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Diagnostic accuracy of shear wave elastography in the evaluation of solid breast lesions and its correlation with histopathology

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Abstract
Title: Diagnostic accuracy of shear wave elastography in evaluation of solid breast lesions & its correlation with histopathology.
Background: To assess role of shear wave elastography in diagnosis of solid breast lesions with histopathological correlation.
Materials and Methods: This cross-sectional analytical study was conducted in 50 patients from January 2021 to June 2022 in Department of Radiodiagnosis, Mahatma Gandhi Medical College and Research Institute, Pondicherry.
Results: Study group consisted of 50 individuals who presented to Department of Radiology for examination of breast for a solid tumor, ranging in age from 26 to 68 years. There were 27 malignant lesions among which 9 were Ductal Carcinoma insitu which is highest number seen in this study, 7 were Invasive ductal carcinoma, 6 were mucinous adenocarcinoma and 5 were Invasive lobular Carcinoma. Among 23 benign lesions, 47% were fibro adenomas followed by Mastitis (26%), Intraductal papilloma (17%), Adenosis (3%) and Intramammary lymph node. In this study sensitivity of shear wave elastography combined with USG was 95.24% & specificity was 97.37%. PPV & NPV values were 97.56% & 94.87% respectively. Mean elasticity value for predicting malignancy was 102.15 kpa & for benign was 41.12 kpa.
Conclusion: A thorough grasp of the characteristics of each elastography technique enables accurate imaging and diagnosis, proving that elastography is a clinically valuable tool.

Keywords: USG, ultrasonography, breast, elastography, shear wave, histopathological correlation

Introduction
Both industrialized and developing nations share a common public health problem with breast cancer. Despite major improvements in diagnostic and therapeutic techniques, this ailment still carries a heavy morbidity and mortality burden, with more than two million cases being diagnosed and more than 600,000 patients passing away from it each year globally. Around 2.1 million new cases of female breast cancer were discovered in 2018, accounting for nearly one in four cancer occurrences [1]. The ability to distinguish between benign and malignant tumors is critical for patient care and proper treatment management [2]
The development of ultrasound elastography (USE) aimed to increase the precision with which breasts were recognized and categorized. Shear wave elastography is a non-invasive method for determining tissue stiffness by measuring the rate of shear wave propagation through the patient's body (elasticity). When a focused ultrasound beam enters the breast, shear waves (also known as transverse waves) are created as a result of the beam's acoustic radiation force [3].
Despite the fact that clinical palpation is the most straightforward assessment technique, it is of limited utility owing to its low sensitivity and accuracy. Clinical examination alone is sometimes insufficient for detecting tiny and early-stage malignancies in many cases. As a result, we were able to establish a link between the ultrasonographic characteristics of breast masses and the results of histopathology [4].

Materials and Methods
This cross-sectional analytical study was conducted for a period of two years from January 2021 to June 2022 in Department of Radiodiagnosis, Mahatma Gandhi Medical College and

Research Institute, Pondicherry.

Inclusion criteria

Women more than 18 years diagnosed to have a solid breast mass referred from the department of General Surgery for ultrasound of breast and planned for tru cut biopsy.

Exclusion criteria

- Patients with cystic breast lesions
- Women who were pregnant or lactating.

Procedure

All patients diagnosed with solid breast mass referred to Radiodiagnosis department for breast ultrasound was evaluated by elastography using Mindray Resona 7, L11-3 probe. The elastography was performed by the primary investigator after being trained by certified radiologists and under his supervision. Adequate privacy settings for the patient were ensured.

The patient was examined in the supine position. The probe was placed on the area of interest so that the targeted lesion appears in the center of the image. A slight rhythmic compression-decompression movement is applied, holding the scan plane always perpendicular on the skin surface, the anterior margin of the lesions and the chest wall.

The region of interest (ROI) must beset to include the lesion, subcutaneous layers and pectoralis muscle, without costal arches. The lesion itself should not exceed 25% of the ROI's width. A minimum 5 mm thickness of normal adjacent parenchyma should be contained within the elasticity box, given the fact that lesion stiffness is assessed in relation with the average elasticity of surrounding tissue.

A good quality elasticity image was acquired secondary to minimal pressure, which does not distort glandular tissue. If the initial compression is adequate the pectoralis muscle appears blue and the subcutaneous fatty tissue appears as a mosaic of green and red. Optimal amplitude of compression-decompression movements was kept minimal, between 0.4–0.8 mm or 1-2 mm according to breast volume, lesion dimension and localization. Indicated compression frequency was of 1-2/sec. During the procedure lateral slipping or rotation of the US probe was avoided.

A minimum two series of images must be acquired with a duration of at least 5 seconds for each lesion. Mean elasticity, maximum elasticity and the elasticity ratio displayed automatically was recorded.

Following elastography evaluation, USG guided tru cut biopsy was done by surgical consultant and specimen was sent for histopathological diagnosis. Subsequent surgical management was done by concerned surgical consultant as per standard institutional protocol.

Data collection

All data was entered into a Data Collection Proforma Sheet (Appendix 1) and was entered into Excel (MS Excel 2019). Other biographical details were also collected including age.

Statistical methods

Statistical analysis was carried out using SPSS version 19.0 (IBM SPSS, US) software with Regression Modules installed.

Results

A total of 50 cases were investigated, with the research group ranging in age from 26 to 68 years. The majority of patients with breast (30%) were in the age bracket of 41 to 50 years. The mean age of the participants was 43.48 years. (Table 1).

In this study, most common clinical feature was a new lump (22%). Other symptoms included a pain (20%), thickening (16%), nipple discharge (14%), irritation (6%) and skin redness (18%). (Table 2)

Malignant were identified in 54% of the Final Diagnosis (HPE) of the investigated breast diseases, whereas benign were noted in 46%.

Among 27 malignant 9 were Ductal Carcinoma insitu which is highest number seen in this study, 7 were Invasive ductal carcinoma, 6 were mucinous adenocarcinoma and 5 were Invasive lobular Carcinoma (Table 3)

Among 23 benign 47% were Fibroadenomas which is seen more in this study followed by Mastitis 26%, Intraductal papilloma 17%, Adenosis 3% and intramammary lymph node. (Table 4)

Regarding benign and malignant among different age group 37% of malignant was observed in the age group of 41 to 50. Benign lesions were observed more in the age group of <30 (30%) followed by 51 to 60 (26%). (Figure 1)

Among 27 malignant lesion elastography labelled 25 as malignant and 2 as benign. Among 23 benign lesions US elastography labelled 22 benign and 1 malignant. (Table 5)

In this current study sensitivity of BIRADS USG with shear wave elastography was 95.24% and specificity was 97.37%. The PPV and NPV value was 97.56% and 94.87%. (Table 6) The mean elasticity value for predicting Malignant was 102.15 kpa and for benign was 41.12 kpa. (Table 7)

Table 1: Age Distribution

Age interval	Frequency %	Age (%)
<30	9	18%
31-40	9	18%
41-50	15	30%
51-60	12	24%
>60	5	10%
Total	50	100%
Range	26 to 68	
Mean	43.48	
SD	12.77	

Table 2: Distribution of symptoms among study population (N=50)

Symptoms	Frequency	% age (%)
New lump	11	22%
Pain	10	20%
Thickening	8	16%
Nipple discharge	7	14%
Irritation	5	6%
Redness or flaky skin	9	18%
Total	50	100%

Table 3: Distribution of Malignant by final HPE among study population (N=27)

Malignant (27)	Frequency	%age (%)
Invasive ductal Carcinoma	7	26%
Invasive lobular Carcinoma	5	18%
Ductal carcinoma in situ	9	33%
Mucinous adenocarcinoma	6	22%
Total	27	100%

Table 4: Distribution of Benign by final HPE among study population (N=23)

Benign (38)	Frequency	% age (%)
Fibroadenoma	11	47%
Adenosis	3	13%
Intraductal papilloma	2	9%
Intramammary lymph node	1	4%
Mastitis	6	26%
Total	23	100%

Table 5: Descriptive analysis of Benign and malignant in US elastography assessment (N=50)

Elastography findings	HPE findings	
	Malignant	Benign
Malignant (27)	25	1
Benign (23)	2	22
Total	27	23
P value	<0.001	
Chi square	33.538	

Table 6: Sensitivity, specificity, PPV and NPV of USG elastography with HPE

Variables	Value	95% CI
Sensitivity	95.24%	83.84% to 99.42%
Specificity	97.37%	86.19% to 99.93%
Positive Likelihood Ratio	36.19	5.23 to 250.64
Negative Likelihood Ratio	0.05	0.01 - 0.19
Disease prevalence (*)	52.50%	41.02% to 63.79%
PPV (*)	97.56%	85.24% to 99.64%
NPV (*)	94.87%	82.70% to 98.62%
Accuracy (*)	96.25%	89.43% to 99.22%

Table 7: The mean elasticity value and stiff ratio of breast (N = 50)

Variables	Mean elasticity	Stiff ratio
Benign lesions	41.12±26.1	3.58±2.16
Malignant lesions	102.15±35.41	16.98±11.10
Positive Cut-off value	> 67.6 kpa	5.95
P Value	<0.001	<0.001

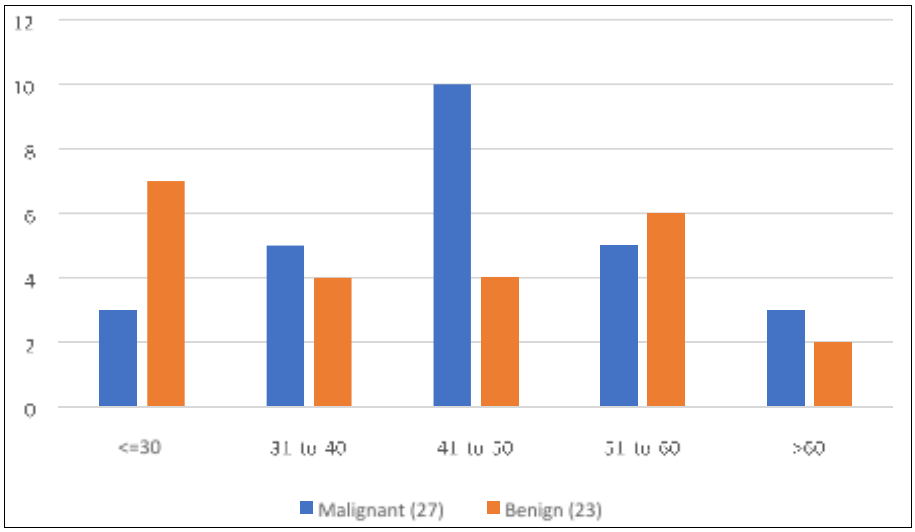

Fig 1: Bar diagram showing association of age with benign and malignant lesions

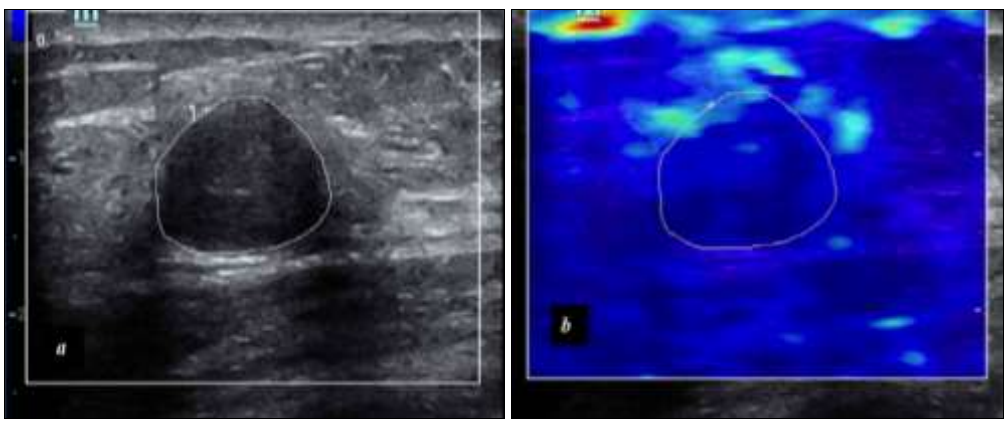

Fig 2: (a) B mode US of biopsy proven fibro adenoma in a 30 year old female which shows a relatively well defined hypoechoic lesion suggesting benign nature. (b)SWE of elastography showed predominantly blue colour coding and mean elasticity of 10 kPa suggesting benign nature

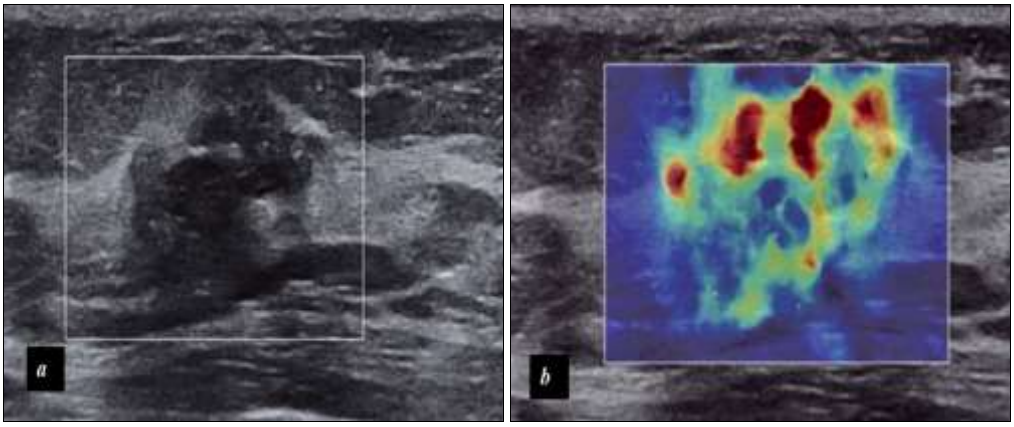

Fig 3: (a) A case of proven invasive ductal carcinoma in a 46 year old female. B-mode US shows an ill-defined heterogenous predominantly hypoechoic lesion with ductal infiltration suggestive of BIRADS 5 lesion (malignant). (b) SWE shows the mass and the stroma around the mass to be yellow and red (stiff). The mean elasticity of the lesion was 145 kPa suggesting malignancy

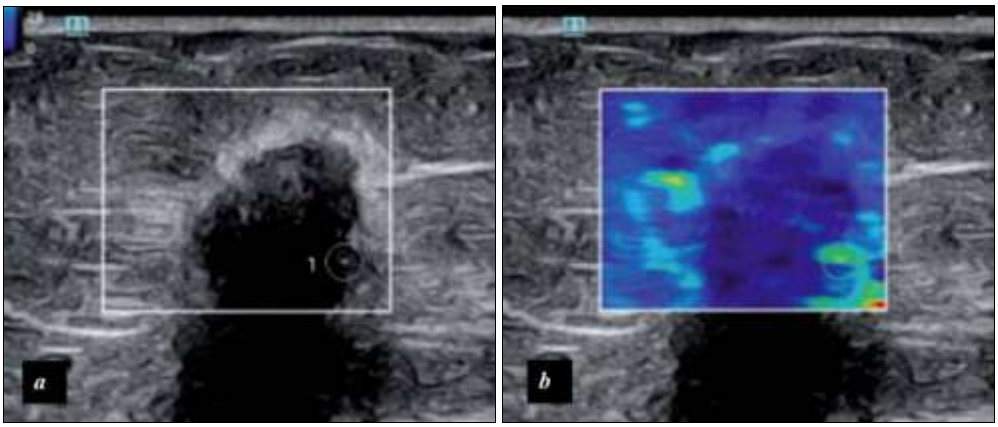

Fig 4: (a) A biopsy proven case of Invasive ductal Carcinoma. B mode US showed a 1.7 cm irregular spiculated hypoechoic mass in the right breast at the 11 o'clock position with a category of BI-RADS 5. (b)SWE showed predominantly blue pattern with mean elasticity value - 38.25 kPa which was under the cut-off value, wrongly suggesting a benign lesion

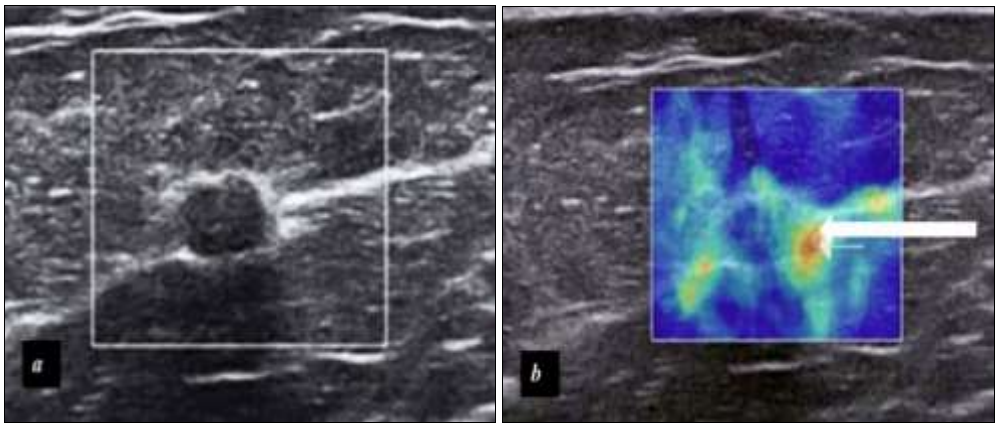

Fig 5: (a) A case of biopsy proven invasive carcinoma. B mode ultrasound characteristics wrongly interpreted the lesion as benign. (b) SWE showed suspicious peri-tumoral stiffness which helped to raise the suspicion of malignancy and opt for a biopsy

Discussion

Using a non-invasive imaging method called ultrasound elastography, abnormal tumours' elasticity (stiffness) is contrasted with healthy tissues. Compared to healthy breast tissue, breast cancer tissue is more brittle. Shear waves are mechanical waves that propagate through tissues at a very high speed. The stiffness of the surrounding tissue affects the waves' direction. The shear wave mechanism is based on Young's modulus, which may evaluate the variations in properties across diverse biological tissues and, secondly, display tissue stiffness quantitatively. This stiffness simulation is consistent with tissue probing during clinical examination.

This cross-sectional analytical study was conducted for a period of two years from January 2021 to June 2022 in Department of Radiodiagnosis, Mahatma Gandhi Medical College and Research Institute, Pondicherry. This research comprised 50 females who were diagnosed with breast lesions and referred to the radiology department for USG.

The age of our study participants was 43.48 years on average, with a standard deviation of 12.77 years. The participants ranged in age from 26 to 68, with the youngest

being 26. The bulk of participants (40%) were between the ages of 31 and 40, while 24%, of the participants were between the ages of 51 and 60. Our age statistics are in line with the rising prevalence of breast cancer among Indian women between the ages of 25 and 50, according to Sandhu *et al*. [5] 2016

11 fibroadenomas (47%) were discovered among the numerous histological diagnoses of the breast that were covered in this investigation. DCIS is typical of cancerous tumours. There were nine (33%) cases of DCIS, 5 cases (18%) of ILC and 7 (26%) incidences of invasive ductal carcinoma. In addition to these benign tumours, adenosis (13%), intraductal papilloma (9%), an intramammary lymph node (4%), and mastitis (26%), were also found during our research.

According to Schoonjans JM *et al*., the most usually diagnosed benign breast tumor is fibroadenoma, while the most frequently diagnosed malignant breast mass is invasive ductal carcinoma [6]. Chang JY *et al*. discovered that malignant invasive ductal carcinoma was more common than benign fibroadenoma. Another study conducted by Ahmed Tohamy *et al.* discovered that 68 of the 132 were cancerous, whereas 64 were benign. In 42 cases, IDC 16, and ILC in 10 cases. All of the benign were fibroadenomas (n = 44), non-specific granulomatous mastitis (n = 4), adenosis (n = 11), and fibrosis (n = 5) [7].

Positive malignant tumors were more prevalent in the age group of 31 to 40. (37%). The benign lesions were more prevalent in the age range 51 to 60 (30%), followed by 41 to 50 (26%).

Malignant had a considerably greater elasticity value than benign in the current research. The current study found that BIRADS USG with shear wave elastography has a sensitivity of 95.24% and a specificity of 97.37%. The PPV and NPV values were 97.56 and 94.87%, respectively. The mean elasticity value for predicting malignant tumors was 102.15kpa, while the mean elasticity value for benign tumors was 41.12 kpa.

According to study by Ahmed Tohamy *et al.*, the computed sensitivity and specificity for classic US were 85 and 94%, respectively [7].

Mirinae Seo *et al.* concluded that optimal cut-off values for benign and malignant, respectively, were 67.8 kPa and 6.43, which matched with our findings (66.4 kPa and 5.8, respectively) [8]

It has been demonstrated that the shear wave elastography characteristics of solid breast tumours can help distinguish between benign and malignant solid breast cancers. Shear wave elastography appears to be fairly repeatable and provides quantitative results when compared to normal elastography. The most significant shear wave characteristic appears to be the mean stiffness within a region of interest (ROI), which appears to be defined by the stiffest part of a recorded image. When the body's average stiffness exceeds 67 kPa, it is highly suggestive of malignancy.

Conclusion

Breast elastography is currently used in conjunction with breast ultrasound. It is simple to conduct in clinical practice and adds only a few seconds to breast ultrasonography. To guarantee that SWE performs well in the detection of breast cancer, the method should be improved to capture high-quality pictures, and practitioners should interpret the generated images and data appropriately. One of the most effective uses of SWE is the classification of breast masses classified as BI-RADS category 3 and 4a in order to avoid needless breast biopsies.

Additionally, SWE can aid in the prediction of breast cancer prognosis and response to NAC. However, during interpretation, the risk of false-positive and false negative results should be noted. A thorough grasp of the characteristics of each elastography technique enables accurate imaging and diagnosis, proving that elastography is a clinically valuable tool.

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Conflict of Interest

Not available

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Not available

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