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Original Article

Correlation of Mammographic and Shear Wave Elastography Findings with Histopathology in the Characterization of Breast Lesions: A Retrospective Study

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ABSTRACT

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Background: Accurate differentiation of benign and malignant breast lesions remains an important challenge in breast imaging. Shear wave elastography (SWE) provides quantitative assessment of tissue stiffness and may offer complementary information to conventional breast imaging.
Objective: To evaluate the role of quantitative SWE in differentiating benign and malignant breast lesions and to assess its correlation with histopathological findings.
Materials and Methods: A retrospective observational study was conducted in the Department of Radiology and Imaging Sciences, Sri Ramachandra Institute of Higher Education and Research, Chennai, India, from August 2019 to April 2020. Twenty-three female patients aged 23–88 years with clinically suspected or imaging-detected breast lesions were included. All patients underwent mammography, SWE, and ultrasound-guided 18-gauge core needle biopsy. Lesions were categorized according to BI-RADS, and quantitative elasticity values were recorded in kilopascals (kPa). SWE findings were compared with histopathological diagnoses.
Results: Histopathological examination identified 12 benign lesions (52%) and 11 malignant lesions (48%). The mean elasticity value was 52 kPa in benign lesions, with a range of 13.7–113.5 kPa**,** compared with 97 kPa in malignant lesions, with a range of 67.6–152.9 kPa. A cutoff value of 97 kPa was identified for differentiating malignant from benign lesions. SWE findings demonstrated a concordance of 95.6% (22/23 cases) with histopathological findings. Higher BI-RADS categories, particularly BI-RADS 4C and 5, were associated with malignancy.
Conclusion: Quantitative SWE demonstrated higher tissue stiffness in malignant breast lesions and showed high concordance with histopathological findings in this study. SWE may serve as a useful adjunct to mammography, conventional ultrasound, and BI-RADS assessment for breast lesion characterization.

Keywords: Breast Lesions, Shear Wave Elastography, Mammography, Ultrasound, BI-RADS

INTRODUCTION

Breast cancer is one of the most important global health challenges among women and remains a major cause of cancer-related morbidity and mortality. Early detection and accurate characterization of breast abnormalities are essential for initiating appropriate treatment, improving prognosis, and reducing unnecessary diagnostic procedures. Breast imaging therefore plays a central role in the detection, characterization, and risk assessment of breast lesions. The increasing availability of multimodality imaging has improved diagnostic evaluation; however, differentiating benign from malignant lesions remains challenging in a proportion of patients. [1] Mammography remains a fundamental imaging modality for breast cancer screening and diagnosis because of its established ability to detect suspicious masses, architectural distortion, and microcalcifications, including abnormalities associated with early-stage malignancy. However, the diagnostic performance of mammography is influenced by breast composition. Dense breast parenchyma can reduce lesion conspicuity and mammographic sensitivity, creating challenges in the detection and characterization of abnormalities. [2,3] Consequently, ultrasound is frequently used as a complementary

modality, particularly for evaluating palpable abnormalities and mammographically occult lesions. Conventional B-mode ultrasonography provides valuable morphological information and is particularly useful for distinguishing cystic from solid lesions; however, its interpretation is partly operator dependent and some benign and malignant lesions may demonstrate overlapping morphological features. [4,5] The Breast Imaging Reporting and Data System (BI-RADS) provides a standardized framework for describing breast imaging findings, assigning assessment categories, and guiding subsequent clinical management. Although BI-RADS improves consistency in breast imaging interpretation, indeterminate lesions may still require additional imaging or tissue sampling for definitive diagnosis. [6] Therefore, techniques that provide information beyond conventional morphology may have an important role in improving lesion characterization.
Elastography has emerged as an advanced ultrasound technique that provides complementary information by assessing the mechanical properties of tissue. Unlike conventional ultrasound, which primarily evaluates lesion morphology and echogenicity, elastography provides information regarding tissue stiffness. Shear wave elastography (SWE) is a quantitative elastographic technique in which acoustic radiation force generates shear waves within tissue, allowing tissue stiffness to be estimated from shear-wave propagation and expressed quantitatively in kilopascals (kPa). [7,8]

Malignant breast lesions frequently exhibit greater stiffness than benign lesions because of pathological processes such as increased cellularity, fibrosis, extracellular matrix alteration, and desmoplastic stromal reaction. Quantitative SWE can therefore provide an objective parameter that may complement conventional ultrasound assessment. Several diagnostic studies and meta-analyses have demonstrated that SWE has useful discriminatory performance for differentiating benign and malignant breast lesions, although reported cutoff values vary considerably between studies because of differences in equipment, acquisition techniques, lesion characteristics, and measurement methods. [9–11] The potential value of SWE is particularly relevant for lesions with indeterminate conventional imaging features. Incorporating quantitative elasticity measurements with conventional ultrasound and BI-RADS assessment may improve diagnostic confidence and assist in further characterization of lesions before biopsy. Evidence also suggests that combining SWE with conventional ultrasound can improve diagnostic performance compared with conventional ultrasound alone. [12,13] However, SWE should be regarded as an adjunctive technique rather than a replacement for histopathological examination when tissue diagnosis is clinically indicated. The interpretation of elasticity measurements also requires consideration of lesion depth, size, heterogeneity, ROI placement, and technical factors that can influence quantitative measurements. [14] Despite increasing evidence supporting the diagnostic utility of SWE, variability in reported elasticity thresholds and differences in study populations highlight the need for institution-specific evaluation and further validation. [15] Therefore, the present study was undertaken to evaluate the relationship between mammographic findings, SWE-derived elasticity measurements, and histopathological diagnoses in breast lesions. The study specifically aimed to assess differences in tissue elasticity between benign and malignant lesions and to determine the potential clinical utility of SWE as an adjunct to conventional breast imaging for breast lesion characterization.

MATERILS AND METHODS

Study Design and Study Setting: This retrospective observational study was conducted in the Department of Radiology and Imaging Sciences, Sri Ramachandra Institute of Higher Education and Research, Chennai, India. The study period extended from August 2019 to April 2020. The study was designed to evaluate the relationship between mammographic findings, quantitative shear wave elastography (SWE) measurements, and histopathological diagnoses in patients with breast lesions.

Study Population: The study included 23 female patients, aged between 23 and 88 years, who presented with clinically suspected breast lesions and underwent breast imaging followed by histopathological evaluation. Patients were included after fulfilling the predefined eligibility criteria.

Inclusion Criteria: Patients were included if they met all of the following criteria:

1. Presence of a clinically palpable or imaging-detected breast lesion.
2. Breast lesion categorized as BI-RADS category 3 or higher.
3. Availability of mammographic evaluation, SWE examination, and histopathological confirmation.

Exclusion Criteria: Patients were excluded if they had:

1. A history of previous breast surgery or breast radiotherapy.
2. Purely cystic breast lesions.
3. No available histopathological confirmation.

Mammographic Evaluation: Mammographic examinations were performed using the FUJIFILM Amulet Innovality digital mammography system. Standard craniocaudal (CC) and mediolateral oblique (MLO) views were obtained for each patient. Breast lesions were assessed according to the American College of Radiology Breast Imaging Reporting and Data System (ACR BI-RADS) classification. The mammographic findings were subsequently correlated with the findings obtained from ultrasound, SWE, and histopathological examination.

Ultrasound and Shear Wave Elastography: SWE examination was performed using a Toshiba Aplio 500 ultrasound system equipped with a 5–12 MHz high-frequency linear transducer. The breast lesion was initially identified and evaluated using conventional B-mode ultrasound. SWE was subsequently performed to obtain quantitative information regarding tissue stiffness. The transducer was positioned over the lesion with minimal additional pressure to avoid altering the mechanical properties of the tissue. A region of interest (ROI) was placed within the lesion, and quantitative elasticity measurements were obtained and expressed in kilopascals (kPa). The elasticity measurement was recorded for each lesion and subsequently used for comparison between benign and malignant lesions. Because SWE measurements can be affected by ROI selection and lesion characteristics, the ROI was positioned within the lesion during quantitative assessment. Previous studies have demonstrated that ROI configuration can influence measured elasticity values and diagnostic performance.

Histopathological Examination: Histopathological examination was used as the reference standard for definitive diagnosis. Ultrasound-guided core needle biopsy using an 18-gauge needle was performed for the evaluated breast lesions. The biopsy specimens were submitted for histopathological assessment and classified as benign or malignant according to the final pathological diagnosis.

Multimodality Imaging Assessment: The imaging evaluation incorporated mammography, conventional B-mode ultrasound, and SWE. Findings from the different imaging modalities were assessed in relation to the final histopathological diagnosis. A representative case demonstrating the multimodality imaging workflow, including mammography, B-mode ultrasound, SWE, and ROI placement, is presented in Figure 1.

Study Variables: The principal study variables included:

- Patient age.
- Mammographic findings.
- BI-RADS category.
- SWE-derived elasticity measurements in kPa.
- Histopathological diagnosis.
- Classification of lesions as benign or malignant.
- Concordance between SWE assessment and histopathological diagnosis.

Statistical Analysis: Descriptive statistical methods were used to summarize the demographic characteristics and SWE measurements of the study population. The mean elasticity values of benign and malignant lesions were compared. A diagnostic threshold was determined to differentiate benign from malignant lesions based on the observed elasticity measurements. The relationship between SWE findings and histopathological diagnosis was assessed, and the concordance between the two methods was calculated.

Ethical Considerations: Institutional Ethics Committee approval was obtained before conducting the study. The study involved retrospective analysis of clinical and imaging data, with histopathological findings used as the reference standard.

RESULTS

A total of 23 female patients with clinically suspected or imaging-detected breast lesions were included in the study. The patients ranged in age from 23 to 88 years, with a mean age of 63 years. The broad age distribution represented both premenopausal and postmenopausal women (Figure-1).

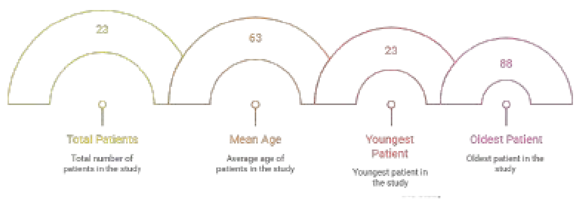

Figure 1. Age Distribution of Female Patients

Histopathological Findings: Histopathological examination identified 12 benign lesions (52%) and 11 malignant lesions (48%) among the 23 evaluated lesions. The benign lesions comprised fibroadenomas, phyllodes tumors, and benign proliferative lesions. The malignant group predominantly consisted of invasive ductal carcinoma, with additional cases of mucinous carcinoma and invasive mammary carcinoma. The distribution of lesions according to histopathological diagnosis is shown in Figure 2.

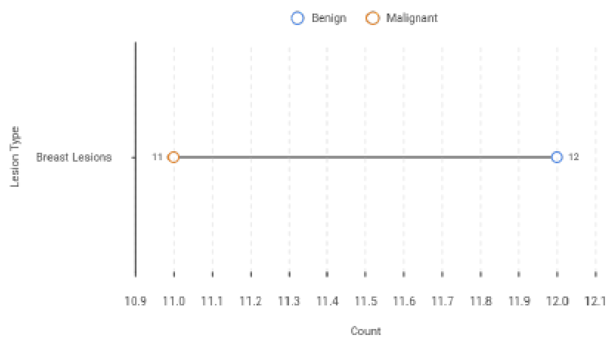

Figure 2. Histopathological Classification of Breast Lesions

Shear Wave Elastography Findings: Quantitative SWE demonstrated a clear difference in tissue elasticity between benign and malignant breast lesions. As presented in Table 1, the mean elasticity value was 52 kPa in benign lesions, with a range of 13.7–113.5 kPa, whereas malignant lesions demonstrated a higher mean elasticity value of 97 kPa, with a range of 67.6–152.9 kPa. Overall, malignant lesions exhibited greater tissue stiffness than benign lesions. The distribution of lesion number, proportion, mean elasticity, and elasticity range is summarized in Table 1.

Table 1. Comparison of quantitative SWE elasticity values between benign and malignant breast lesions

Lesion category	Number of lesions	Percentage	Mean elasticity	Elasticity range
Benign	12	52%	52 kPa	13.7–113.5 kPa
Malignant	11	48%	97 kPa	67.6–152.9 kPa
Total	23	100%	—	—

A 97 kPa elasticity threshold was identified as the optimal cutoff in the present study for differentiating malignant from benign lesions. The distribution and comparison of SWE elasticity values between the two groups are illustrated in Figure 3.

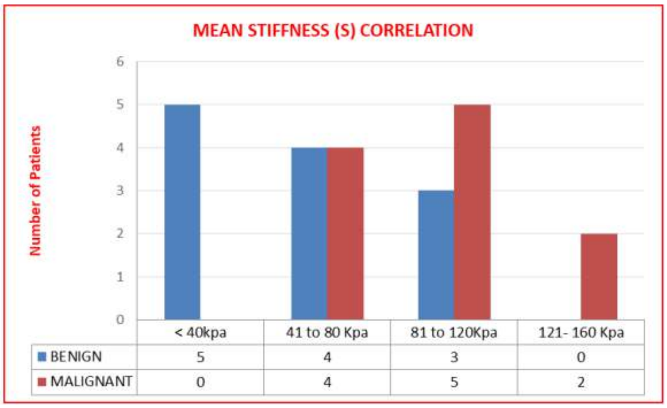

Figure 3. Comparison of SWE elasticity values between the two groups

SWE findings demonstrated a concordance rate of 95.6% (22/23 cases) with the final histopathological diagnosis. The findings indicate a close relationship between quantitative tissue stiffness measurements and the histopathological classification of the evaluated lesions.

Correlation with BI-RADS Classification: Higher BI-RADS categories were associated with malignant lesions in the study population. In particular, BI-RADS categories 4C and 5 demonstrated a strong association with malignancy. The combination of BI-RADS assessment and quantitative SWE measurements provided complementary morphological and mechanical information for lesion characterization.

Multimodality Imaging Findings: The study incorporated mammography, conventional B-mode ultrasound, and SWE as components of the imaging assessment. Representative multimodality findings are presented in Figure 4, demonstrating the relationship between conventional breast imaging and quantitative tissue-stiffness assessment.

A B C

Figure 4. Multimodality imaging correlation of a breast lesion: (A) mammography showing irregular mass, (B) Bmode ultrasound demonstrating hypoechoic lesion, and (C) SWE showing increased stiffness.

DISCUSSION

The present study demonstrates the potential value of quantitative shear wave elastography (SWE) as an adjunct to conventional breast imaging for differentiating benign and malignant lesions. Malignant lesions showed higher mean elasticity than benign lesions (97 kPa vs. 52 kPa), supporting the established association between increased tissue stiffness and malignant pathology. Previous systematic reviews and meta-analyses have similarly demonstrated the diagnostic value of SWE for differentiating benign and malignant breast lesions. A 97 kPa cutoff was identified in the present study for differentiating malignant from benign lesions. However, SWE thresholds vary across studies because of differences in ultrasound systems, acquisition protocols, lesion characteristics, and ROI selection. In particular, ROI placement can significantly influence measured elasticity values; therefore, the present cutoff should be considered study-specific and requires external validation.

The observed 95.6% concordance (22/23 cases) between SWE findings and histopathology further supports the potential of quantitative stiffness assessment as a complementary diagnostic parameter. Combining SWE with conventional ultrasound has been reported to improve lesion characterization compared with conventional ultrasound alone. In the present study, higher BI-RADS categories, particularly BI-RADS 4C and 5, were also strongly associated with malignancy, suggesting that SWE may provide additional information alongside morphological assessment. Despite these findings, SWE should not replace histopathological examination when tissue diagnosis is indicated. The principal limitations of this study were the small sample size of 23 lesions, retrospective design, and potential variability in SWE measurements related to lesion depth, heterogeneity, ROI placement, and technical factors. Larger prospective multicenter studies with standardized acquisition protocols are required to validate the 97 kPa cutoff and establish its broader clinical applicability.

CONCLUSION

Quantitative shear wave elastography demonstrated a clear difference in tissue stiffness between benign and malignant breast lesions, with malignant lesions showing higher mean elasticity values than benign lesions. In this study, a 97 kPa cutoff was identified for differentiation between the two groups, with 95.6% (22/23) concordance between SWE findings and histopathological diagnosis. These findings support the potential role of SWE as a complementary technique to mammography, conventional ultrasound, and BI-RADS assessment for improving the characterization of breast lesions. However, given the small sample size and retrospective study design, the findings should be interpreted cautiously, and larger prospective multicenter studies are required to validate the observed cutoff and establish standardized clinical applications of SWE.

DECLARATIONS

Ethics Approval and Consent to Participate: Institutional Ethics Committee approval was obtained for this study. The study was conducted in accordance with applicable institutional ethical guidelines.
Consent for Publication: Not applicable.
Availability of Data and Materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.
Competing Interests: The authors declare that there are no competing interests regarding the publication of this article.
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