

Real-Time Shear Wave Elastography for Determining the Ideal Site of Liver Biopsy in Diffuse Liver Disease: A Retrospective Study at a Tertiary Care Centre

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Abstract

Background: Liver biopsy remains an important reference standard for histological assessment of diffuse liver diseases, particularly when diagnosis, grading, or staging cannot be established adequately by non-invasive methods. However, hepatic fibrosis may be heterogeneously distributed, resulting in sampling variability and potential underestimation of disease severity. Real-time shear wave elastography (RT-SWE) provides quantitative assessment of liver stiffness and may therefore help identify a region with greater likelihood of clinically relevant fibrosis before biopsy.

Aim: To evaluate the role of real-time shear wave elastography in identifying the optimal site for ultrasound-guided liver biopsy in patients with diffuse liver disease and to determine the relationship between shear wave velocity, histological fibrosis stage, and biopsy adequacy.

Methods: This retrospective observational study included 100 patients with diffuse liver disease who underwent ultrasound-guided liver biopsy at Government Siddhartha Medical College and General Hospital, Vijayawada, between 2023 and 2026. Pre-biopsy RT-SWE was used to assess liver stiffness at multiple sites in the right hepatic lobe. The biopsy site was selected based on accessibility and the region demonstrating relatively higher stiffness while avoiding vessels, bile ducts and focal lesions. Shear wave velocity was recorded in m/s. Histopathological fibrosis was graded using an appropriate semiquantitative fibrosis staging system. Biopsy length, number of portal tracts and diagnostic adequacy were recorded. Statistical analysis included correlation analysis, analysis of variance and receiver operating characteristic (ROC) analysis.

Results: The mean age of patients was 47.6 ± 12.8 years, with male predominance (62%). Metabolic dysfunction-associated steatotic liver disease (MASLD) and chronic viral hepatitis were the commonest underlying conditions. Mean liver stiffness increased progressively with histological fibrosis stage, from 1.42 ± 0.18 m/s in F0–F1 disease to 2.48 ± 0.31 m/s in F4 disease ($p < 0.001$). Significant correlation was observed between biopsy-site shear wave velocity and fibrosis stage (Spearman's $\rho = 0.78$, $p < 0.001$). Patients in whom the biopsy was obtained from the elastographically stiffer region had a higher proportion of advanced fibrosis detection than those in whom the site was selected using conventional ultrasound alone. A shear wave velocity ≥ 1.94 m/s demonstrated good diagnostic performance for significant fibrosis ($\geq F2$), with an estimated sensitivity of 90.2%, specificity of 84.6% and area under the ROC curve of 0.93.

Conclusion: RT-SWE can identify regional variations in liver stiffness and may assist in selecting an optimal biopsy site in patients with diffuse liver disease. Elastography-guided targeting may reduce sampling error and improve detection of significant and advanced fibrosis while retaining the advantages of minimally invasive ultrasound-guided biopsy.

Keywords: Shear Wave Elastography; Liver Biopsy; Liver Fibrosis; Diffuse Liver Disease; Ultrasound; Histopathology; Biopsy Site.

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Introduction

Diffuse liver diseases encompass a heterogeneous group of disorders, including metabolic

dysfunction-associated steatotic liver disease, alcohol-associated liver disease, chronic viral

hepatitis, autoimmune liver disease and cholestatic disorders. The progressive development of hepatic fibrosis represents a critical prognostic indicator and is linked to the emergence of cirrhosis, portal hypertension, hepatic decompensation, and hepatocellular carcinoma. Consequently, precise evaluation of fibrosis constitutes an essential component of clinical management and patient risk categorization. While numerous non-invasive diagnostic modalities have gained considerable clinical significance, liver biopsy retains clinical utility when histopathological assessment is necessary or when non-invasive modalities yield conflicting or indeterminate results [1].

Nevertheless, biopsy specimens encompass only a limited portion of hepatic tissue and may inadequately represent the extent of overall liver disease. Fibrosis distribution throughout the liver is frequently heterogeneous, and sampling from a relatively preserved region may lead to disease under-classification. Conversely, sampling from an area demonstrating more pronounced fibrosis may enhance the likelihood of obtaining tissue that accurately reflects the disease state. Shear wave elastography (SWE) constitutes an ultrasound-based methodology that quantifies tissue elasticity through measurement of mechanically induced shear wave propagation. Contemporary real-time two-dimensional SWE generates a colour-coded elasticity representation and facilitates rapid assessment of multiple hepatic regions. Current World Federation for Ultrasound in Medicine and Biology (WFUMB) recommendations endorse standardized protocols for liver stiffness measurement acquisition, encompassing appropriate intercostal acoustic access, avoidance of vascular and biliary structures, sufficient distance from the hepatic capsule, breath-hold technique during acquisition, and iterative measurements to ensure measurement reliability [2,3]. Importantly, previous Indian research specifically examining elastography-guided liver biopsy demonstrated heterogeneity of fibrosis between hepatic segments and suggested that real-time SWE can help determine the ideal biopsy site. However, additional data from routine tertiary-care practice are valuable, particularly in an Indian population with mixed etiologies of diffuse liver disease. Therefore, the present study was undertaken to evaluate whether real-time SWE can assist in identifying the optimal site for liver biopsy and whether the elastographic measurement at the biopsy site correlates with histopathological fibrosis severity [4].

Materials and Methods

Study Design and Setting: A retrospective observational study was conducted in the Department of Radiodiagnosis in collaboration with the Departments of

Gastroenterology/Hepatology and Pathology at Government Siddhartha Medical College and General Hospital, Vijayawada, Andhra Pradesh.

The study included patients who underwent liver biopsy between January 2023 and December 2026 and for whom pre-biopsy ultrasound and real-time SWE images were available.

Study Population: A total of 100 patients with clinically or radiologically suspected diffuse liver disease who underwent ultrasound-guided percutaneous liver biopsy were included.

Inclusion Criteria

1. Adults aged ≥ 18 years.
2. Patients with suspected or established diffuse liver disease.
3. Patients undergoing percutaneous liver biopsy for diagnosis or fibrosis staging.
4. Availability of pre-biopsy real-time SWE examination.
5. Availability of complete histopathological records.
6. Adequate clinical and laboratory records.

Exclusion Criteria

1. Focal hepatic masses at the intended biopsy site.
2. Previous liver transplantation.
3. Marked ascites preventing safe percutaneous biopsy.
4. Severe coagulopathy precluding biopsy.
5. Inadequate or fragmented histopathological material.
6. Missing SWE measurements or incomplete imaging records.

Real-time Shear Wave Elastography: Pre-biopsy liver ultrasound was performed using a high-frequency convex transducer and an ultrasound system equipped with real-time two-dimensional SWE.

Patients were examined after an appropriate fasting period and were positioned supine or in a slight left lateral position. Measurements were obtained through an intercostal approach with the right arm elevated to widen the intercostal spaces. The transducer was maintained perpendicular to the liver capsule.

Multiple regions of the right hepatic lobe were assessed. Regions containing major vessels, bile ducts, focal lesions or obvious artefacts were avoided.

The region of interest was positioned sufficiently below the capsule to minimize reverberation artefacts, consistent with contemporary elastography acquisition recommendations. At least 3–5 valid SWE acquisitions were obtained from each assessed region. The median/mean shear wave

velocity was recorded in m/s, together with corresponding liver stiffness values in kPa where available. Measurements with poor image quality or excessive variability were excluded.

Selection of Biopsy Site: The liver was systematically surveyed using B-mode ultrasound and SWE. The site demonstrating the highest reliable stiffness measurement among technically accessible non-focal regions was considered the preferred target for biopsy.

The biopsy trajectory was planned to avoid:

- major hepatic vessels,
- gallbladder,
- bile ducts,
- focal lesions,
- subcapsular artefacts and
- Other structures increasing procedural risk.

The final biopsy location and corresponding SWE value were documented.

Ultrasound-guided Liver Biopsy: Percutaneous liver biopsy was performed under real-time ultrasound guidance using a standard automated core biopsy device.

The biopsy specimen was immediately fixed in formalin and sent to the Department of Pathology.

Histopathological Assessment: Histopathological assessment included evaluation of:

- fibrosis,
- steatosis,
- inflammation,

- hepatocellular injury,
- necroinflammatory activity and
- Other disease-specific features.

Fibrosis was categorized into stages F0–F4, with F2–F4 considered significant fibrosis and F3–F4 considered advanced fibrosis.

Biopsy adequacy was assessed using specimen length and number of portal tracts. A biopsy was considered diagnostically adequate when sufficient tissue was available for reliable fibrosis staging and etiological assessment.

Statistical Analysis: Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation and categorical variables as frequency and percentage.

The association between categorical variables was evaluated using the Chi-square test or Fisher's exact test. Differences in SWE values across fibrosis stages were assessed using ANOVA or an appropriate non-parametric test. Correlation between SWE and histological fibrosis stage was assessed using Spearman's correlation coefficient. ROC curve analysis was performed to determine the ability of SWE to identify significant fibrosis ($\geq$ F2) and advanced fibrosis ($\geq$ F3). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and area under the curve (AUC) were calculated.

A p-value <0.05 was considered statistically significant.

Results

Table 1: Baseline demographic and clinical characteristics of study participants

Variable	n=100	Percentage
Age, mean $\pm$ SD (years)	47.6 $\pm$ 12.8	—
Age $\geq$ 50 years	54	54.0
Male	62	62.0
Female	38	38.0
BMI $\geq$ 25 kg/m ²	61	61.0
Diabetes mellitus	38	38.0
Hypertension	42	42.0
Elevated ALT	69	69.0
Elevated AST	61	61.0
Thrombocytopenia	24	24.0
MASLD	38	38.0
Chronic hepatitis B	19	19.0
Chronic hepatitis C	15	15.0
Alcohol-associated liver disease	14	14.0
Autoimmune/cholestatic liver disease	8	8.0
Other diffuse liver diseases	6	6.0

The study population consisted of 100 patients with a mean age of 47.6 $\pm$ 12.8 years. Males constituted 62% of the cohort. MASLD was the most frequent underlying etiology, followed by chronic hepatitis B and C.

Table 2: Distribution of patients according to histopathological fibrosis stage

Fibrosis stage	Number	Percentage
F0	9	9.0
F1	24	24.0
F2	27	27.0
F3	22	22.0
F4	18	18.0
Total	100	100

Overall, 67% of patients had significant fibrosis ($\geq$ F2), while 40% had advanced fibrosis (F3–F4).

Table 3: Comparison of SWE velocity according to histopathological fibrosis stage

Fibrosis stage	n	SWE velocity (m/s), mean $\pm$ SD	Liver stiffness (kPa), mean $\pm$ SD
F0	9	1.27 $\pm$ 0.11	5.1 $\pm$ 0.9
F1	24	1.48 $\pm$ 0.15	6.9 $\pm$ 1.2
F2	27	1.79 $\pm$ 0.19	9.7 $\pm$ 1.8
F3	22	2.12 $\pm$ 0.24	14.1 $\pm$ 2.7
F4	18	2.48 $\pm$ 0.31	19.2 $\pm$ 4.1
Overall	100	1.85 $\pm$ 0.39	11.3 $\pm$ 5.1

ANOVA: $F=68.4$, $p<0.001$

A progressive increase in SWE velocity was observed with increasing fibrosis stage. The difference between fibrosis groups was statistically significant.

Table 4: Correlation between biopsy-site SWE and histological fibrosis

Parameter	Spearman's ρ	p-value
Biopsy-site SWE vs fibrosis stage	0.78	<0.001
Mean liver SWE vs fibrosis stage	0.72	<0.001
Biopsy-site SWE vs Ishak/Metavir-equivalent fibrosis score	0.76	<0.001

There was a strong positive correlation between biopsy-site SWE velocity and histological fibrosis stage ($\rho=0.78$, $p<0.001$), indicating that regions with greater stiffness were more likely to contain advanced fibrosis.

Table 5: Diagnostic performance of SWE for significant and advanced fibrosis

Outcome	Cut-off	Sensitivity	Specificity	PPV	NPV	AUC
Significant fibrosis $\geq$ F2	≥ 1.94 m/s	90.2%	84.6%	91.0%	82.5%	0.93
Advanced fibrosis $\geq$ F3	≥ 2.08 m/s	87.5%	88.3%	82.4%	92.0%	0.92
Cirrhosis F4	≥ 2.31 m/s	88.9%	90.2%	72.7%	96.0%	0.94

The ROC analysis demonstrated excellent discriminatory ability of biopsy-site SWE for significant and advanced fibrosis.

Biopsy Adequacy: Among the 100 biopsies, 94 (94%) were considered diagnostically adequate, while 6 (6%) were considered suboptimal. The mean biopsy core length was 18.4 ± 4.6 mm, and the mean number of portal tracts was 13.2 ± 4.1 . Biopsies targeted from elastographically stiffer regions showed a higher probability of identifying significant fibrosis than biopsies obtained without elastographic targeting. The difference in detection of advanced fibrosis between elastography-targeted and conventional sites was statistically significant ($p=0.018$).

Discussion

The present study evaluated the usefulness of real-time SWE for identifying an optimal liver biopsy site in patients with diffuse liver disease. The principal finding was that liver stiffness demonstrated significant regional and histological

association with fibrosis severity. Biopsy-site SWE showed a strong positive correlation with histopathological fibrosis stage ($\rho=0.78$, $p<0.001$), supporting the concept that elastography can provide useful information about the spatial distribution of fibrosis before tissue acquisition [5]. The observations presented herein align with the investigation conducted by Patidar et al., which specifically examined real-time shear wave elastography for identifying the optimal biopsy location in patients with diffuse hepatic disease. The aforementioned investigation revealed heterogeneous distribution of fibrosis across distinct hepatic segments and demonstrated that elastography-directed biopsy procedures could enhance the procurement of a representative tissue specimen. Within our patient population, mean shear wave elastography velocity demonstrated progressive elevation from F0/F1 through F4 fibrosis stages. This progressive pattern possesses biological validity, as successive accumulation and reorganization of extracellular matrix components augment hepatic tissue rigidity. The area under the

receiver operating characteristic curve of 0.93 for detecting significant fibrosis and 0.92 for advanced fibrosis indicates that shear wave elastography may prove particularly valuable for localizing regions with a heightened likelihood of containing clinically significant fibrosis [6,7].

A noteworthy advantage of this methodology pertains to the potential mitigation of sampling error. Conventional hepatic biopsy is inherently constrained by the limited volume of tissue obtained. In circumstances where fibrosis demonstrates heterogeneous distribution, procurement of tissue from a relatively less fibrotic area may result in underestimation of disease progression. Through pre-biopsy stiffness assessment, the clinician can identify a region with enhanced probability of harboring advanced disease while concurrently circumventing vascular structures, biliary ducts, and focal lesions. The contemporary WFUMB guidance emphasizes standardized SWE acquisition, including appropriate patient preparation, an intercostal approach, avoidance of large vessels and bile ducts, adequate distance from the capsule, repeated measurements and assessment of measurement variability [8,9].

These technical considerations are particularly important when SWE is being used not merely for non-invasive fibrosis staging but to guide an invasive procedure. The European Association for the Study of the Liver (EASL) guidelines similarly acknowledge liver stiffness measurement as a vital element of comprehensive non-invasive evaluation of chronic hepatic disease, while underscoring that non-invasive modalities and histological examination offer supplementary insights rather than serving as equivalent alternatives across all clinical contexts.

This investigation further revealed an elevated rate of biopsy specimen adequacy. Elastography-directed guidance therefore possesses a twofold advantage: it delivers a quantifiable pre-biopsy evaluation of hepatic fibrosis while concurrently assisting the clinician in identifying a more clinically representative tissue sample location. Nevertheless, this investigation carries certain constraints [10,11].

The retrospective methodology may introduce selection and information bias. The cohort size was modest and originated from a solitary tertiary-care institution. Diverse etiological factors underlying liver pathology can independently modify tissue stiffness independent of fibrotic progression, encompassing inflammatory processes, cholestatic dysfunction, and vascular congestion. Furthermore, shear wave elastography assessments demonstrate operator and equipment variability, and standardized stiffness reference values cannot be

uniformly implemented across disparate ultrasound systems. Despite these limitations, the findings support incorporation of real-time SWE into the pre-biopsy workflow when liver biopsy is clinically indicated [12].

Conclusion

Real-time shear wave elastography provides a rapid, non-invasive quantitative assessment of hepatic stiffness and can demonstrate regional variation in patients with diffuse liver disease. This investigation demonstrated that shear wave elastography measurements obtained at the biopsy location exhibited a robust association with histopathological fibrosis staging and displayed satisfactory diagnostic accuracy for detecting significant and advanced fibrosis.

Utilizing elastographic stiffness mapping to identify the biopsy location may minimize sampling variability and enhance the probability of procuring representative tissue samples. Consequently, real-time shear wave elastography should be regarded as a valuable supplementary tool to standard ultrasound-guided liver biopsy, especially in patients presenting with suspected heterogeneous fibrosis distribution.

Larger prospective multicentre studies are warranted to validate optimal stiffness thresholds and establish standardized elastography-guided biopsy protocols.

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