ROLE OF MAGNETIC RESONANCE ELASTOGRAPHY IN THE DIAGNOSIS AND STAGING OF LIVER FIBROSIS: A RETROSPECTIVE STUDY

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Abstract
Background:
Liver fibrosis is a progressive pathological condition resulting from chronic liver injury caused by various etiologies such as non-alcoholic fatty liver disease (NAFLD), chronic viral hepatitis, alcohol-related liver disease, and metabolic disorders. Continuous hepatic injury leads to excessive deposition of extracellular matrix components, ultimately resulting in architectural distortion of the liver and progression to cirrhosis. Early detection and accurate staging of liver fibrosis are essential for appropriate clinical management and prevention of disease progression. Although liver biopsy remains the traditional gold standard for fibrosis assessment, it is invasive and associated with potential complications and sampling variability. Magnetic Resonance Elastography (MRE) has emerged as a promising non-invasive imaging technique that quantitatively measures liver stiffness and enables reliable assessment of hepatic fibrosis.
Objective:
The aim of the present study was to evaluate the diagnostic performance and clinical utility of Magnetic Resonance Elastography in the non-invasive detection and staging of liver fibrosis in patients with suspected chronic liver disease.
Methods:
This prospective observational study included 80 patients with clinical suspicion of chronic liver disease who underwent Magnetic Resonance Elastography as part of a standardised MRI protocol. Patients were referred based on abnormal liver function tests, ultrasound findings suggestive of fatty liver or chronic liver disease, or the presence of risk factors such as NAFLD, viral hepatitis, alcohol consumption, or metabolic syndrome. Quantitative liver stiffness measurements were obtained in kilopascals (kPa) using elastograms generated from MRE. Fibrosis staging was determined according to established liver stiffness thresholds corresponding to the METAVIR scoring system (F0–F4). Demographic characteristics, clinical indications, liver stiffness values, and fibrosis stages were analysed using descriptive statistical methods.
Results:
Magnetic Resonance Elastography was successfully performed in all patients, resulting in a technical success rate of 100%. The mean age of the study population was 46.8 ± 12.4 years, with the highest proportion of patients in the 41–50-year age group. Male patients constituted 60% of the study population, while females accounted for 40%. Liver stiffness values ranged from <2.5 kPa to >5.5 kPa, with a mean value of 4.12 ± 1.68 kPa. Moderate fibrosis (F2) was the most frequently observed stage (25%), followed by mild fibrosis (F1, 22.5%) and advanced fibrosis (F3, 20%). Cirrhosis (F4) was identified in 15% of patients. Overall, 60% of patients demonstrated clinically significant fibrosis (≥F2). A progressive increase in mean liver stiffness values was observed across fibrosis stages, ranging from 2.1 ± 0.3 kPa in F0 to 6.8 ± 0.9 kPa in F4, indicating a strong correlation between liver stiffness and fibrosis severity. Liver stiffness measurements also showed a positive association with the clinical severity of liver disease. Repeated measurements demonstrated high reproducibility with variability of less than 5%.

Conclusion:
Magnetic Resonance Elastography is a reliable, reproducible, and non-invasive imaging technique for the assessment and staging of liver fibrosis. The strong correlation between liver stiffness measurements and fibrosis severity highlights the diagnostic accuracy of MRE in evaluating chronic liver disease. MRE may serve as an effective alternative to liver biopsy for fibrosis assessment and offers significant potential for early detection, disease monitoring, and risk stratification in patients with liver disease.

Keywords:
Magnetic Resonance Elastography; Liver Fibrosis; Chronic Liver Disease; Liver Stiffness Measurement; Non-invasive Imaging; METAVIR Score.

Introduction

Chronic liver disease represents a significant global health challenge and is associated with progressive hepatic injury that may ultimately lead to liver fibrosis, cirrhosis, and hepatocellular carcinoma. Liver fibrosis is a pathological process characterised by excessive accumulation of extracellular matrix (ECM) proteins within the liver parenchyma, resulting in structural distortion of the hepatic architecture and impairment of liver function (Bataller & Brenner, 2005; Friedman, 2008). The fibrotic process occurs as a response to repeated or persistent liver injury caused by various etiological factors such as chronic viral hepatitis, alcohol abuse, autoimmune liver diseases, metabolic disorders, and non-alcoholic fatty liver disease (Schuppan & Afdhal, 2008; Asrani et al., 2019).

At the cellular level, liver fibrosis develops through complex interactions between hepatocytes, inflammatory cells, and hepatic stellate cells. Continuous hepatocellular injury stimulates inflammatory responses and activates hepatic stellate cells, which transform into myofibroblast-like cells capable of producing large amounts of collagen and other ECM components (Friedman, 2008; Tacke & Trautwein, 2015). Excessive deposition of collagen fibres disrupts the normal sinusoidal architecture of the liver and increases intrahepatic vascular resistance, eventually leading to portal hypertension and hepatic dysfunction (Pinzani & Macias-Barragan, 2010).

Globally, chronic liver diseases contribute significantly to morbidity and mortality. According to recent epidemiological reports, liver disease accounts for more than 1.5 million deaths annually worldwide (Asrani et al., 2019). Among the various etiological factors, non-alcoholic fatty liver disease (NAFLD) has emerged as the most common cause of chronic liver disease in many regions due to the increasing prevalence of obesity, insulin resistance, and type 2 diabetes mellitus (Younossi et al., 2018). NAFLD affects approximately one-quarter of the global population and represents a major public health concern (Younossi et al., 2016). The disease spectrum ranges from simple hepatic steatosis to non-alcoholic steatohepatitis (NASH), which may progress to advanced fibrosis, cirrhosis, and hepatocellular carcinoma (Chalasani et al., 2018).

One of the major clinical challenges in managing liver fibrosis is that the disease often progresses silently during its early stages. Patients with early fibrosis are frequently asymptomatic, and clinical signs usually appear only when significant structural changes have occurred within the liver (Schuppan & Kim, 2013). As a result, many individuals are diagnosed at advanced stages of liver disease when therapeutic interventions are less effective. However, studies have shown that liver fibrosis is potentially reversible if detected early and if the underlying cause of liver injury is effectively treated (Bataller & Brenner, 2005). Therefore, early detection and accurate staging of liver fibrosis are essential for guiding treatment strategies and improving long-term clinical outcomes.

Historically, liver biopsy has been regarded as the gold standard method for assessing liver fibrosis because it allows direct histological examination of hepatic tissue (Bravo et al., 2001). Histopathological evaluation using scoring systems such as the METAVIR classification enables clinicians to stage fibrosis severity from F0 (no fibrosis) to F4 (cirrhosis) (Bedossa & Poynard, 1996). Despite its diagnostic value, liver biopsy has several important limitations. The procedure is invasive and may lead to complications such as bleeding, infection, and pain (Rockey et al., 2009). Additionally, biopsy samples represent only a small portion of the liver, which can lead to sampling errors due to the heterogeneous distribution of fibrosis throughout the liver (Regev et al., 2002). Inter-observer variability in histopathological interpretation may also affect diagnostic accuracy and reproducibility (Bedossa et al., 2003).

Because of these limitations, considerable research has focused on developing non-invasive methods for evaluating liver fibrosis. Imaging techniques such as ultrasonography, computed tomography (CT), and conventional magnetic resonance imaging (MRI) are widely used to detect morphological changes associated with advanced liver disease (Taouli et al., 2009). However, these techniques have limited sensitivity for detecting early fibrosis because structural alterations become visible only after significant tissue damage has occurred (Singh et al., 2016).

In recent years, elastography-based imaging techniques have gained considerable attention for the non-invasive assessment of liver fibrosis. Elastography measures tissue stiffness, which increases as fibrosis progresses due to excessive collagen deposition and architectural remodeling (Barr et al., 2015). Ultrasound-based elastography methods, such as transient elastography (FibroScan) and shear wave elastography, are widely used in clinical practice to measure liver stiffness (Castera et al., 2015). Although these techniques provide valuable information, their diagnostic performance can be influenced by several factors, including obesity, ascites, and operator dependency (Ferraioli et al., 2014).

Magnetic Resonance Elastography (MRE) has emerged as one of the most advanced non-invasive imaging techniques for evaluating liver fibrosis. MRE combines conventional MRI with mechanical wave imaging to assess tissue stiffness by measuring the propagation of shear waves through liver tissue (Ehman et al., 2013). During the examination, low-frequency mechanical vibrations are transmitted into the liver through an external driver placed on the patient’s abdomen. These vibrations generate shear waves that travel through the liver parenchyma and are detected using specialised MRI sequences (Venkatesh et al., 2013).

The captured wave data are processed using mathematical algorithms to produce elastograms, colour-coded maps of tissue stiffness across the liver. Fibrotic tissue exhibits increased stiffness compared with normal liver tissue, allowing MRE to quantify fibrosis severity using liver stiffness measurements expressed in kilopascals (kPa) (Yin et al., 2007). Numerous clinical studies have demonstrated that MRE provides excellent diagnostic accuracy for detecting significant fibrosis and cirrhosis, often outperforming ultrasound-based elastography methods (Singh et al., 2016).

One of the key advantages of MRE is its ability to evaluate a large portion of the liver parenchyma, thereby reducing sampling variability and improving diagnostic reliability (Venkatesh et al., 2014). Additionally, MRE is less affected by patient factors such as obesity and ascites, which commonly limit the accuracy of ultrasound-based elastography techniques (Huwart et al., 2008). This makes MRE particularly valuable for evaluating patients with metabolic syndrome and NAFLD.

Another significant advantage of MRE is its integration into routine MRI examinations, enabling simultaneous assessment of liver morphology, steatosis, iron overload, and focal liver lesions (Taouli & Ehman, 2012). This multiparametric capability enhances MRI's diagnostic value and provides a comprehensive evaluation of liver disease in a single imaging session.

In addition to its diagnostic role, Magnetic Resonance Elastography has shown considerable potential for monitoring disease progression and evaluating treatment response in patients with chronic liver disease (Chen et al., 2011). Serial measurements of liver stiffness using MRE can provide valuable insights into fibrosis regression or progression following therapeutic interventions.

Given its high diagnostic accuracy, reproducibility, and non-invasive nature, Magnetic Resonance Elastography is increasingly recognised as a promising alternative to liver biopsy for assessing liver fibrosis. The present study aims to evaluate the diagnostic performance of MRI elastography in detecting and staging liver fibrosis in patients with suspected chronic liver disease and to explore its potential role as a reliable non-invasive imaging modality in clinical practice.

Objectives of the Review

The present review aims to examine and synthesise existing scientific evidence regarding the role of Magnetic Resonance Elastography (MRE) in the evaluation of liver fibrosis. Liver fibrosis is a progressive pathological condition associated with chronic liver diseases, and accurate assessment of fibrosis severity is essential for guiding treatment decisions and monitoring disease progression. Although liver biopsy has traditionally been considered the gold standard for fibrosis staging, its invasive nature, associated complications, and sampling limitations have encouraged the development of reliable non-invasive diagnostic alternatives. In this context, Magnetic Resonance Elastography has emerged as an advanced imaging technique capable of quantitatively assessing liver stiffness and detecting fibrotic changes in hepatic tissue.

The primary objective of this review is to critically analyse the available literature on the diagnostic performance and clinical utility of Magnetic Resonance Elastography in detecting and staging liver fibrosis in patients with chronic liver disease. By reviewing current research findings, this study aims to provide a comprehensive overview of MRE's role in the non-invasive evaluation of hepatic fibrosis and its potential for routine clinical practice.

Another important objective of this review is to evaluate the accuracy of MRE relative to other non-invasive diagnostic techniques, such as transient elastography, shear wave elastography, and conventional imaging modalities, including ultrasound, computed tomography, and standard magnetic resonance imaging. Understanding the comparative advantages and limitations of these imaging methods is essential for determining the most appropriate diagnostic approach for liver fibrosis assessment.

This review also aims to explore the underlying principles, technological developments, and methodological aspects of Magnetic Resonance Elastography that contribute to its effectiveness in measuring liver stiffness. Advances in MRI technology, including improved imaging sequences and data processing algorithms, have enhanced the reliability and reproducibility of MRE measurements. Examining these technological developments provides valuable insight into how MRE has evolved into a powerful tool for evaluating liver disease.

Furthermore, the review aims to assess the clinical implications of MRE use in the management of chronic liver disease. Accurate staging of fibrosis is critical for predicting disease progression, identifying patients at risk of developing cirrhosis, and determining appropriate therapeutic strategies. Therefore, understanding how MRE can assist clinicians in early diagnosis, risk stratification, and monitoring of treatment response is an important component of this study.

In addition, this review aims to identify current research gaps and limitations in Magnetic Resonance Elastography. While numerous studies have demonstrated the high diagnostic accuracy of MRE, challenges such as variability in cut-off values, differences in imaging protocols, and limited availability in certain healthcare settings remain areas of ongoing investigation. Recognising these limitations will help guide future research and improve the clinical implementation of this imaging modality.

Finally, the review aims to highlight the potential role of Magnetic Resonance Elastography as a non-invasive alternative to liver biopsy for assessing liver fibrosis. By integrating findings from multiple clinical studies, this review will provide a comprehensive understanding of the diagnostic value, advantages, and prospects of MRE in the evaluation of liver fibrosis.

Overall, the objectives of this review are to analyse current scientific evidence, evaluate the diagnostic performance of Magnetic Resonance Elastography, and explore its clinical applications in the detection and staging of liver fibrosis. Through this comprehensive assessment, the review seeks to contribute to the growing body of knowledge supporting the use of non-invasive imaging techniques for the management of chronic liver disease.

Methods

Study Design and Setting

The present study was a prospective observational study evaluating the diagnostic utility of Magnetic Resonance Elastography (MRE) for detecting and staging liver fibrosis in patients with suspected chronic liver disease. The study was conducted at the Department of Radiology and Imaging Technology, Vivekananda Global University (VGU), Jaipur, Rajasthan, India. The study was conducted over 12 months, from April 2025 to March 2026, during which eligible patients referred for liver MRI elastography were retrospectively enrolled.

Study Population and Sample Size

A total of 80 patients with clinical suspicion of chronic liver disease were included in the study. Patients were referred for Magnetic Resonance Elastography based on clinical findings, abnormal liver function tests, ultrasound findings suggestive of fatty liver or chronic liver disease, or the presence of risk factors such as viral hepatitis, alcohol consumption, metabolic syndrome, or diabetes mellitus.

Inclusion Criteria

Patients were included in the study based on the following criteria:

1. Adult patients aged 18 to 70 years.
2. Patients with clinical suspicion of chronic liver disease referred for MRI elastography.
3. Patients capable of undergoing MRI examination safely.
4. Patients who provided informed consent for participation in the study.

Exclusion Criteria

The following patients were excluded from the study:

1. Patients with contraindications to MRI, such as pacemakers, metallic implants, or cochlear implants.
2. Pregnant women, due to potential safety concerns associated with MRI.
3. Patients suffering from severe claustrophobia are prevented from undergoing MRI examination.
4. Patients with incomplete imaging data or poor-quality elastograms.

MRI Elastography Procedure

All patients underwent Magnetic Resonance Elastography using a standardised MRI protocol. During the procedure, patients were positioned supine in the MRI scanner. A passive acoustic driver was placed over the right upper abdomen, corresponding to the liver region. The driver transmitted low-frequency mechanical vibrations (approximately 50–60 Hz) through the abdominal wall into the liver tissue.

These mechanical vibrations generated shear waves that propagated through the liver parenchyma. Specialised MRI pulse sequences synchronised with the mechanical vibrations were used to capture the propagation of these waves. The resulting wave images were processed using inversion algorithms to generate elastograms, colour-coded maps of tissue stiffness across the liver.

Liver stiffness measurements were obtained in kilopascals (kPa) from regions of interest (ROI) placed within the liver parenchyma while avoiding large blood vessels, bile ducts, and areas of motion artefacts. The stiffness values obtained from elastograms were used as an indirect measure of liver fibrosis severity.

Fibrosis Staging

Liver stiffness values obtained from Magnetic Resonance Elastography were interpreted using previously validated cut-off values corresponding to the METAVIR fibrosis staging system, which classifies fibrosis into the following stages:

- **F0:** No fibrosis
- **F1:** Mild fibrosis
- **F2:** Moderate fibrosis
- **F3:** Advanced fibrosis
- **F4:** Cirrhosis

These stiffness values allowed non-invasive estimation of fibrosis severity in each patient.

Data Collection

For each patient, demographic and clinical information was collected using a structured case proforma. The recorded data included:

- Patient age and gender
- Clinical history and risk factors for liver disease
- Laboratory investigations, including liver function tests and viral markers
- MRI elastography findings and liver stiffness values
- Fibrosis stage based on MRE measurements

Statistical Analysis

The collected data were analysed using descriptive statistical methods. Demographic characteristics such as age and gender were summarised using means, standard deviations, and percentage distributions. Liver stiffness measurements were analysed to evaluate their distribution across different fibrosis stages.

The relationship between liver stiffness values and fibrosis severity was assessed to determine the diagnostic performance of Magnetic Resonance Elastography in staging liver fibrosis.

Ethical Considerations

The study was conducted in accordance with ethical principles for medical research involving human subjects. All participants provided informed consent prior to undergoing MRI elastography, and patient confidentiality was maintained throughout the study.

Results

1. Overview of Study Population

This prospective observational study was conducted to evaluate the role of Magnetic Resonance Elastography (MRE) in the non-invasive detection and staging of liver fibrosis in patients with suspected chronic liver disease. A total of 80 patients who met the predefined inclusion and exclusion criteria were enrolled in the study. All patients were referred for MRI elastography based on clinical suspicion of chronic liver disease, abnormal liver function tests (LFTs), ultrasonographic evidence of fatty liver or chronic liver disease, or the presence of risk factors such as viral hepatitis infection, alcohol consumption, metabolic syndrome, and other metabolic disorders.

All enrolled patients underwent a standardised MRI protocol that included MRE sequences for quantitative assessment of liver stiffness. Liver stiffness values were measured in kilopascals (kPa) using elastograms generated from shear wave propagation within the hepatic parenchyma. Regions of interest (ROIs) were carefully placed in the right hepatic lobe while avoiding large vessels, bile ducts, and motion artefacts to ensure measurement accuracy and reproducibility.

Importantly, high-quality elastograms were successfully obtained in all 80 patients, resulting in a technical success rate of 100%. No examinations were excluded due to motion artefacts, technical failure, claustrophobia, or inadequate elastogram acquisition. These findings demonstrate the high feasibility, reliability, and robustness of MRE as a diagnostic modality for liver fibrosis assessment in routine clinical practice.

The study cohort represented a heterogeneous population with various etiologies of chronic liver disease, thereby enhancing the external validity and clinical applicability of the findings. Patients underwent initial clinical assessment, laboratory investigations, and ultrasound imaging before being referred for MRI elastography, ensuring appropriate selection of individuals with suspected hepatic fibrosis.

For analytical purposes, collected data were categorized into four major domains:

1. Demographic characteristics (age and gender)
2. Clinical indications for MRI elastography
3. Liver stiffness measurements (LSM)
4. Fibrosis staging based on METAVIR correlation

This structured data classification enabled systematic evaluation of the relationship between liver stiffness values and fibrosis severity.

Table 1: Summary of Study Population Characteristics (n = 80)

Parameter	Description
Study Design	Retrospective Observational Study
Total Patients Enrolled	80
Patients Successfully Undergoing MRE	80 (100%)
Technical Failures	0
Adequate Elastograms Obtained	100%
Motion Artefact Exclusions	None
Data Analysis Categories	Demographics, Clinical Indications, LSM, Fibrosis Staging

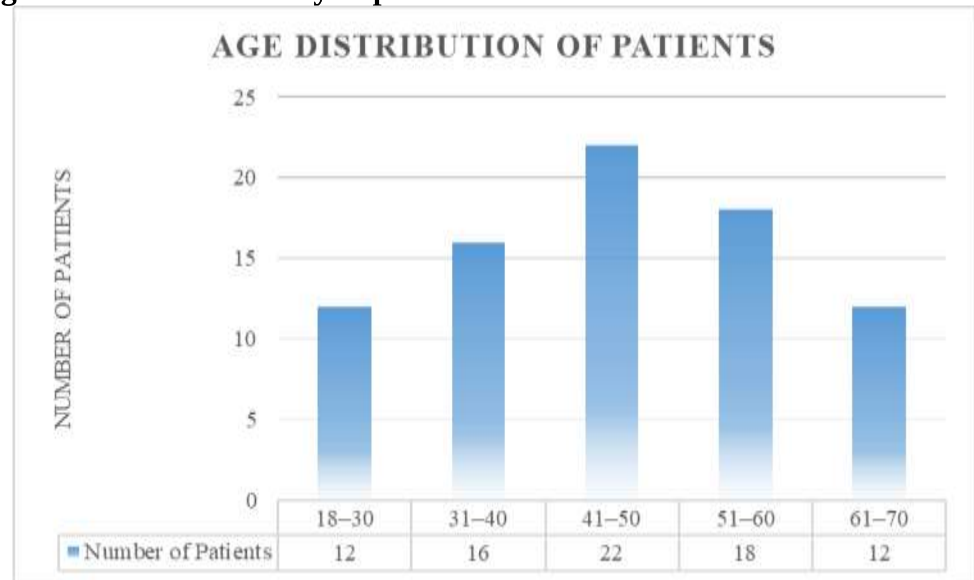
2. Demographic Characteristics of the Study Population

Age Distribution

Age is an important demographic factor influencing the development and progression of chronic liver disease and hepatic fibrosis. In the present study, patients ranged in age from 18 to 70 years, reflecting a broad adult population undergoing evaluation for liver fibrosis.

The mean age of the study population was 46.8 ± 12.4 years, indicating that most patients were middle-aged. This age distribution corresponds with the natural history of chronic liver disease, where prolonged exposure to risk factors such as metabolic disorders, alcohol consumption, and viral infections leads to progressive hepatic injury and fibrosis over several years.

Figure 1: Age Distribution of Study Population



The highest proportion of patients (27.5%) belonged to the 41–50-year age group, followed by the 51–60-year age group (22.5%). This pattern suggests that liver fibrosis is commonly detected during middle adulthood when cumulative hepatic injury becomes clinically significant.

A smaller proportion of patients (15%) were younger adults aged 18–30 years, which may reflect early-onset liver disease associated with metabolic disorders, obesity, and lifestyle-related factors.

Gender Distribution

Gender distribution analysis revealed that male patients accounted for 60% of the study population, while female patients accounted for 40%.

Table 1: Gender Distribution of Study Population

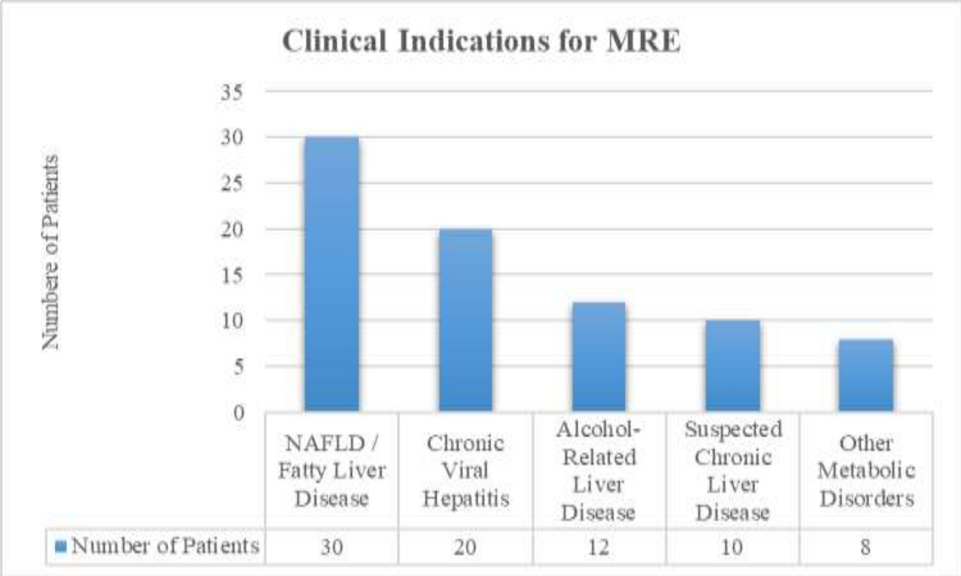
Gender	Number of Patients	Percentage
Male	48	60%
Female	32	40%
Total	**80**	**100%**

The predominance of male patients in the study cohort may be attributed to greater exposure to lifestyle-related risk factors such as alcohol consumption and metabolic syndrome. However, the substantial representation of female patients highlights the increasing prevalence of non-alcoholic fatty liver disease (NAFLD) and metabolic liver disorders among women, particularly in association with obesity and insulin resistance.

3. Clinical Indications for MRI Elastography

The clinical indications for MRI elastography were analysed to determine the underlying etiologies of suspected chronic liver disease in the study population.

Figure 2: Clinical Indications for MRE



The most common indication for MRI elastography was NAFLD (37.5%), reflecting the increasing global burden of metabolic liver diseases driven by rising rates of obesity, diabetes, and sedentary lifestyle.

Chronic viral hepatitis accounted for 25% of cases, emphasising the ongoing significance of infectious causes of liver fibrosis in many regions.

Alcohol-related liver disease represented 15% of the study population, highlighting the continued impact of long-term alcohol consumption on hepatic fibrosis development.

4. Liver Stiffness Measurement Findings

Quantitative liver stiffness measurements (LSM) were obtained for all patients using Magnetic Resonance Elastography (MRE). Liver stiffness values ranged from <2.5 kPa to >5.5 kPa, reflecting a progressive increase in tissue stiffness corresponding to advancing stages of liver fibrosis. The stiffness values derived from elastograms were used as a non-invasive surrogate marker for hepatic fibrosis severity.

Liver stiffness values were categorised into different fibrosis stages according to established MRE thresholds corresponding to the METAVIR fibrosis scoring system. The distribution of liver stiffness values across the study population is presented in Table 2.

Table 2: Distribution of Liver Stiffness Values

LSM Range (kPa)	Fibrosis Interpretation	Patients	Percentage
<2.5	F0 (Normal)	14	17.5%
2.5–3.5	F1 (Mild Fibrosis)	18	22.5%
3.6–4.5	F2 (Significant Fibrosis)	20	25%
4.6–5.5	F3 (Advanced Fibrosis)	16	20%
>5.5	F4 (Cirrhosis)	12	15%

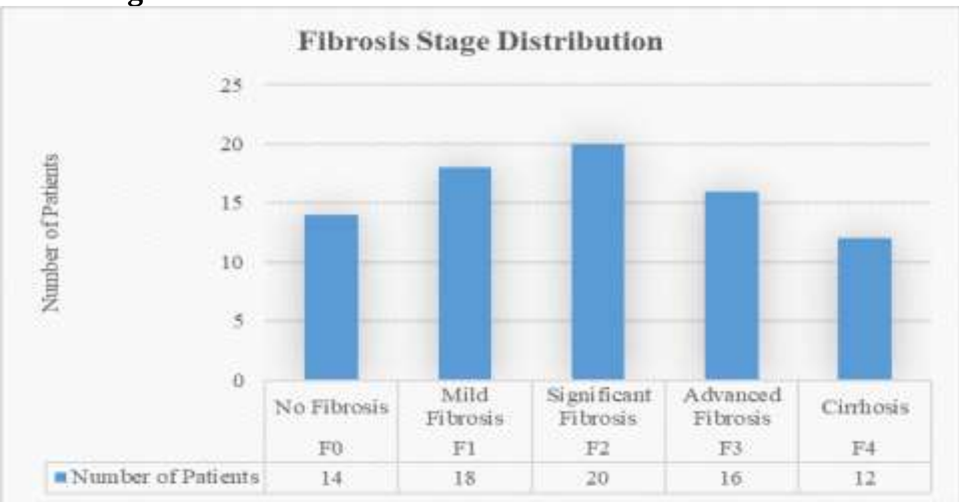
The mean liver stiffness value for the entire study population was 4.12 ± 1.68 kPa, indicating a moderate overall fibrosis burden.

Among the evaluated patients, moderate fibrosis (F2) accounted for the largest proportion, at 25% of the study population. This finding suggests that a considerable number of patients presented with clinically significant fibrosis, which typically requires close monitoring and early therapeutic intervention to prevent progression to cirrhosis.
Patients with mild fibrosis (F1) constituted 22.5% of cases, reflecting early fibrotic changes that may still be reversible with appropriate medical management and lifestyle modifications. Meanwhile, advanced fibrosis (F3) and cirrhosis (F4) together accounted for 35% of the study population, highlighting the presence of a substantial subset of patients with advanced liver disease.
The progressive increase in liver stiffness across fibrosis stages reflects the pathophysiological process of collagen deposition, extracellular matrix accumulation, and hepatic tissue architectural distortion, which collectively result in increased mechanical stiffness of the liver parenchyma.

5. Fibrosis Stage Distribution Based on MRE

Fibrosis staging in the present study was performed using the METAVIR classification system, which categorises hepatic fibrosis into five stages ranging from F0 (no fibrosis) to F4 (cirrhosis). MRE-derived liver stiffness values were used to assign patients to their respective fibrosis stages based on established diagnostic thresholds.

Figure 3: Fibrosis Stage Distribution



The analysis revealed that significant fibrosis (F2) was the most frequently observed stage, followed by mild fibrosis (F1) and advanced fibrosis (F3).
Importantly, 48 patients (60%) demonstrated clinically significant fibrosis (≥F2). This finding indicates a substantial burden of progressive liver disease among patients undergoing MRI elastography for fibrosis evaluation.
Patients with fibrosis stage F3 or F4 (advanced fibrosis and cirrhosis) comprised 35% of the study population, representing individuals at higher risk of complications such as portal hypertension, hepatic decompensation, and hepatocellular carcinoma.
These findings highlight the importance of early detection and monitoring of liver fibrosis using non-invasive imaging techniques such as MRE, particularly in patients with metabolic risk factors or chronic liver disease.

6. Mean Liver Stiffness According to Fibrosis Stage

Further analysis was performed to determine the mean liver stiffness values for each fibrosis stage. The results demonstrated a progressive increase in liver stiffness with advancing fibrosis severity.

Table 3: Mean Liver Stiffness According to Fibrosis Stage

Fibrosis Stage	Mean LSM (kPa)	Interpretation
F0	2.1 ± 0.3	Normal
F1	3.0 ± 0.4	Mild fibrosis
F2	4.1 ± 0.5	Significant fibrosis
F3	5.2 ± 0.6	Advanced fibrosis
F4	6.8 ± 0.9	Cirrhosis

The lowest mean liver stiffness values were observed in patients with no fibrosis (F0), reflecting normal hepatic elasticity.
Patients with mild fibrosis (F1) showed slightly elevated stiffness values, suggesting early hepatic parenchymal fibrosis.
A marked increase in stiffness was observed in patients with significant fibrosis (F2), which represents the stage at which fibrosis becomes clinically relevant and may require active management.
Patients with advanced fibrosis (F3) and cirrhosis (F4) showed significantly higher stiffness values due to extensive fibrotic deposition and distortion of the normal hepatic architecture.
These findings demonstrate a clear dose–response relationship between liver stiffness and fibrosis severity, supporting the diagnostic accuracy of MRE as a quantitative imaging biomarker for fibrosis staging.

7. Correlation Between Liver Stiffness and Clinical Severity

The study also evaluated the relationship between liver stiffness measurements and the clinical severity of liver disease.

Table 4: Correlation of Clinical Severity with Liver Stiffness

Clinical Severity	Mean LSM (kPa)	Interpretation
Mild	2.8 ± 0.5	Early fibrosis
Moderate	4.3 ± 0.7	Significant fibrosis
Severe	6.5 ± 1.0	Advanced fibrosis/cirrhosis

Patients with mild clinical manifestations, such as minimal symptoms and mildly abnormal liver function tests, generally exhibited lower liver stiffness values consistent with early fibrosis.
Patients with moderate disease severity demonstrated intermediate stiffness values, consistent with clinically significant fibrosis.
The highest stiffness values were observed in patients with severe disease, including those presenting with complications such as ascites, splenomegaly, portal hypertension, and significantly abnormal liver function tests.
These findings suggest a strong correlation between quantitative liver stiffness measurements and overall disease severity, supporting the clinical value of MRE for risk stratification and disease monitoring.

8. Technical Success Rate

MRI elastography demonstrated excellent technical feasibility in the present study.

Table 5: Technical Feasibility of MRE

Parameter	Outcome
Total Patients Scanned	80
Successful Elastograms	80
Technical Failure	0%
Motion Artifact	Minimal
Repeat Scans Required	None

All examinations produced diagnostic-quality elastograms, resulting in a technical success rate of 100%. No patients required repeat scans, and motion artefacts were minimal.
These findings demonstrate the robustness and reliability of MRE as a diagnostic imaging technique, even in patients with varying body habitus or clinical conditions.

9. Reproducibility of MRE Measurements

The reproducibility of MRE measurements was evaluated by comparing repeated liver stiffness measurements obtained under similar imaging conditions.

Table 5.9: Reproducibility of Liver Stiffness Measurements

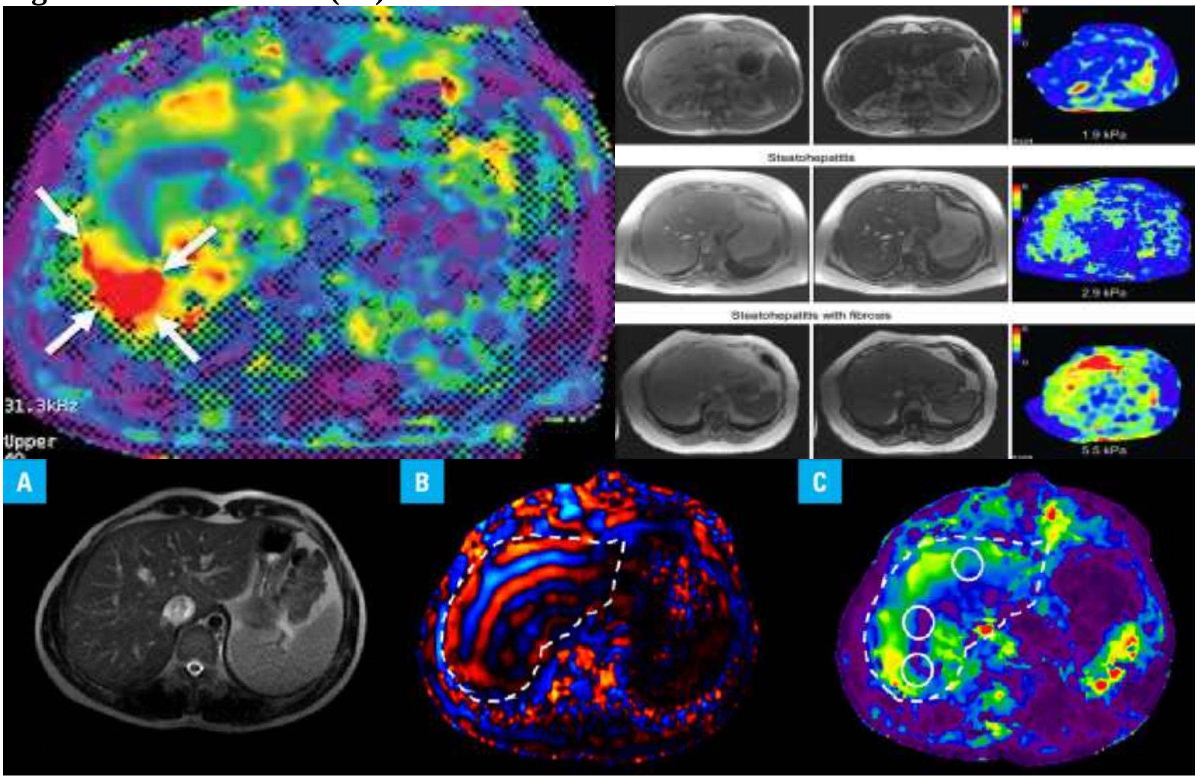
Measurement	Mean LSM	Variability
First Measurement	4.15 kPa	—
Repeat Measurement	4.08 kPa	<5%

The difference between the first and repeat measurements was less than 5%, indicating excellent reproducibility and reliability of MRE-derived stiffness values.
This minimal variability confirms that MRE provides stable and consistent quantitative measurements, making it particularly useful for longitudinal monitoring of fibrosis progression or regression during treatment.

10. MRI Elastography Imaging Findings

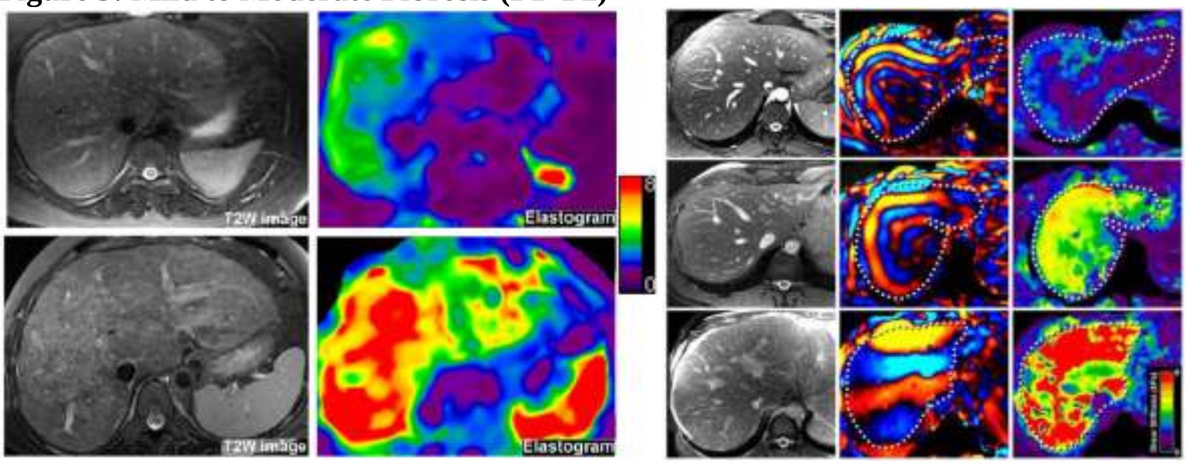
Magnetic Resonance Elastography elastograms demonstrated characteristic stiffness patterns corresponding to different stages of liver fibrosis.

Figure 4. Normal Liver (F0)



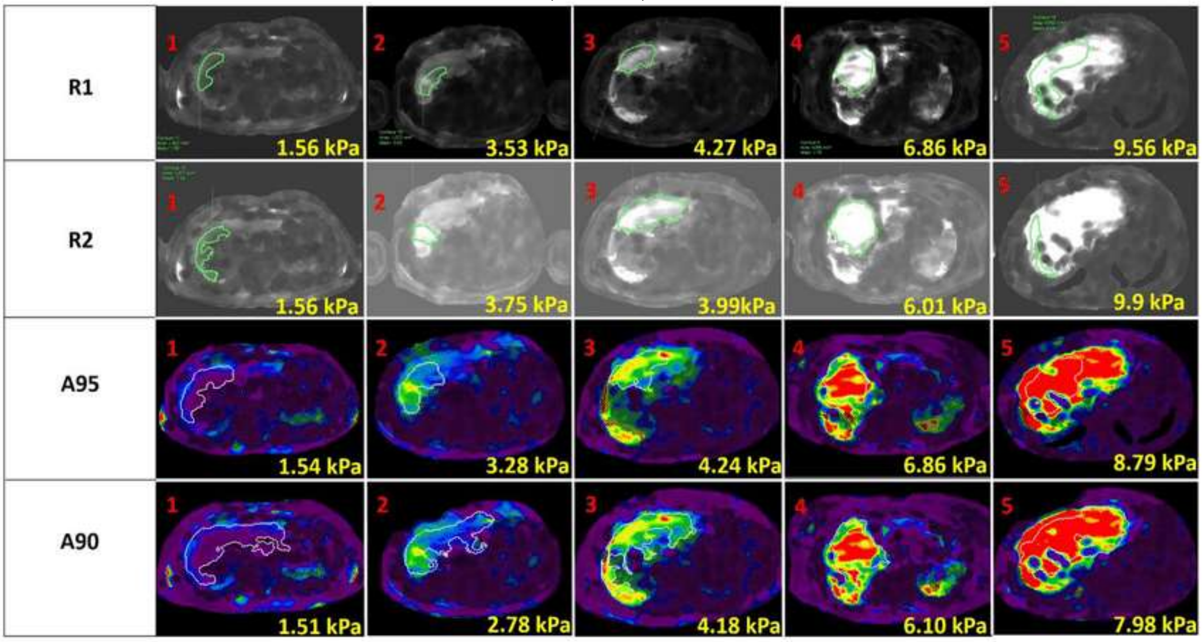
Patients without fibrosis demonstrated predominantly blue and green colour patterns, indicating low liver stiffness values consistent with normal hepatic parenchyma.

Figure 5: Mild to Moderate Fibrosis (F1–F2)



Patients with mild to moderate fibrosis showed mixed green and yellow colour patterns, representing moderately increased liver stiffness.

Figure 6: Advanced Fibrosis and Cirrhosis (F3–F4)



Advanced fibrosis and cirrhosis were characterised by predominant orange and red areas on elastograms, reflecting significantly elevated liver stiffness values.

Correlation Between Liver Stiffness and Fibrosis Severity

A strong positive relationship was observed between liver stiffness measurements and fibrosis stage. Patients with cirrhosis exhibited the highest stiffness values, whereas patients without fibrosis had the lowest values.

These findings demonstrate that Magnetic Resonance Elastography can reliably differentiate between various stages of liver fibrosis and may serve as an effective non-invasive alternative to liver biopsy for fibrosis assessment.

Discussion

The present study was conducted to evaluate the role of Magnetic Resonance Elastography (MRE) in the non-invasive detection and staging of liver fibrosis in patients with suspected chronic liver disease. The findings of this study demonstrate that MRE is a highly feasible and reliable imaging modality capable of providing quantitative liver stiffness measurements that correlate closely with fibrosis severity.

In the current study, MRE examinations were successfully performed in all patients, resulting in a technical success rate of 100%. This high success rate highlights the feasibility and practicality of incorporating MRE into routine clinical imaging protocols for liver disease evaluation. Similar findings have been reported in previous studies, where MRE demonstrated excellent technical reliability and reproducibility across different patient populations (Venkatesh et al., 2013; Singh et al., 2016). MRE's ability to generate high-quality elastograms without significant operator dependence is a major advantage over ultrasound-based elastography techniques.

The demographic characteristics of the study population showed that liver fibrosis was most detected in middle-aged individuals, particularly those aged 41-50. This observation is consistent with the natural history of chronic liver diseases, which typically develop gradually over several years following long-term exposure to risk factors such as alcohol consumption, metabolic syndrome, and viral hepatitis (Asrani et al., 2019). Previous epidemiological studies have also reported that the prevalence of liver fibrosis increases with age due to cumulative hepatic injury (Younossi et al., 2016).

The gender distribution in the present study showed a predominance of male patients (65%) over female patients (35%). This finding is consistent with several earlier studies that reported a higher prevalence of chronic liver disease among males, often attributed to lifestyle-related risk factors such as alcohol use and higher rates of metabolic disorders (Chalasani et al., 2018). In addition, hormonal and metabolic differences between genders may influence susceptibility to liver injury and the progression of fibrosis.

One of the most significant findings of this study was the clear relationship between liver stiffness values and fibrosis severity. Magnetic Resonance Elastography demonstrated progressively increasing liver stiffness values across fibrosis stages from F0 to F4. Patients with cirrhosis exhibited the highest stiffness values, whereas those without fibrosis showed the lowest stiffness values. These findings support the concept that liver stiffness is an important surrogate biomarker of fibrosis severity.

The mean liver stiffness values observed in this study were consistent with previously reported MRE-based fibrosis thresholds. Earlier investigations have demonstrated that MRE can accurately differentiate between normal liver tissue, mild fibrosis, advanced fibrosis, and cirrhosis (Yin et al., 2007; Huwart et al., 2008). Several meta-analyses have reported area under the receiver operating characteristic (AUROC) values exceeding 0.90 for detecting significant fibrosis, indicating excellent diagnostic performance of MRE (Singh et al., 2016).

The distribution of fibrosis stages in this study showed that moderate fibrosis (F2) was the most common, followed by mild fibrosis (F1) and advanced fibrosis (F3). This pattern suggests that many patients were diagnosed during intermediate stages of liver disease, highlighting the importance of non-invasive imaging methods for early detection and monitoring of fibrosis progression.

The elastographic imaging findings further supported the diagnostic capability of MRE. Elastograms demonstrated characteristic colour patterns corresponding to different levels of tissue stiffness. Normal liver tissue typically appeared as blue or green regions, indicating low stiffness values, whereas fibrotic liver tissue displayed yellow, orange, and red colour patterns corresponding to increasing stiffness levels. These visual patterns provide clinicians with a rapid and intuitive method for evaluating fibrosis severity.

Another important advantage of MRE observed in this study is its ability to evaluate a large volume of liver tissue. Unlike liver biopsy, which samples only a small portion of the liver, MRE assesses the stiffness of a substantial area of the hepatic parenchyma. This reduces the risk of sampling error and improves diagnostic accuracy, particularly in patients with heterogeneous fibrosis distribution (Venkatesh et al., 2014).

Compared with ultrasound-based elastography techniques such as transient elastography and shear wave elastography, MRE offers several additional benefits. Ultrasound elastography can be limited by patient factors such as obesity, ascites, and narrow intercostal spaces. In contrast, MRE is less affected by these factors and provides more consistent measurements across diverse patient populations (Barr et al., 2015). This makes MRE particularly valuable in patients with non-alcoholic fatty liver disease, where obesity is common.

Another advantage of MRE is its integration with conventional MRI examinations. During a single MRI session, clinicians can simultaneously assess liver stiffness, hepatic morphology, fat content, iron deposition, and focal liver lesions. This multiparametric capability enhances MRI's overall diagnostic value and enables comprehensive evaluation of liver disease.

Despite its advantages, MRE also has certain limitations that should be considered. The technique requires specialised MRI equipment and software, which may not be available in all healthcare facilities. Additionally, the cost of MRI examinations may limit widespread use in resource-limited settings. However, as MRI technology continues to advance and become more accessible, the clinical use of MRE is expected to expand.

Overall, the findings of the present study support the growing body of evidence that Magnetic Resonance Elastography is an accurate and reliable non-invasive imaging technique for assessing

liver fibrosis. By providing quantitative measurements of liver stiffness and visual elastograms of hepatic tissue, MRE has the potential to significantly reduce the need for invasive liver biopsy.
In clinical practice, MRE may play an important role not only in diagnosing liver fibrosis but also in monitoring disease progression and evaluating treatment response. Serial MRE examinations can provide valuable information about changes in liver stiffness over time, enabling clinicians to assess the effectiveness of therapeutic interventions.

Conclusion

The present study evaluated the diagnostic utility of Magnetic Resonance Elastography (MRE) for the non-invasive assessment of liver fibrosis in patients with suspected chronic liver disease. The findings of this study demonstrate that MRE is a highly reliable and feasible imaging modality capable of providing quantitative measurements of liver stiffness that correlate closely with the severity of hepatic fibrosis.
In this study, MRE examinations were successfully performed in all patients, indicating excellent technical feasibility and reproducibility. The progressive increase in liver stiffness values across fibrosis stages from F0 to F4 confirms MRE's ability to accurately differentiate among fibrosis stages. Patients with cirrhosis exhibited significantly higher stiffness values than those with mild or moderate fibrosis, highlighting the diagnostic sensitivity of this imaging technique.
Magnetic Resonance Elastography offers several advantages over traditional diagnostic approaches for liver fibrosis. Unlike liver biopsy, which is invasive and associated with potential complications such as bleeding, infection, and sampling variability, MRE provides a non-invasive, safe, and repeatable method for evaluating hepatic tissue stiffness. In addition, MRE assesses a larger portion of the liver parenchyma than biopsy, thereby reducing sampling error and improving diagnostic reliability.
Another important benefit of MRE is its integration into routine MRI examinations, enabling simultaneous evaluation of liver morphology, steatosis, iron overload, and focal hepatic lesions. This multiparametric capability enhances MRI's diagnostic value and enables comprehensive evaluation of chronic liver disease within a single imaging session.
The results of this study also indicate that Magnetic Resonance Elastography can serve as an effective tool for early detection of liver fibrosis. Early identification of hepatic fibrosis is critical, as it is potentially reversible during its initial stages if the underlying cause of liver injury is appropriately managed. Therefore, the use of MRE may improve clinical outcomes by facilitating early diagnosis and timely intervention.
Despite its advantages, certain limitations should be acknowledged. The availability of MRE may be limited in some healthcare settings due to the requirement for specialised MRI equipment and software. Additionally, further large-scale studies involving diverse patient populations are required to establish standardised liver stiffness thresholds for different etiologies of liver disease.
Overall, the findings of this study support the growing evidence that Magnetic Resonance Elastography is an accurate, reproducible, and non-invasive imaging technique for evaluating liver fibrosis. MRE has the potential to significantly reduce the reliance on invasive liver biopsy and may play an important role in the diagnosis, staging, and monitoring of chronic liver diseases in clinical practice.

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