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TO DETERMINE THE ROLE OF SONOELASTOGRAPHY IN DIFFERENTIATING BENIGN AND MALIGNANT LESIONS OF THE BREAST

Radio-Diagnosis

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ABSTRACT

Background: Breast cancer remains a leading cause of mortality among women globally. Differentiating benign from malignant breast lesions is crucial for early diagnosis and appropriate treatment. Sonoelastography, specifically Virtual Touch Quantification (VTQ), offers a non-invasive method to assess tissue stiffness, enhancing diagnostic accuracy beyond conventional ultrasound. **Aim:** To evaluate the role of VTQ sonoelastography in differentiating benign and malignant breast lesions and assess its diagnostic accuracy, sensitivity, and specificity. **Methods:** A cross-sectional observational study was conducted over 18 months on female patients with palpable breast lumps at a tertiary hospital in Udaipur. All patients underwent B-mode ultrasound, VTQ elastography, and histopathological correlation. **Results:** VTQ scores <70 kPa indicated benign lesions; >100 kPa suggested malignancy with **100% sensitivity** and **83.3% specificity**. Intermediate scores were useful in stratifying **BI-RADS 3 and 4A** lesions. **Conclusion:** VTQ sonoelastography is a valuable adjunct in breast lesion evaluation, improving diagnostic precision and reducing unnecessary biopsies.

KEYWORDS

Breast cancer, Sonoelastography, Virtual Touch Quantification, VTQ, BI-RADS, Shear wave elastography, Diagnostic accuracy.

INTRODUCTION

Breast cancer is the most commonly diagnosed cancer in women globally and a leading cause of cancer-related mortality. Early detection is essential for better prognosis, but limitations in existing imaging modalities hinder accurate differentiation between benign and malignant lesions. While mammography and ultrasonography remain primary diagnostic tools, their reduced specificity-especially in dense breast tissue-often leads to unnecessary biopsies and delayed interventions.

Sonoelastography, an ultrasound-based imaging technique, evaluates tissue stiffness to improve lesion characterization. Malignant tumors typically exhibit greater stiffness than benign ones, making sonoelastography a promising adjunct to conventional imaging. Among the two types-strain and shear wave elastography-Virtual Touch Quantification (VTQ) is a shear wave technique offering quantitative assessment through shear wave velocity (SWV).

India, where access to advanced imaging like MRI is limited and ultrasound is widely used, offers a vital context for validating sonoelastography's utility. The technique is particularly beneficial for refining BI-RADS 3 (probably benign) and 4A (low suspicion) categories, potentially reducing follow-ups and biopsies.

This study aims to evaluate the diagnostic accuracy, sensitivity, and specificity of VTQ in distinguishing benign from malignant breast lesions, contributing region-specific evidence to support its integration into routine breast imaging protocols.

MATERIALS AND METHODS

This was a cross-sectional observational study conducted over 18 months (June 2023 to November 2024) at the Department of Radiodiagnosis, Pacific Institute of Medical Sciences, Udaipur. Female patients with palpable breast lumps underwent both conventional B-mode ultrasonography and Virtual Touch Quantification (VTQ) sonoelastography, followed by histopathological confirmation, which served as the gold standard.

Inclusion criteria comprised females of any age with breast lumps who consented and underwent histopathology. Exclusion criteria included prior breast treatments or refusal of consent. A total of 42 eligible patients were enrolled using convenience sampling.

B-mode ultrasound evaluated lesion characteristics and assigned BI-RADS categories. Sonoelastography measured shear wave velocity (SWV) values in kilopascals (kPa), using a Samsung V8 machine. Ten VTQ readings per lesion were averaged. Lesions were categorized as benign or malignant based on SWV thresholds and correlated with histopathology.

Special focus was placed on BI-RADS 3 and 4A lesions for evaluating diagnostic refinement. Statistical analysis included calculation of sensitivity, specificity, and diagnostic accuracy. ROC curves were used to determine optimal SWV cutoffs for malignancy prediction. Data analysis was performed using SPSS, with p-values <0.05 considered statistically significant.

RESULT AND OBSERVATIONS

Out of 42 patients, 71.4% had benign lesions (mostly fibroadenomas), while 28.6% were malignant (mainly intraductal carcinoma). BI-RADS 3 lesions (n=27) were entirely benign, with 88.9% showing VTQ scores <70 kPa, reinforcing the high negative predictive value. BI-RADS 4A cases (n=6) showed a balanced benign-malignant distribution, with most lesions falling in the 70–100 kPa range. BI-RADS 5 lesions (n=9) were predominantly malignant, with 77.8% having VTQ scores >100 kPa.

VTQ scoring demonstrated clear stratification: all lesions <70 kPa were benign, while all >100 kPa were malignant. The intermediate range (70–100 kPa) was diagnostically ambiguous, including both benign (n=5) and malignant (n=3) lesions. The mean VTQ scores progressively increased with BI-RADS categories—55.96 kPa for BI-RADS 3, 83.75 kPa for 4A, and 127.91 kPa for BI-RADS 5-correlating with malignancy risk.

Performance metrics revealed a sensitivity of 100%, specificity of 83.3%, and overall diagnostic accuracy of 88.1%, underscoring VTQ's reliability. These findings support the integration of VTQ into conventional ultrasound for accurate lesion characterization, particularly in BI-RADS 3 and 4A lesions, reducing unnecessary biopsies and improving patient management.

VTQ Score Categories Across BI-RADS 3 and 4A Lesions

BI-RADS Category	< 70 kPa	70–100 kPa	> 100 kPa	Total Cases
3	24	3	0	27
4A	1	4	1	6
Total	25	7	1	33

Diagnostic Accuracy Based on VTQ Scores And Histopathology

VTQ Score Category	Benign (n)	Malignant (n)	Total Cases
< 70 kPa	25	0	25
70–100 kPa	5	3	8
> 100 kPa	0	9	9
Total	30	12	42

Performance Statistics Of VTQ Scoring In Differentiating Malignant From Benign Breast Lesions

Statistic	Value	VTQ Score Range
True Positives (TP)	12	3 from 70–100 kPa, 9 from >100 kPa
False Positives (FP)	5	Benign in 70–100 kPa
True Negatives (TN)	25	Benign in <70 kPa
False Negatives (FN)	0	N/A
Sensitivity	100%	N/A
Specificity	83.3%	N/A
Accuracy	88.1%	N/A

DISCUSSION

This study highlights the significant diagnostic utility of sonoelastography using Virtual Touch Quantification (VTQ) in differentiating benign and malignant breast lesions. The results demonstrated a clear correlation between VTQ shear wave velocity (SWV) values and histopathological outcomes, supporting the role of tissue stiffness as a reliable biomarker for malignancy. Lesions with VTQ scores <70 kPa were consistently benign, whereas those with scores >100 kPa were malignant, with a sensitivity of 100% and specificity of 83.3%. Intermediate values (70–100 kPa) comprised both benign and malignant lesions, primarily within BI-RADS 4A, highlighting the potential of VTQ in refining indeterminate classifications.

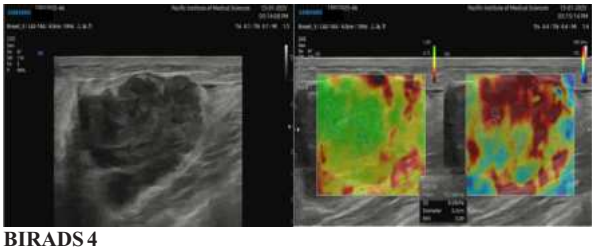
These findings are consistent with earlier studies that reported improved specificity and diagnostic accuracy with the addition of elastographic assessment to conventional sonography. In particular, the ability of VTQ to aid in the stratification of BI-RADS 3 and 4A lesions is clinically significant, as these categories often pose a dilemma, leading to either unnecessary short-interval follow-up or avoidable biopsies. In this study, integration of VTQ reduced the need for biopsies in clearly benign cases and improved confidence in diagnosing malignancies.

The predominant benign lesion was fibroadenoma, while intraductal carcinoma emerged as the most common malignancy, consistent with global and regional breast cancer patterns. Additionally, the progressive increase in mean VTQ values from BI-RADS 3 to 5 supports the concept that sonoelastography not only assists in binary classification but also offers a gradient-based risk assessment.

Given its non-invasive, reproducible, and operator-independent nature, VTQ elastography can serve as a valuable adjunct to B-mode ultrasound, especially in settings with limited access to advanced imaging like MRI or digital mammography. However, standardization of cutoff values and validation in larger, multicentric Indian cohorts is warranted to optimize its widespread clinical implementation.

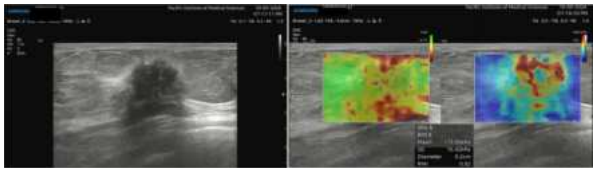
Birads 3

Fig.1 (A) B-mode USG image shows well defined hypoechoic breast lesion- Fibroadenoma (B) SWE images with mean VTQ value 60.8 kPa.



BIRADS 4

Fig. 2 (A) B-mode image shows irregular shaped hypoechoic breast mass- Invasive ductal carcinoma (B) SWE images with mean VTQ value 110.3 kPa.



BIRADS 5

Fig. 3 (A) B-mode image shows irregular shaped spiculated margins heteroechoic breast mass with posterior acoustic shadowing- Invasive lobular carcinoma (B) SWE images with mean VTQ value 123.9 kPa.

SUMMARY

This study evaluated the effectiveness of sonoelastography, specifically Virtual Touch Quantification (VTQ), in differentiating benign and malignant breast lesions. Conducted over 18 months at Pacific Institute of Medical Sciences, Udaipur, the cross-sectional study included female patients with palpable breast lumps. Each underwent B-mode ultrasonography, VTQ sonoelastography, and histopathological evaluation. Lesions with VTQ values <70 kPa were benign, and those >100 kPa were malignant, achieving 100% sensitivity and 83.3% specificity. Intermediate scores (70–100 kPa) included both lesion types, especially within BI-RADS 4A. The study demonstrated a strong correlation between VTQ scores and histopathology, with fibroadenoma being the most common benign and intraductal carcinoma the most common malignant lesion. Integration of VTQ into routine BI-RADS classification improved diagnostic accuracy, reduced unnecessary biopsies, and optimized patient management. VTQ sonoelastography emerges as a reliable, non-invasive, and cost-effective adjunct to conventional ultrasound, especially beneficial in resource-limited settings

CONCLUSIONS

Sonoelastography, particularly using Virtual Touch Quantification (VTQ), proves to be a valuable adjunct to conventional ultrasonography in the evaluation of breast lesions. The study demonstrated that higher VTQ scores are significantly associated with malignant histopathology, while lower scores reliably indicate benignity. With a sensitivity of 100% and specificity of 83.3% at the >100 kPa threshold, VTQ enhances diagnostic confidence, especially in BI-RADS 3 and 4A lesions where diagnostic uncertainty often leads to unnecessary biopsies or follow-ups. Incorporating VTQ into standard ultrasound protocols improves lesion characterization, allows for better risk stratification, and facilitates more informed clinical decisions. The modality's ability to reduce avoidable interventions while maintaining high diagnostic accuracy underscores its clinical utility. In resource-limited settings like India, VTQ offers a cost-effective, non-invasive, and accessible tool for early breast cancer detection, supporting its integration into routine breast imaging practices to improve patient outcomes and optimize healthcare resource utilization.

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