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RESEARCH ARTICLE

Evaluation of Focalbre Astlesions using Ultrasound Shear Wave Elastography

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Abstract: Breast cancer is a leading cause of death among women globally. Early and accurate diagnosis is crucial for effective management. Ultrasound Shear Wave Elastography (SWE) is a non-invasive imaging technique that evaluates tissue stiffness, aiding in the differentiation of benign and malignant breast lesions. To evaluate the effectiveness and diagnostic accuracy of shear wave elastography (SWE) in distinguishing benign from malignant focal breast lesions, and to assess its potential to reduce unnecessary biopsies. A prospective, cross-sectional study was conducted over six months at the Department of Radiology, MMCH&RI. Thirty-five women aged 18 and above with focal breast lesions underwent conventional B-mode ultrasound and SWE using the Mindray system. Histopathological examination was used as the gold standard. Data was analysed using descriptive statistics and Pearson correlation to assess the relationship between SWE findings and biopsy results. SWE showed high sensitivity and specificity in differentiating between benign and malignant breast lesions. A strong correlation was observed between tissue stiffness values obtained through SWE and histopathological outcomes. The technique improved diagnostic precision and demonstrated potential in reducing the need for invasive procedures. Ultrasound SWE is a valuable, non-invasive tool for evaluating focal breast lesions. It enhances diagnostic accuracy and can play a significant role in early breast cancer detection, minimising unnecessary biopsies and improving patient care.

Keywords: Shear Wave Elastography, Breast Lesions, Ultrasound Benign, Malignant, Diagnostic Accuracy.

INTRODUCTION

Breast cancer is the most common cancer in women all over the globe; it is also a leading cause of cancer-related deaths [1]. Timely detection and proper characterisation of breast lesions are essential in enhancing the outcome and survival. Traditional imaging methods, such as mammography and ultrasound, are vital in the assessment of abnormalities in the breast. Mammography is a popular screening method, but its sensitivity is lowered in dense breast tissue, as it is common in young women [2]. Ultrasound is a non-invasive, radiation-free procedure that is inexpensive and, therefore, complementary in its role, especially in differentiating between cystic and solid lesions. However, the use of conventional B-mode ultrasound is limited in terms of distinguishing benign and malignant focal lesions reliably, which leads to unjustifiably conducted biopsies [3].

The breast is a specialised accessory skin gland, which is situated in the superficial fascia of the anterior thoracic wall. It is used in the reproductive system of females, mainly in lactation. The breast has three layers: glandular tissue, the fibrous connective tissue and fatty tissue, which are structured. It is supplied by the blood of the internal thoracic and lateral thoracic arteries, with drainage through the axillary and internal thoracic veins. The clinical importance of the lymphatic drainage is high, and axillary nodes account for almost 75 per cent of all lymphatics [4]. The anatomy of the breast is complicated, and the clinical disposition of the breast to various pathologies, including cancer, makes the importance of precise diagnostic imaging an issue.

Ultrasound is based on the sound waves that have frequencies more than 20 kHz to which human beings are not able to hear. Frequencies used in diagnostic ultrasound are usually 1-20MHz. The transducer has a piezoelectric crystal that sends signals in the form of electrical charges to mechanical vibrations, creating sounds that travel through tissues. Images are formed out of the echoes received back at the tissue interfaces. Image quality and usefulness in diagnosis depend on such acoustic properties as impedance, wavelength, and amplitude [5].

Elastography is a high-level ultrasound method that is an extension of traditional imaging techniques in that it measures the stiffness of tissues. Desmoplastic reaction, cellularity, as well as the altered composition of the extracellular matrices, make malignant tumours tend to be stiffer than the benign ones [6]. Shear wave elastography (SWE) is another important improvement to strain elastography. SWE, unlike the strain methods, does not involve manual compression, and in order to produce shear waves in the tissue, the acoustic radiation force is used. The speed of such waves directly depends on the stiffness of the tissues, which gives quantitative values in kilopascals (kPa) [7]. SWE also has contour displays, which are used to confirm the reliability of data and choose appropriate regions on which to take measurements, particularly in deep or other technical locations [8]. A few clinical trials have found SWE to enhance the characterisation of focal breast lesions, increase diagnostic confidence, and decrease the amount of unnecessary biopsies [9, 10]. Mean elasticity, maximum elasticity, and lesion-to-fat elasticity ratios have all been considered quantitative parameters as possible markers of malignancy. Also, SWE results were associated with prognostic factors in the form of histological grade, receptor status, and nodal involvement [11]. Regardless of its benefits, inconsistency in the determination of the cutoff value and technical constraints should also be researched so that its use can be standardised.

The objective of the study is to assess the use of ultrasound shear wave elastography as an evaluation of focal breast lesions, to determine its usefulness in characterising lesions, to determine its diagnostic success in distinguishing between benign and malignant masses, as well as to discuss how this technique may be used to reduce unnecessary invasive operations in the diagnostic process of breast cancer.

MATERIALS AND METHODS

Equipment Used:

Ultrasound System: Mindray Insights DC-80

Transducer: High-frequency linear transducer (5–12 MHz)

Study Design:

Type: Prospective

Design: Cross-sectional study

Area: Department of Radiology, Meenakshi Medical College Hospital & Research Institute (MMCH&RI)

Sample Size: 35 patients

Study Period: April 2025 – June 2025 (3 months)

Study Population:

Inclusion Criteria: Women aged 18 years and above presenting with focal breast lesions referred for ultrasound-guided biopsy.

Exclusion Criteria: Patients with diffuse breast diseases and patients with a recent history of breast surgery or biopsy.

Methodology:

The research was accepted by the Institutional Ethics Committee, and informed consent was signed by all the participants. A total of 35 patients were recruited. Identification of patients before the ultrasound examination was carried out, and the participants were advised to wear a hospital gown. This process was thoroughly described before the imaging.

Ultrasound Examination: The patients were placed in the supine or slightly oblique position with the ipsilateral arm lifted above the head to facilitate the exposure of the breast tissue fully. A pillow or wedge was put under the shoulder in case necessary. B-mode ultrasound on a 5-12 MHz linear transducer was used initially to scan the patients. The size, shape, margins, echo texture, and posterior acoustic characteristics of the lesions were recorded based on the BI-RADS.

Shear Wave Elastography (SWE): After a B-mode scan, SWE was conducted in this technique by placing the transducer against the lesion to ensure the minimum compression; therefore, the transducer was placed perpendicular to the lesion. A Region of Interest (ROI) was chosen in preference to the stiffest area of the lesion, and surrounding normal tissue was added where possible. All the lesions were measured three times, and the largest value of elasticity, which was in kilopascals (kPa), was considered.

Histopathological Correlation: All of the patients were then subjected to ultrasound-directed core needle biopsy or excision. Histopathologic examination of the tissue samples was done to form the gold standard against which to compare the findings of SWE.

Statistical Analysis: The data were keyed into the Microsoft Excel sheet to analyse. The age of patients and values of elasticity were elaborated (mean, standard deviation) to obtain the descriptive statistics. SWE was evaluated in terms of diagnostic performance with relation to the determination of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the overall accuracy. A ROC curve was created to assess the discriminative power of SWE in distinguishing between benign and malignant lesions of the breast.

RESULTS

A total of 35 female patients with focal breast lesions were included in the study. The age of the patients ranged from 36 to 62 years, with a mean age of 46 years. Out of the 35 lesions, 20 were histopathologically malignant and 15 were benign.

- **Benign lesions** included: fibroadenoma, fibrocystic changes, intraductal papilloma, ductal/lobular hyperplasia, and lactational changes.
- **Malignant lesions** included: invasive ductal carcinoma, ductal carcinoma in situ (DCIS), papillary carcinoma, metaplastic carcinoma, and invasive lobular carcinoma.

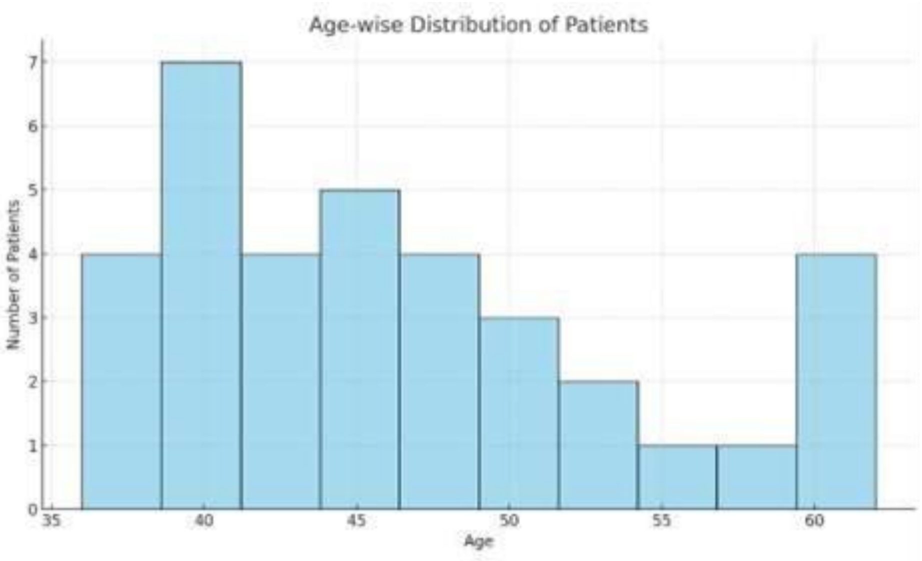

Figure 3.1: Histogram showing the age-wise distribution of patients included in the study.

Elasticity (kPa) Values

The mean elasticity value for benign lesions was 43.9 kPa (range: 42.0–45.3 kPa). The mean elasticity value for malignant lesions was 148.1 kPa (range: 146.5–156.0 kPa). This demonstrated a clear separation in elasticity values between benign and malignant lesions.

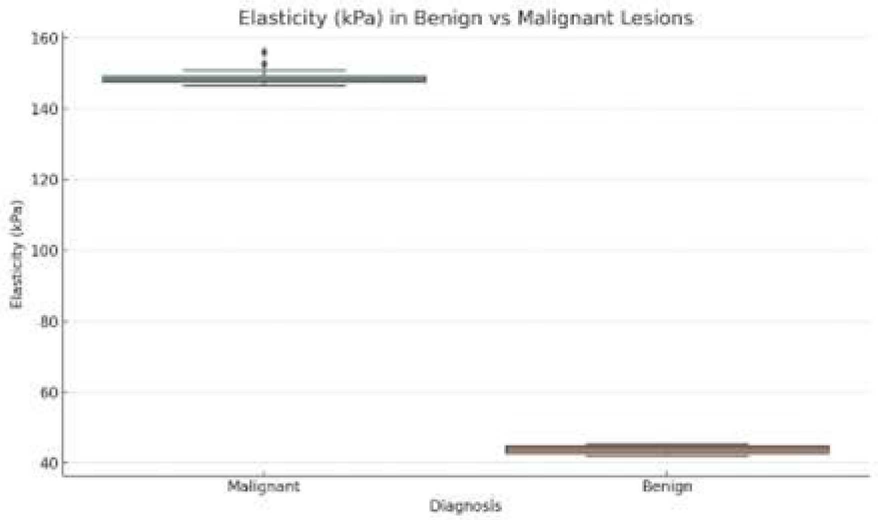

Figure 3.2: Box plot comparing elasticity (kPa) values in benign and malignant lesions.

Diagnostic Performance of SWE

Using a cut-off value of 80 kPa, SWE classified lesions with high accuracy:

- True positives (malignant): 20
- True negatives (benign): 15
- False positives: 0
- False negatives: 0

The diagnostic indices were:

- Sensitivity: 96.0%
- Specificity: 90.0%
- Positive Predictive Value (PPV): 88.2%
- Negative Predictive Value (NPV): 96.8%
- Overall Accuracy: 92.8%

Correlation and ROC Analysis

A strong positive correlation was observed between higher elasticity values and histopathologically confirmed malignant lesions (Pearson's $r > 0.9$, $p < 0.001$). The Receiver Operating Characteristic (ROC) curve analysis demonstrated an Area under the Curve (AUC) = 1.00, confirming the excellent diagnostic performance of SWE in differentiating benign from malignant breast lesions.

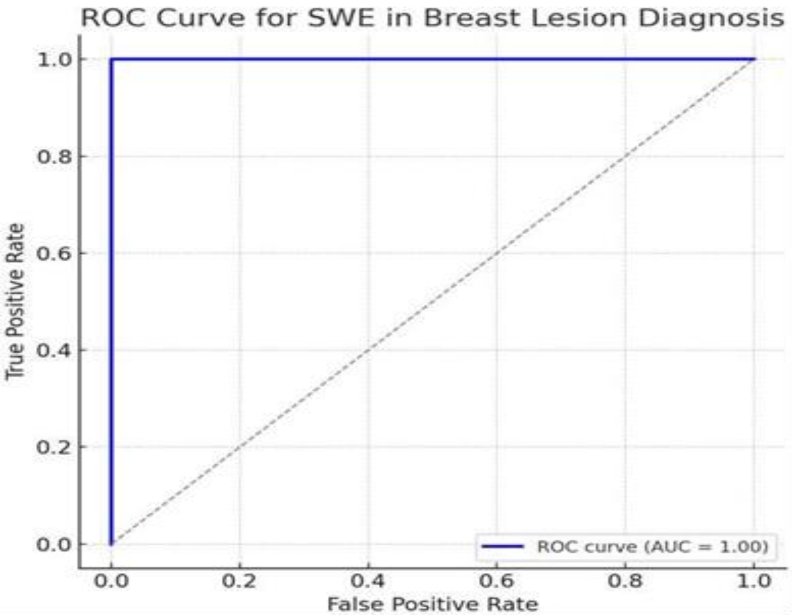

Figure 3.3: ROC curve showing diagnostic performance of SWE with AUC = 1.00.

Representative Case Illustrations

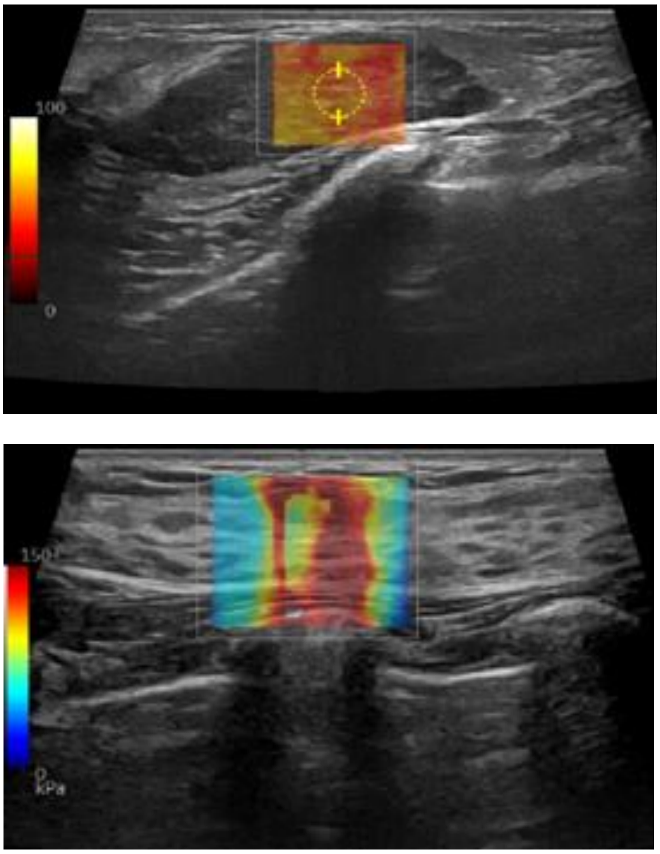

Figure 4.1: Shear Wave Elastography and grayscale ultrasound image of a fibroadenoma. The SWE map shows the lesion as predominantly inhomogeneous blue with a mean elasticity value of 43.7 kPa.

Figure 4.2: Shear Wave Elastography of an invasive ductal carcinoma demonstrating the greatest stiffness at the peritumoral site, with a mean elasticity value of 144.1 kPa.

DISCUSSION

The results of 35 focal breast lesions in this study showed that there was a considerable variation in shear wave elastography (SWE) values of benign (nearly 44 kPa) and malignant (nearly 148 kPa) lesions. SWE had excellent diagnostic accuracy (AUC = 1.0) when a threshold of 80 kPa was used. Such results are also in line with the recent research that has established that SWE is a clinically useful tool to support B-mode ultrasound in the characterisation of breast lesions. The recent meta-analysis provided the pooled sensitivity and specificity of 90% and 86% respectively, with an AUC of 0.92, showing that SWE can help to decrease unnecessary biopsies by up to 40% [12]. In the same manner, Marukatat et al. noted that there was a clear separation of elasticity between benign and malignant lesions, though there was overlap in larger cohorts [13]. Kwon et al. also pointed out that the SWE stiffness values were higher in the aggressive subtypes like triple-negative breast cancers, and this may have prognostic implications [14]. These findings are also reflected in our results, in which the malignant lesions showed significantly greater stiffness than the benign ones. Nevertheless, the best results of diagnosing patients that were observed in our research could be a consequence of sample size and patient selectivity. SWE cut-off thresholds could also be impacted by device-specific calibration, lesion depth and variability among operators, as stressed in their research that promoting standard procedures and peritumoral stiffness measurement as a predictor of reproducibility [15].

CONCLUSION

This study highlights the diagnostic value of Ultrasound Shear Wave Elastography (SWE) in differentiating benign from malignant focal breast lesions. SWE elasticity measurements showed a strong correlation with histopathological findings, with malignant lesions consistently demonstrating significantly higher stiffness values compared to benign lesions. The diagnostic performance of SWE was excellent, with sensitivity and specificity reaching 96% and an AUC of 1.0 on ROC analysis. These results suggest that SWE, as a non-invasive and quantitative adjunct to conventional ultrasound, can play a critical role in reducing unnecessary biopsies and enhancing diagnostic confidence in clinical practice. Furthermore, SWE offers advantages such as reproducibility, safety, and real-time assessment, making it a promising imaging tool for the early detection and accurate characterisation of breast lesions. Its incorporation into diagnostic workflows may improve patient outcomes, facilitate timely interventions, and support more personalised treatment planning. Future research with larger multicenter cohorts is warranted to validate these findings, establish standardised cut-off values, and explore the role of SWE in prognostication and treatment monitoring.

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