relevant fibrosis thresholds.

The aim of this study was to evaluate whether real-time SWE can optimize liver biopsy site selection in patients with diffuse liver disease.

The objectives:

1. To measure intrahepatic stiffness variability using segmental SWE assessment.
2. To correlate elastographic findings with histopathological staging.
3. To compare staging concordance between SWE-guided biopsy and conventional targeting.
4. To propose practical imaging criteria for biopsy site selection.

MATERIALS AND METHODS

Study Design: Hospital based observational study.

Study population: 40 adult patients (>18 years) with clinical or biochemical suspicion of chronic diffuse liver disease scheduled for percutaneous biopsy.

Inclusion Criteria:

- Age > 18yrs
- Clinical / biochemical suspicion of chronic liver disease
- Informed consent

Exclusion Criteria:

- Focal hepatic mass lesions
- Significant ascites
- Coagulation abnormalities
- Hemodynamic instability

Technique

SWE Protocol

- Convex transducer (3–5 MHz)
- Right intercostal acoustic window
- ROI placed ≥1.5 cm below capsule
- Breath-hold acquisitions
- Minimum 5 valid measurements per segment
- Reliability criterion: IQR/median <30%

Stiffness variability was calculated across segments to assess heterogeneity.

Biopsy Procedure

Biopsy was performed under real-time ultrasound guidance using an 18-gauge core needle. The selected target region met the following criteria:

- Uniform stiffness distribution
- Median stiffness approximating overall segmental average
- Absence of major vascular or biliary structures
- Adequate parenchymal depth

Specimen adequacy was defined by core length (>15 mm) and sufficient portal tracts.

RESULTS

Demographic Data

Total participants: 40
Mean age: 44 ± 12 years
Male: 72%
Female: 28%

Etiology Distribution:

Chronic viral hepatitis: 40%
MASLD: 35%
Autoimmune hepatitis: 15%
Others: 10%

Intrahepatic Stiffness Variability

Segmental stiffness variability ranged from 16–23% (mean 20.3 ± 4.1%). Moderate fibrosis (F2–F3) showed significantly higher heterogeneity compared to cirrhosis ($p = 0.02$).

SWE Stiffness Values by Fibrosis Stage

Table 3: The Stiffness Values Obtained for Different Stages of Hepatic Fibrosis.

Fibrosis stage	Mean + SD (kPa)	Range (kPa)
F0 - F1	5.8 + 1.2	4.2 – 7.1
F2	8.4 + 1.6	6.9 – 10.3
F3	11.2 + 2.1	9.1 – 14.6
F4	18.5 + 3.8	14.2 – 25.4

A strong positive correlation was observed between stiffness and fibrosis stage.

Diagnostic Performance

For >F2 fibrosis: Sensitivity 85–88%, Specificity 82–86%, AUROC ~0.89
For >F3 fibrosis: Sensitivity 88–91%, Specificity 85–88%, AUROC ~0.92
For F4 fibrosis: Sensitivity 92–95%, Specificity 90–93%, AUROC ~0.95

Staging Concordance

Conventional biopsy targeting achieved 72% concordance.
SWE-guided targeting improved concordance to 86% ($p < 0.01$).

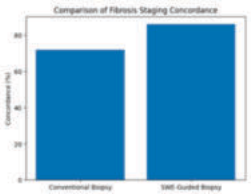

Image 1: Bar Graph Comparing Staging Concordance Between Conventional Biopsy and in SWE Guided Biopsy.

Case Study

The study demonstrates that hepatic fibrosis distribution is heterogeneous, especially in moderate stages. Conventional biopsy may therefore misrepresent disease severity depending on sampling location. SWE enables quantitative stiffness mapping across segments, facilitating identification of representative sampling areas.

The diagnostic accuracy observed is consistent with previous literature reporting high AUROC values for SWE in fibrosis staging. Importantly, this study highlights an additional application of SWE—optimizing biopsy targeting. Improved staging concordance with SWE guidance suggests reduced sampling error and enhanced diagnostic reliability.

Moderate fibrosis showed the highest variability, reinforcing the importance of targeted sampling during transitional disease stages. Cirrhotic livers exhibited relatively uniform high stiffness values, explaining lower variability in advanced disease.

CONCLUSIONS

Real-time shear wave elastography is a valuable adjunct to ultrasound-guided liver biopsy. It enables non-invasive stiffness quantification, identifies representative sampling regions, improves histopathological concordance, and may reduce the need for repeat biopsy. Integration of SWE into routine biopsy protocols can enhance diagnostic precision in diffuse liver disease.

Limitations

- Moderate sample size
- Single-center study
- Operator dependence of SWE measurements
- Potential stiffness elevation in acute inflammation

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