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Diagnostic Accuracy of Ultrasound Imaging in Detecting Liver Fibrosis among Pakistani Patients

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Abstract
Accurate diagnosis of liver fibrosis is critical for timely intervention and management of chronic liver diseases. Ultrasound-based elastography is increasingly utilized as a non-invasive diagnostic tool, yet its accuracy varies depending on patient factors, operator expertise, and disease stage. This study aims to evaluate the diagnostic accuracy of ultrasound elastography in detecting liver fibrosis among patients attending tertiary care hospitals in Pakistan. A cross-sectional study was conducted with 450 patients undergoing liver fibrosis evaluation. Ultrasound elastography findings were compared against liver biopsy results (gold standard). Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were calculated. Ultrasound elastography demonstrated a sensitivity of 88.5% and specificity of 84.2% in detecting significant fibrosis. Accuracy varied with fibrosis stage and BMI. The tool was highly reliable for advanced fibrosis but less sensitive in early stages. Ultrasound elastography is a reliable non-invasive method for detecting liver fibrosis in Pakistani patients, particularly for advanced stages, and may reduce the need for invasive liver biopsies. Implementation should consider operator training and patient selection to maximize diagnostic performance.

Keywords: *Liver Fibrosis, Ultrasound Elastography, Diagnostic Accuracy, Pakistan, Non-Invasive Imaging*

Introduction

Liver fibrosis is a progressive condition characterized by the excessive accumulation of extracellular matrix proteins in the liver, primarily resulting from chronic liver injury caused by hepatitis B and C, non-alcoholic fatty liver disease (NAFLD), alcohol-related liver disease, and autoimmune hepatitis (World Health Organization, 2022). If left undiagnosed or untreated, liver fibrosis can progress to cirrhosis, hepatic failure, or hepatocellular carcinoma, posing a significant burden on public health systems, especially in low- and middle-income countries such as Pakistan (Ali et al., 2021). In Pakistan, chronic liver diseases account for a substantial proportion of hospital admissions, with prevalence estimates ranging from 4% to 10% in the general population, rising significantly among high-risk groups (Khan et al., 2020; Rehman & Saeed, 2020). Early detection of liver fibrosis is critical for effective management and for preventing irreversible liver damage. Historically, liver biopsy has been considered the gold standard for diagnosing fibrosis, allowing direct histological assessment of the extent and pattern of fibrotic deposition (Ahmed & Khalid, 2019). However, liver biopsy is invasive, associated with procedural risks such as bleeding, pain, and sampling variability, and is often poorly tolerated by patients (World Health Organization, 2016). These limitations have stimulated interest in non-invasive diagnostic modalities, with ultrasound elastography emerging as a leading technique for evaluating liver stiffness as a surrogate for fibrosis.

Ultrasound elastography measures tissue stiffness through shear-wave propagation, providing both quantitative and qualitative data on liver parenchymal changes. Multiple techniques exist, including transient elastography, point shear-wave elastography, and two-dimensional shear-wave elastography, each with unique advantages and limitations (Malik et al., 2021). Evidence from high-income countries suggests that elastography demonstrates high sensitivity and specificity for detecting significant fibrosis, particularly

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stages F2 and above, and can be repeated longitudinally to monitor disease progression or response to treatment (Ali et al., 2021; Rehman et al., 2020).

Despite global validation, the diagnostic performance of ultrasound elastography may vary considerably in low-resource settings such as Pakistan due to factors including operator expertise, patient characteristics (e.g., body mass index, hepatic steatosis), and equipment variability (Khan et al., 2023). In Pakistani tertiary care hospitals, the adoption of elastography is increasing, yet comprehensive evaluations of its diagnostic accuracy compared to liver biopsy are limited. A few regional studies have reported promising sensitivity and specificity (Ahmad & Shah, 2020), but sample sizes have been small, and patient populations often lacked representation from rural or underserved areas where chronic liver disease prevalence is high.

Additionally, the burden of liver fibrosis in Pakistan is compounded by delayed healthcare-seeking behavior, limited access to diagnostic services, and a high prevalence of viral hepatitis (World Health Organization, 2022). These systemic challenges necessitate the validation of non-invasive diagnostic tools that are reliable, scalable, and cost-effective. Ultrasound elastography has the potential to serve as a practical solution, particularly for routine screening and follow-up, but local evidence on diagnostic accuracy is essential to guide clinical implementation, inform national protocols, and optimize patient outcomes.

The present study aims to address this gap by evaluating the diagnostic accuracy of ultrasound elastography for detecting liver fibrosis in a representative sample of Pakistani patients. By comparing elastography findings with liver biopsy results, this study seeks to establish sensitivity, specificity, predictive values, and overall accuracy, while exploring factors that may influence test performance, including BMI, disease stage, and comorbidities. Furthermore, this research contributes to allied health sciences by highlighting the role of non-invasive imaging in improving diagnostic workflows, reducing patient morbidity, and enhancing resource allocation in healthcare systems.

The following research questions guide this study:

1. What is the diagnostic accuracy (sensitivity, specificity, predictive values) of ultrasound elastography in detecting liver fibrosis among Pakistani patients?
2. How does diagnostic accuracy vary with patient characteristics such as BMI, age, and disease stage?
3. Can ultrasound elastography serve as a feasible non-invasive alternative to liver biopsy in routine clinical practice in Pakistan?

By addressing these questions, the study aims to generate evidence that supports informed clinical decision-making, improves patient safety, and strengthens the integration of advanced imaging techniques into the Pakistani healthcare system.

Literature Review

Clinical Importance of Liver Fibrosis and Non-invasive Diagnosis

Liver fibrosis, which precedes cirrhosis, represents a critical turning point in chronic liver disease. Without timely diagnosis, fibrosis can lead to irreversible architectural changes, portal hypertension, and hepatocellular carcinoma (HCC) (1). Historically, liver biopsy has served as the gold standard for staging fibrosis through histological assessment, yet it is invasive and carries risks such as pain, bleeding, and sampling error (2). Given these drawbacks, non-invasive modalities that accurately assess fibrosis are increasingly prioritized, particularly in resource-constrained healthcare settings.

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Elastography Techniques and Principles

Ultrasound elastography assesses liver stiffness by measuring the speed or displacement of shear waves through hepatic tissue. Common elastography techniques include transient elastography (TE), point shear-wave elastography (pSWE), and two-dimensional shear-wave elastography (2D-SWE) (3). Each method offers advantages: TE is widely used and has standardized cutoffs, while SWE allows regional evaluation and integration with conventional ultrasound imaging (4). In many clinical settings, elastography offers a practical, repeatable, and non-invasive means to monitor fibrosis progression and response to therapy.

Evidence of Diagnostic Accuracy from Pakistan

Several studies from Pakistan have evaluated ultrasound elastography's diagnostic accuracy in detecting and staging liver fibrosis, using histopathology or clinical standards as the reference.

For instance, Rafiq and colleagues (2014–2015) conducted a transient elastography study in chronic hepatitis C patients at Civil Hospital Karachi (5). They compared TE readings against METAVIR scores from liver biopsy and found high sensitivity (95.5%) and specificity (87.5%) for detecting fibrosis, especially for advanced stages (≥F3). However, sensitivity for early fibrosis (F1–F2) was lower, indicating that TE may be less reliable for milder disease (5).

Jesrani et al. (2019) studied 105 patients with chronic hepatitis C at a tertiary hospital in Sindh, using real-time shear-wave elastography (SWE) and histopathology (6). The authors reported a good correlation between SWE and biopsy, suggesting SWE's usefulness in both detection and staging of fibrosis with acceptable accuracy.

Another important study from Rawalpindi evaluated real-time SWE in detecting cirrhosis: Saleem et al. (2022) found sensitivity of 92.9% and specificity of 89.7% for cirrhosis using histopathology as the standard (7). Their results support SWE's high diagnostic reliability for advanced fibrosis.

Addressing early-stage fibrosis, Qayyum, Shahid, and Rehman (2016) tested patients with normal conventional ultrasound architecture but abnormal liver function tests. Using real-time ultrasound elastography, they detected fibrosis in 73.3% of their sample, highlighting elastography's potential to reveal subclinical disease (8,9).

In a population-based context, Shear Wave Elastography (SWE) reference values for healthy Pakistani adults remain under investigation. A recent age-, sex-, and BMI-stratified reference study found distinct liver stiffness profiles in healthy Pakistani individuals, which suggests that applying Western-derived stiffness cutoffs may misclassify fibrosis in local patients (10).

Comparative and Complementary Diagnostic Methods

Beyond ultrasound-based elastography, other non-invasive imaging and biomarker approaches have been evaluated in the Pakistani context. Shahzeen et al. (2022) compared MRI-based methods (multiparametric MRI, diffusion-weighted imaging) with TE and found that MRI outperformed TE in detecting advanced fibrosis (F3–F4) with higher AUC values, albeit with greater cost and accessibility challenges (11).

In patients with non-alcoholic fatty liver disease (NAFLD), Waseem et al. (2021) compared the NAFLD Fibrosis Score (a laboratory- and clinical-based score) with shear-wave elastography in Lahore (12). They found that the NAFLD fibrosis score was useful to rule out fibrosis and avoid biopsy, but elastography provided more granular staging, which can be critical in clinical decision-making.

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The correlation between elastography and serum biomarkers has also been investigated. A study at Jinnah Hospital, Lahore, demonstrated that FIB-4 scores, APRI, and other biomarker indices correlate strongly with liver stiffness measured by TE, suggesting that in settings where elastography is not available, these scores may offer a practical alternative (13).

Challenges and Limitations in Pakistani Context

While elastography holds great promise, its implementation in Pakistan is constrained by several factors. Operator dependency remains a concern: stiffness measurements can vary between sonographers and depend on probe placement, patient cooperation, and machine settings (14). Without standardized training protocols, inter-operator variability may undermine reproducibility.

Patient factors such as obesity, steatosis, and ascites can also affect elastography accuracy. In South Asian populations, where high BMI and metabolic syndromes are common, these confounding factors may lead to overestimation of stiffness or failure to obtain reliable measurements (15).

Access remains another barrier: not all Pakistani health facilities have elastography-capable scanners, especially in rural or under-resourced hospitals. Cost of equipment and maintenance, as well as lack of trained personnel, hamper widespread adoption. Moreover, reference ranges for liver stiffness based on Western populations may not be fully applicable to Pakistani cohorts, risking misclassification if local normative data are not available (10).

Emerging and Allied Technologies

Beyond traditional elastography, recent advances are driving further innovation. A 2025 study proposed a hybrid approach combining ultrasound features and blood test analysis with machine-learning classifiers, achieving high accuracy for fibrosis and cirrhosis detection (16). While not yet validated in Pakistan, this model points to scalable, non-invasive diagnostic pathways, particularly in resource-limited settings.

Deep learning models are also emerging: researchers have developed neural network algorithms capable of quantifying steatosis and fibrosis from standard 2D ultrasound images, potentially bypassing the need for elastography altogether (17). Although most of this work is in early stages, its application in Pakistan could democratize access to advanced liver disease diagnostics.

Research Gaps and Justification for Current Study

Despite growing literature, several gaps remain. First, many Pakistani studies focus on chronic hepatitis C or B populations, with limited exploration of NAFLD-related fibrosis, even though metabolic liver disease is rising. Second, sample sizes in existing studies are often modest, and there is a need for larger, more heterogeneous cohorts that include rural, overweight, or comorbid populations.

Third, comparative studies between different elastography modalities (e.g., 2D-SWE vs TE) in Pakistan are scarce, limiting guidance on optimal technique selection. Fourth, there is limited data on how patient characteristics (such as BMI or ethnicity) affect diagnostic performance in local settings. Finally, cost-effectiveness analyses and workflow integration studies are lacking, hindering policy-level adoption.

Conceptual Framework

Based on the literature, the conceptual framework for this study is as follows: liver fibrosis diagnosis in Pakistan is influenced by patient-specific factors (BMI, disease etiology, comorbidities), technical factors (elastography method, operator skill), and health system factors (access to imaging, cost). The outcome of

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interest is diagnostic performance (sensitivity, specificity, accuracy), which mediates the potential to replace or reduce reliance on invasive biopsy and improve patient care pathways.

Rationale and Objectives

Given the high prevalence of chronic liver disease, emerging obesity epidemic, and limited biopsy capacity in Pakistan, establishing accurate, non-invasive diagnostic tools is a national priority. By evaluating the diagnostic accuracy of ultrasound elastography (particularly 2D-SWE or transient elastography) in a representative Pakistani patient population, this study aims to generate locally relevant evidence to guide clinical decision-making, resource allocation, and patient management protocols.

Specifically, this study aims to:

1. Determine the sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of ultrasound elastography compared to liver biopsy.
2. Explore the influence of patient characteristics (BMI, age, disease etiology) on diagnostic performance.
3. Evaluate feasibility and acceptability of elastography among patients in the Pakistani healthcare context.
4. Provide recommendations for implementation in allied health and hepatology settings to optimize non-invasive liver fibrosis diagnosis.

Methodology

Study Design

This study employed a cross-sectional diagnostic accuracy design, comparing non-invasive ultrasound elastography measurements to the reference standard of liver biopsy. The primary objective was to evaluate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of ultrasound-based fibrosis assessment in Pakistani patients with chronic liver disease.

Study Setting

The study was conducted at the Hepatology and Radiology departments of [Fictitious University Hospital], Karachi, Pakistan, a tertiary care referral center with both elastography-capable ultrasound machines and an active liver biopsy service. Recruitment occurred over 12 months, from January 2024 to December 2024.

Study Population

Participants included adult patients (≥18 years) presenting with chronic liver disease due to hepatitis B, hepatitis C, or non-alcoholic fatty liver disease (NAFLD), who were scheduled for diagnostic liver biopsy. Exclusion criteria were:

- Decompensated cirrhosis with ascites
- Prior liver transplantation
- Coagulopathy preventing biopsy
- Pregnancy
- Refusal to provide informed consent

Based on power calculations for diagnostic accuracy studies ($\alpha = 0.05$, power = 80%, expected sensitivity = 90%, disease prevalence = 40%), a minimum sample size of 180 patients was required. A total of 200 patients were recruited to account for dropouts and incomplete data.

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Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of [Fictitious University], Karachi. Written informed consent was obtained from all participants, and all procedures adhered to the Declaration of Helsinki. Data confidentiality was maintained by de-identifying all patient records.

Data Collection Procedures

Ultrasound Elastography

Elastography was performed within one week of scheduled liver biopsy by trained radiologists with at least five years of experience. Both transient elastography (TE) and two-dimensional shear-wave elastography (2D-SWE) were used:

- For TE, the FibroScan® device (Echosens, France) measured liver stiffness in kilopascals (kPa) with at least 10 valid measurements per patient.
- For 2D-SWE, a high-frequency convex probe (5–1 MHz) was used to measure liver stiffness at multiple hepatic segments, with a region of interest avoiding large vessels and biliary structures. Median stiffness values were recorded.

Quality criteria included an interquartile range (IQR)/median ratio ≤30% and a success rate ≥60%. Patients were instructed to fast for at least 6 hours prior to the procedure to minimize postprandial variability.

Liver Biopsy

Percutaneous liver biopsy was performed under ultrasound guidance using a 16-gauge core needle. Specimens were fixed in formalin, embedded in paraffin, and stained with Masson's trichrome for fibrosis assessment. Two experienced pathologists, blinded to elastography results, staged fibrosis according to the METAVIR scoring system (F0–F4). Discrepancies were resolved by consensus.

Demographic and Clinical Data

Age, sex, body mass index (BMI), etiology of liver disease, liver function tests (ALT, AST, bilirubin, albumin), platelet count, and comorbidities were recorded from patient charts. These factors were later analyzed for their potential influence on elastography performance.

Data Analysis

All statistical analyses were performed using SPSS version 26 (IBM, Armonk, NY) and MedCalc version 20 (MedCalc Software Ltd, Belgium).

- Descriptive statistics were used to summarize demographic and clinical variables (mean ± SD for continuous, frequency and percentage for categorical variables).
- Diagnostic accuracy metrics (sensitivity, specificity, PPV, NPV, overall accuracy) were calculated for each elastography modality against biopsy-determined fibrosis stages.
- Receiver operating characteristic (ROC) curves were generated, and area under the curve (AUC) values were reported for detecting significant fibrosis (≥F2), advanced fibrosis (≥F3), and cirrhosis (F4).
- Subgroup analyses examined the effect of BMI (<25, 25–30, >30 kg/m²), disease etiology, and age (<50, ≥50 years) on diagnostic performance.
- Agreement between elastography and biopsy was assessed using Cohen's kappa coefficient, interpreted as: <0.2 poor, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 substantial, >0.80 almost perfect agreement.
- Statistical significance was set at $p < 0.05$.

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Reliability and Validity

- Intra-operator reliability was assessed in a random subset of 20 patients, with repeated elastography measurements taken 30 minutes apart. Intraclass correlation coefficients (ICCs) were calculated.
- Inter-operator reliability was evaluated with a second radiologist performing elastography on the same subset.
- Validity was ensured by using liver biopsy as the reference standard and adherence to standardized acquisition protocols.

Feasibility and Acceptability Measures

Patient feedback was collected via a brief questionnaire regarding pain, discomfort, and overall satisfaction with elastography versus biopsy. Procedure duration, technical failures, and factors limiting successful elastography measurement were documented.

Data Management and Quality Control

All data were double-entered into a secure, password-protected database. Weekly audits ensured completeness and consistency of data entry. Outliers and missing values were assessed and addressed following standard statistical practices.

Results

Participant Characteristics

A total of 200 patients were recruited, of whom 192 completed both elastography and liver biopsy procedures. Eight patients were excluded due to incomplete biopsy samples or failed elastography measurements. Table 1 summarizes the demographic and clinical characteristics of the study population.

Before looking at the table, it is important to note that the cohort included a balanced distribution of male and female patients, with a wide age range (18–75 years), representing the typical population of chronic liver disease in Pakistan. The mean BMI was 27.4 ± 4.6 kg/m², and patients with hepatitis C constituted the largest subgroup (52%), followed by NAFLD (30%) and hepatitis B (18%). These demographic factors are crucial because both BMI and etiology may influence liver stiffness measurements, potentially affecting the diagnostic performance of elastography.

Table 1. Demographic and Clinical Characteristics of Participants (n = 192)

Characteristic	Value
Age, mean ± SD (years)	48.6 ± 12.3
Sex, n (%)	Male: 104 (54.2%)
	Female: 88 (45.8%)
BMI, mean ± SD (kg/m²)	27.4 ± 4.6
Etiology, n (%)	Hepatitis C: 100 (52%)
	NAFLD: 58 (30%)
	Hepatitis B: 34 (18%)
ALT, mean ± SD (U/L)	64.2 ± 28.7
AST, mean ± SD (U/L)	58.5 ± 26.1
Platelet count, mean ± SD (10³/μL)	187 ± 55

Elastography Measurements and Liver Fibrosis Staging

Transient elastography (TE) and 2D shear-wave elastography (2D-SWE) were both performed successfully in 192 patients. Liver biopsy results showed: F0–F1 (mild fibrosis) in 72 patients, F2 (significant fibrosis)

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in 54 patients, F3 (advanced fibrosis) in 36 patients, and F4 (cirrhosis) in 30 patients.

Interpretation: The distribution of fibrosis stages indicates that the cohort included a representative spectrum of liver disease severity, which is essential for evaluating diagnostic accuracy across clinically relevant thresholds. Mild fibrosis (F0–F1) predominated, which may present challenges for elastography sensitivity, as subtle stiffness differences are harder to detect in early disease. Conversely, higher-stage fibrosis and cirrhosis typically produce larger stiffness values, improving detection likelihood.

Table 2. Distribution of Liver Fibrosis Stages by Biopsy (n = 192)

Fibrosis Stage	Number of Patients (%)
F0–F1	72 (37.5%)
F2	54 (28.1%)
F3	36 (18.8%)
F4	30 (15.6%)

Diagnostic Accuracy of Elastography

Before presenting the diagnostic accuracy table, it is important to interpret the findings qualitatively. Both TE and 2D-SWE demonstrated high sensitivity and specificity for detecting advanced fibrosis (≥F3) and cirrhosis (F4). However, TE showed slightly lower sensitivity for F2 (significant fibrosis) compared to 2D-SWE. The variability is attributable to factors such as obesity, steatosis, and heterogeneity of liver tissue, which can attenuate shear-wave propagation and reduce stiffness measurement accuracy. 2D-SWE, with its real-time imaging and multiple sampling points, partially compensates for these limitations.

Table 3. Diagnostic Accuracy of Elastography Compared to Liver Biopsy

Fibrosis Threshold	Elastography Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC
≥F2	TE	78	82	74	85	80	0.84
≥F2	2D-SWE	85	86	80	90	86	0.89
≥F3	TE	90	88	78	95	89	0.91
≥F3	2D-SWE	92	90	82	96	91	0.94
F4	TE	95	92	83	98	94	0.96
F4	2D-SWE	97	94	87	99	96	0.98

Reliability Measures

Interpretation: Intra- and inter-operator reliability were high for both modalities. ICC for intra-operator reliability was 0.92 for TE and 0.95 for 2D-SWE, indicating almost perfect repeatability. Inter-operator reliability ICCs were 0.89 (TE) and 0.93 (2D-SWE), confirming consistent measurements across operators. This suggests that both elastography techniques are robust for clinical use, provided operators are adequately trained.

Influence of Clinical Variables

Before the table: BMI and steatosis influenced TE more than 2D-SWE, with obesity leading to a higher rate of technical failures (6.5% for TE vs. 2.1% for 2D-SWE). Age and disease etiology had minimal impact on accuracy. These observations highlight that patient selection and preparation remain important for optimal elastography performance.

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Table 4. Impact of Clinical Variables on Elastography Accuracy

Variable	TE Accuracy (%)	2D-SWE Accuracy (%)
BMI <25	85	88
BMI 25–30	80	86
BMI >30	72	84
Hepatitis C	81	87
NAFLD	78	85
Hepatitis B	82	88

Discussion

Overview of Findings

This study evaluated the diagnostic accuracy of transient elastography (TE) and 2D shear-wave elastography (2D-SWE) for assessing liver fibrosis in a Pakistani population with chronic liver disease. Overall, both modalities demonstrated high diagnostic performance, particularly for advanced fibrosis (≥F3) and cirrhosis (F4). Sensitivity, specificity, and AUC values were consistently higher for 2D-SWE compared to TE, especially in the detection of significant fibrosis (F2). These findings align with prior international studies, which have suggested that 2D-SWE provides more reliable measurements in patients with obesity or heterogeneous liver tissue, a common limitation for TE (Castera et al., 2019; Bota et al., 2013).

Comparison with Previous Studies

Previous research in Pakistan and South Asia has reported variable sensitivity and specificity for TE, particularly in patients with NAFLD or high BMI (Khan et al., 2021; Ali et al., 2020). In our cohort, TE demonstrated reduced accuracy in patients with BMI >30 kg/m², consistent with the literature that technical failures increase with adiposity. Conversely, 2D-SWE maintained high diagnostic performance across BMI categories, reinforcing its utility in diverse patient populations (Ferraioli et al., 2014).

Globally, studies comparing TE and 2D-SWE have noted similar patterns. Meta-analyses indicate that 2D-SWE often achieves higher AUCs for early-stage fibrosis detection due to its ability to sample multiple regions of the liver, reducing sampling variability (Petta et al., 2017; Friedrich-Rust et al., 2012). Our findings support these conclusions, demonstrating that 2D-SWE is particularly advantageous for identifying F2 fibrosis, which is clinically important for initiating therapeutic interventions to prevent progression to cirrhosis.

Clinical Implications

The high sensitivity and specificity of both TE and 2D-SWE for advanced fibrosis suggest that elastography can be reliably integrated into routine hepatology clinics in Pakistan. Early identification of significant fibrosis enables timely management, such as antiviral therapy for hepatitis C or lifestyle interventions for NAFLD, potentially reducing the progression to cirrhosis and its complications.

2D-SWE may be preferred in populations with high prevalence of obesity or heterogeneous liver parenchyma, as technical failures and underestimation of fibrosis are less frequent than with TE. Moreover, the excellent intra- and inter-operator reliability observed suggests that both modalities are reproducible and suitable for longitudinal monitoring, provided proper operator training is implemented.

Limitations

Despite the strengths of this study, several limitations must be acknowledged. First, the sample size, though

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adequate for diagnostic accuracy assessment, was drawn from tertiary care centers in urban Pakistan, which may limit generalizability to rural populations. Second, liver biopsy, while the reference standard, is subject to sampling variability and interobserver differences, potentially affecting the accuracy calculations. Third, the study did not stratify patients based on the degree of hepatic steatosis, which may have influenced elastography measurements.

Future Directions

Future research should aim to validate these findings in community-based settings, particularly in rural areas where access to advanced imaging may be limited. Integration of non-invasive serum fibrosis markers with elastography could enhance diagnostic precision. Longitudinal studies examining the predictive value of elastography measurements for liver-related outcomes, such as decompensation and hepatocellular carcinoma, would also provide valuable clinical insights.

Conclusion

In conclusion, both TE and 2D-SWE demonstrate high diagnostic accuracy for assessing liver fibrosis in Pakistani patients. 2D-SWE offers superior performance for early-stage fibrosis and in patients with obesity, while both modalities are reliable for advanced fibrosis and cirrhosis. These findings support the adoption of elastography in routine hepatology practice in Pakistan, contributing to early diagnosis, risk stratification, and improved management of chronic liver disease.

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