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Comparative Role of X-ray Mammography and Sonography with Sonoelastography in Palpable Breast Lesions.

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ABSTRACT

Background: Palpable abnormalities in the breast are a major cause of concern in females from their adolescence to postmenopausal state. Majority of the palpable lesions are benign but malignant lesions are always dreadful. Imaging provides a wide spectrum of noninvasive choices for evaluating these lesions ranging from x-ray mammography to magnetic resonance mammography. Ultrasonography of breast (sonomammography) is most suitable in majority of cases and is not only noninvasive but also radiation-free. Introduction: Due to wide availability, sonomammography is the most popular imaging tool for noninvasive evaluation of palpable breast lesions. Sonoelastography, a recent advancement in the field of ultrasound imaging has added a new dimension to sonomammography allowing differentiation of benign and malignant lesions based on their stiffness. Malignant lesions are usually harder than benign lesions. **Methods:** Fifty female patients with palpable breast lesions were evaluated with x-ray mammography and sonomammography with sonoelastography in tandem on the same day. The results obtained were compared with final histological diagnosis in terms of benign & malignant lesions followed by statistical evaluation and conclusions. **Results & Conclusions:** Observations when analysed revealed higher sensitivity, specificity, positive & negative predictive values and accuracy of sonomammography than x-ray mammography. The figures further improved when sonoelastography was added to sonomammography. Based on these results, we conclude that sonoelastography should be added in the sonomammography protocol of evaluating any breast lesion not only to prevent invasive procedure but also to provide image guidance when such invasive features are indicated.

Keywords: Mammography, sonomammography, sonoelastography, benign, malignant

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INTRODUCTION

Development of breast is a secondary sexual characteristic in females and is constantly under the influence of female hormones.[1,2] After menarche, the breast contains dense connective tissue which achieves mixed glandular pattern with progression of age and finally fibroglandular tissues involute into fatty tissue at menopause. Any aberration in this process leads to a spectrum of pathologies ranging from hyperplasia to neoplasia. Among the various pathologies afflicting breast, cancers are most often encountered and are the most dreaded.[1,2]

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Several diagnostic tools are available for imaging of breast lesions such as x-ray-Mammography (XRM), Sonomammography (SM) & MR mammography (MRM). Breast masses range from benign to malignant lesions with fibroadenoma being the commonest benign & invasive ductal carcinoma being the commonest malignancy.[1] Most of the breast masses are of benign nature but breast cancer is the most common cancer and is the second leading cause of deaths by cancer in women.[3]

XRM is a diagnostic technique aimed at producing high-resolution images of the breast using dedicated x-ray mammographic equipment allowing early diagnosis of breast lesions especially malignancy.

SM is not only useful in differentiating solid from cystic masses, which accounts for approximately 25% of breast lesions but also helps in differentiating benign from malignant lesions.[4] It is especially useful in palpable masses not visible in

radiographically dense breasts, abscesses and young patients to avoid radiation exposure.[5,6]

Dynamic contrast-enhanced MRM is a highly sensitive modality for detecting breast cancers especially those difficult to diagnose on physical examination, XRM & SM.[7] Investigators have used enhancement kinetics & morphology of the lesion to differentiate benign from malignant breast lesions on MRM.

However, recent introduction of breast elastography (BELG) have increased the specificity of SM in diagnosis of breast cancer. BELG quantifies the hardness of a breast lesion in relation to surrounding tissue, thus helping in differentiating benign from malignant lesions.[8,9] Malignant tumors are hard with reduced elasticity hence deform less and display larger dimensions on elastography.[10,11] The benign lesions are relatively soft, similar to surrounding tissue and deform to a higher degree.[12,13] Several clinical studies showed that sonoelastography was useful for differentiation benign and malignant breast lesions, with sensitivity ranging from 78-100% & specificity from 91-98.5%.[14-16]

Hence, the present study was carried out to evaluate the diagnostic accuracy of X–Ray mammography & Sonomammography with use of Sonoelastography in evaluating the palpable breast lesions.

Aims and Objectives

Aim

- To evaluate the diagnostic accuracy of X–Ray mammography & Sonomammography with use of Sonoelastography in evaluating palpable breast lesions

Objectives

- To evaluate the diagnostic accuracy of X –Ray mammography in palpable breast lesions.
- To evaluate the diagnostic accuracy Sonomammography in palpable breast lesions.
- To compare the diagnostic accuracy of X-Ray mammography & Sonomammography.
- To compare the diagnostic accuracy of Sonomammography & Sonoelastography.

MATERIALS & METHODS

The study was performed on fifty female patients over a period of one and a half years with the following criteria:

Inclusion criterion:

All patients with palpable breast lesions.

Exclusion criterion:

Lactating mothers.

All the patients included in our study underwent X-ray Mammography (XRM) followed by Sonomammography (SM) with Sonoelastography. After radiological evaluation patient underwent guided fine needle aspiration cytology or biopsy to obtain a pathologic diagnosis.

XRM: Optimal craniocaudal (CC) & mediolateral oblique (MLO) views were taken. Additional spot magnification view was taken whenever required. Images obtained were then evaluated for lesion size & margins, presence of spiculations & microcalcifications and adherence to underlying pectoralis muscle.

SM: Routine ultrasonographic images were obtained using normal B mode. The lesion is then located and evaluated for size & margins; presence of spiculations & vascularity; adherence to underlying pectoralis muscle; echopattern of surrounding parenchyma and presence of lymph nodes with its internal vascularity. This was followed by sonoelastography (SE) which includes virtual touch imaging (VTI) & virtual touch tissue quantification (VTTQ) measurements & the data were recorded in m/sec.

The lesions were than graded as per BIRADS (Breast Imaging, Reporting and Data System) II to V criteria separately by XRM and SM. According to BIRADS classification, the lesions are classified as: BIRADS 0: Incomplete, further imaging required, BIRADS I: Negative, symmetrical & no masses or architectural distortion, BIRADS II: high suggestive of benign findings, BIRADS III: probably benign, BIRADS IV: probably malignant, BIRADS V: Highly suggestive of malignancy and BIRADS VI: Biopsy proven malignancy.

The software used for the statistical analysis was SPSS (statistical package for social sciences) version 21.0 and Epi-info version 3.0. Chi-square test was used to investigate whether distributions of categorical variables differ from one another.

RESULTS

[Table 1] shows the mean age of the study population in benign & malignant disease group. The mean age of over study group was 31.82±15.58 years. Mean age of patients with malignant disease was higher than benign disease.

Table 1: Comparison of mean Age of the study population

				AGE
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Benign	13	45	26.24	8.43
Malignant	50	73	61.13	10.67
Over-all	13	73	31.82	15.58

[Table 2] shows distribution of lesions on XRM as per BIRADS classification. Majority of the lesions were in BIRADS III category.

Table 2: Distribution of the lesions according to X-ray Mammography

BIRADS	Frequency	Percent
II	5	10.0%
III	35	70.0%
IV	10	20.0%
Total	50	100.0%

[Table 3] shows distribution of cases according to USG diagnosis. Benign lesions formed a major group and were seen in 39 out of 50 (78.0%) patients.

Table 3: Distribution of the lesions according to USG DIAGNOSIS

USG diagnosis	Frequency	Percent
Benign	39	80.0%
Malignant	11	10.0%
Total	50	100.0%

[Table 4] shows distribution of cystic & solid lesions based on gray scale of elastosonography. Majority of the lesions were solid i.e. 45 out of 50 (90.0%) patients.

Table 4: Distribution of lesions according to GREY SCALE of Elastosonography

Grey Scale	Frequency	Percent
Cystic	5	10.0%
Solid	45	90.0%
Total	50	100.0%

[Table 5] shows distribution of lesions based on their hard / soft consistency as noted on VTI. Soft lesions formed a major group i.e. 42 out of 50 (84.0%) patients.

Table 5: Distribution of the lesions according to VTI score

VTI	Frequency	Percent
Hard	9	18.0%
Soft	41	82.0%
Total	50	100.0%

[Table 6] shows distribution of lesions based on velocity on VTTQ within the lesion. Majority of lesions in study group were in 2.5-2.99 m/s & XX.Xm/s (10 each out of 50) being a predominant range.

Table 6: Distribution of the lesions according to VTTQ

VTTQ	Frequency	Percent
1.49-1.99	03	6.0%
2.00-2.49	07	14.0%
2.50-2.99	10	20.0%
3.00-3.49	05	10.0%
3.50-3.99	04	8.0%
4.00-4.49	08	16.0%
4.50-4.99	03	6.0%
XX.X	10	20.0%
Total	50	100.0%

[Table 7] shows distribution of lesions based on FNAC & biopsy findings. Benign lesions formed the predominant group being 42 out of 50 (84.0%) patients.

Table 7: Distribution of lesions according to FNAC/BIOPSY

FNAC/Biopsy	Frequency	Percent
Benign	42	84.0%
Malignant	08	16.0%
Total	50	100.0%

[Table 8] shows distribution of benign and malignant lesions based on FNAC / biopsy vs Mammographic Findings. Based on the table we can conclude that many lesions identified as malignant using the XRM were significantly lesser with FNAC / BIOPSY findings and the difference was statistically different when Chi-square test was used.

Table 8: Comparison between FNAC/BIOPSY and Mammographic findings

	FNAC/BIOPSY		Mammographic findings	
	Frequency	Percentage	Frequency	Percentage
Benign	42	84.0%	35	70.0%
Malignant	08	16.0%	15	30.0%
Total	50	100.0%	50	100.0%

Chi-square value = 2.345, p-value = 0.044* (significant difference)

[Table 9] shows distribution of benign and malignant lesions on FNAC/BIOPSY vs SM. Though the number of malignant lesions diagnosed on SM was higher than actual on FNAC/biopsy yet the difference was not statistically significant when evaluated by Chi-square test.

Table 9: Comparison between FNAC / BIOPSY and USG diagnosis

	FNAC/BIOPSY		Sonomammography	
	Frequency	Percent	Frequency	Percent
Benign	42	84.0%	39	78.0%
Malignant	8	16.0%	11	22.0%
Total	50	100.0%	50	100.0%

Chi-square value = 1.585, p-value = 0.129#

[Table 10] shows the distribution of benign and malignant lesions on FNAC/BIOPSY vs Sonoelastography with statistical evaluation using the Chi-square test which does not reveal significant difference.

Table 10: Comparison between FNAC/BIOPSY and Sonoelastography

	FNAC/BIOPSY		SE	
	Frequency	Percent	Frequency	Percent
Benign	42	84.0%	41	82.0%
Malignant	8	16.0%	9	18.0%
Total	50	100.0%	50	100.0%
Chi-square value = 0.071, p-value = 0.790*insignificant				

[Table 11] summarises the sensitivity, specificity, positive & negative predictive values and accuracy of XRM, SM & SE when compared with FNAC/biopsy. Based on the values, we can conclude that SE scores over both XRM & SM.

Table 11: Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Accuracy of different diagnostic techniques in identification of benign & malignant breast lesions

Statistical Parameter	XRM	SM	SE
Sensitivity	83.33%	92.86%	97.62%
Specificity	53.33 %	72.73 %	88.89 %
Positive predictive value	83.33%	92.86%	97.62%
Negative predictive value	53.33 %	72.73 %	88.89 %
Accuracy	83.33%	92.86%	97.62%

[Table 12] shows statistical evaluation figures for Sonoelastography when compared with FNAC/biopsy for a benign breast lesion.

Table 12: Statistical figures for identification of Benign breast lesion by Sonoelastography

	Sonoelastography
Sensitivity	97.62%
Specificity	100.00%
Positive predictive value	100.00%
Negative predictive value	88.89 %
Accuracy	97.62%

[Table 13] shows statistical evaluation figures for Sonoelastography when compared with FNAC/biopsy for a malignant breast lesion.

Table 13: Statistical figures for identification of Malignant breast lesion by Sonoelastography

	Sonoelastography
Sensitivity	100.00 %
Specificity	97.62%
Positive predictive value	100.00 %
Negative predictive value	97.62%
Accuracy	100.00 %

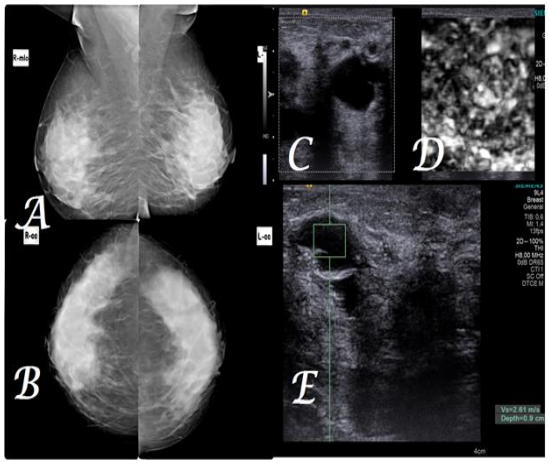

Figure 1: X-ray mammogram of bilateral breasts showing both MLO (A) & CC (B) views depict no obvious abnormality. B-mode scan (C) right breast shows presence of a hypoechoic lesion which on subsequent VTI (D) shows a relatively soft lesion depicted as grey colour in the area of the lesion suggesting a softer mass indicating a benign pathology. On subsequent VTTQ (E) shear wave velocity was seen to be 2.6 m/sec which further supports that the lesion is relatively soft suggesting a benign pathology.

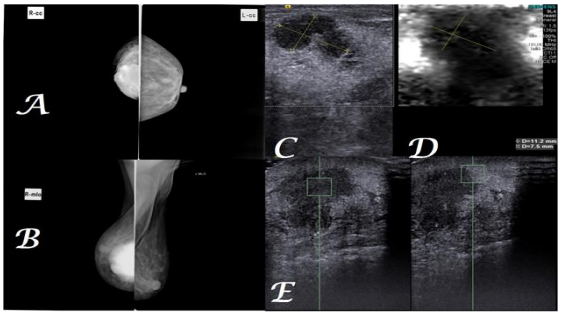

Figure 2: X-ray mammogram of bilateral breasts showing both CC (A) and MLO (B) views reveals a radio-opacity with lobulated margins and in close proximity to the chest wall in the inferomedial quadrant of right breast. B-mode scan image (C) shows presence of ill-defined hypoechoic lesion which on VTI (D) shows relatively hard lesion seen as black area in the field of view. On subsequent VTTQ (E) shear wave velocity within the lesion and in surrounding parenchyma show x.xx m/sec values suggesting hard lesion favoring malignant nature.

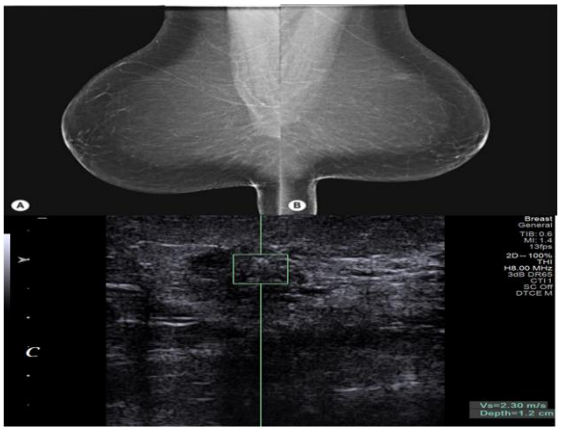

Figure 3: X-ray mammogram of both breast (A-right, B-left) show no obvious focal lesion. On subsequent B-mode imaging & VTTQ (C), a hypoehoic lesion with a shear-waver velocity of 2.3 m/sec is seen in left breast suggesting soft nature of the lesion and thus favoring benign etiology.

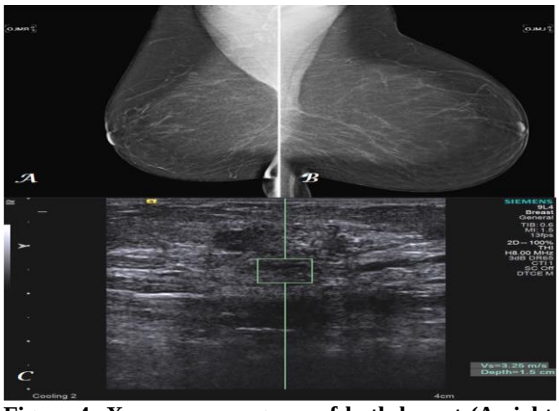

Figure 4: X-ray mammogram of both breast (A-right, B-left) show no obvious focal lesion. On subsequent B-mode & VTTQ (C), a hypoechoic lesion is seen in left breast with shear wave velocity up to 3.25 m/sec in adjacent normal-appearing breast parenchyma suggesting relative hardness but still within the range of benign lesions.

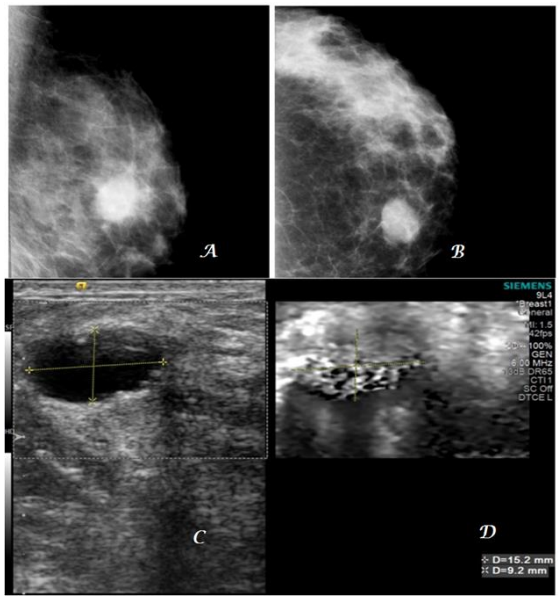

Figure 5: X-ray mammogram (A, B) of left breast shows well-defined opacity in inferomedial segment without obvious parenchymal distortion. On subsequent B-mode (C), a well-defined hypoechoic lesion is seen which on VTI (D) appears as relatively-hard lesion. VTTQ revealed a shear wave velocity of 3.02 m/sec favouring benign nature of the lesion.

DISCUSSION

Considering that an incorrect diagnosis of breast diseases is many times directly related to a failure in perception of the lesion by the investigator, it becomes essential to evaluate the diagnostic capability of various imaging methods for detecting true positive results (sensitivity) and true negative results (specificity).

With the progress in medical technologies, it is now possible to utilize sonoelastography in routine diagnosis. Such method presents some advantages viz. the data obtained is immediately evaluated and superimposed over the B-mode US images, and it does not require significantly more time than conventional B-mode US. Previous studies demonstrated low sensitivity and high specificity of sonoelastography as compared with B-mode US With regards to XRM, its sensitivity and specificity in comparison to other imaging modalities is still scarce in the medical literature.[17-19]

SM is the most important adjunctive imaging modality for breast cancer diagnosis. Over the years, it has also undergone significant improvements extending its utility for breast imaging. Its traditional was to differentiate cysts from solid masses.20,21 Two important clinical advances in SM is the development of criteria that allow improved benign/malignant differentiation of solid breast lesions and its use in guiding interventional procedures as needle aspirations, core-needle biopsies and pre-biopsy needle localizations of breast masses or calcifications.[22,23]

Masses within the breast (whether symptomatic or asymptomatic) are frequently detected on XRM. It is essential to exactly define the mass lesion characteristics for differentiating benign from malignant lesions. XRM, a primary method of detection and diagnosis of breast disease has a proven sensitivity of 85%-95%.[24] However additional diagnostic procedures often become necessary due to low specificity of XRM. Our results revealed that BIRADS II lesions were found among 5 (10.0%) patients, BIRADS III lesions among 35 (70.0%) and BIRADS IV lesions among 5 (10.0%) patients. This revealed a sensitivity of 83.33% and specificity of 53.33 % coinciding with the previous literature.

Younger women have denser breasts due to higher proportion of fibroglandular tissue. Use of oestrogen replacement therapy during and shortly after the beginning of menopause also increases breast density. This is the reason of lower mammographic sensitivity in some of these women. Presently, non-invasive imaging methods like magnetic resonance imaging (MRI), thermography and colour doppler ultrasound (USG) are being used as adjunctive procedures in these category of patients.[24] Though a definitive diagnosis is possible with non-invasive imaging in most lesions yet biopsy / fine needle aspiration cytology are considered as gold standard for obtaining reliable results.[24-26] Since the majority of lesions are benign, surgical is unnecessary unless the clinical signs and symptoms warrant for it.[24]

Breast cancers are associated with tumour angiogenesis. Increased number of blood vessels, increased vascular permeability, increased tumour blood volume, arteriovenous shunt formation, altered capillary bed transit time and increased interstitial pressure due to absent lymphatic vessels in tumours result from tumour angiogenesis and create characteristic, identifiable patterns including the distribution pattern of intravenously injected contrast medium that can be distinguished from those associated with benign lesions. This positive rim sign can also be delineated by colour doppler ultrasound system. Vessel density in fibroadenoma is more uniform throughout the tumour than in carcinoma, with no statistical difference between periphery and centre. Rim enhancing carcinoma is observed to have varying degrees of central desmoplasia associated with lower vessel density. In one study, rim enhancement was observed in 5 of 16 carcinoma but none of the rim enhancing carcinoma exhibited central necrosis.[24]

XRM can help physicians determine whether a lesion is potentially malignant and also screens for occult disease in the surrounding tissue.[27-29] Radio-opaque ball bearings marks the location of the mass and spot compression and magnification views can clarify the breast mass and determine its density.[30,31] If old films are available, they are compared with the new images. XRM is up to 87%

accurate in detecting cancer while its specificity is 88% with a positive predictive value may be as high as 92%.[4,32-36]

SM can effectively distinguish solid from cystic masses, which account for approximately 25% of breast lesions.[4,32] When strict criteria for cyst diagnosis are met, SM has a sensitivity of 89% and specificity of 78% in detecting abnormalities in symptomatic women.[12] Recurrent or complex cysts may signal malignancy; therefore, further evaluation of these lesions is required.4 Although SM is not considered a screening test, it is more sensitive than XRM in detecting lesions in especially in women with dense breast tissue. It is not only useful in discriminating between benign and malignant solid masses but is also superior to XRM in diagnosing clinically benign palpable masses (up to 97% accuracy versus 87%).[32,35,37] In our study, SM had a sensitivity of 92.86% and specificity of 72.73% which is similar to previous studies in literature. Literature describes XRM as a well-established diagnostic modality for the breast pathologies with high diagnostic yield but is not 100% accurate.[38,39] However, when XRM is combined with SM, significant improvement in accuracy rates can be expected.

The primary objective of our study was to evaluate the diagnostic performance of real-time freehand elastography in different breast masses with histopatho-/cytopathological correlation. Our study revealed that elastography has a sensitivity of 97.62% with specificity of 88.89% for combined detection of malignant & benign breast lesions and a sensitivity of 97.62% with Specificity of 100% for isolated detection of malignant/benign breast lesions. Itoh et al,[9] published one of the first clinical trials aimed at evaluating he diagnostic possibilities of elastography by examining 111 nodules (59 benign,[] 52 malignant; confirmed by cytology/histology) with a dimension of less than 30mm in diameter. SM images were classified according to the BI-RADS criteria and elastography images according to a 5 level score system proposed by the authors. Mean score of elasticity was significantly higher in malignant lesions (score 4.2 ± 0.9) than in benign lesions (score 2.1 ± 1). Using a cut-off value between 3 and 4, elastography achieved a sensitivity, specificity and accuracy of 86.5%, 89.8% and 88.3%, respectively. Using a cut-off value between 4 and 5, elastography reached a sensitivity, specificity & accuracy of 71.2%, 96.6% and 84.7% respectively. An elastography sensitivity of 77.6% & 79.6% and specificity of 91.5% & 84.5% were the results of examination of 108 breast lesions by two examiners in a study published by Thomas A et al.[17] Zhiet al,[40] in a recent study demonstrated that SE is the most specific, with specificity of 95.7% and with lowest false positive rate of 4.3%.

SE complements conventional B-mode ultrasound by providing information about lesion mechanical properties. Strain Elastography requires continuous transducer compression or external mechanical compression through respiratory movements and cardiac pulsations.[41] Disadvantage of this technique is that compression cannot be quantified and the compression site cannot be restricted to the area of interest, leading to movement of target and distortion of measured results. Shear-wave Elastography employs automatically generated impulses to induce shear waves within the area of interest and therefore does not rely on the operator to apply appropriate manual pressure.[41] Moreover, quantitative measurements such as shear-wave velocity (SWV) measured in m/s are available in shear-wave elastography.

In present study, the lesions showing 'X.XXm/s' at least once were considered to be unmeasurable and regarded as the malignant lesions since they were extremely dense. Various causes for shear-wave velocity display as 'X.XXm/s' are tissue heterogeneity in ROI, the low amplitude of shear wave, high noise-to-signal ratio is high and extremely high velocity of shear wave is.[42] The suggestions for managing 'X.XXm/s' readings include repeated measurements (up to 23),5 placing ROI on the margin of area of interest,[42] and substitute 9.10 m/s for 'X.XXm/s'.[43,44] Our results indicated that a breast lesion that could not be quantitatively assessed by VTTQ was suspicious for malignancy and the diagnosis was confirmed by FNAC as malignant lesion. Almost all the malignant lesions were characterized as unmeasurable, which was a significantly higher rate than seen for benign lesions or normal tissues ($p<0.001$). Furthermore, the high rate was similar to rate observed by other studies.[42,43] Although an unmeasurable lesion cannot definitively be determined to be benign or malignant, our findings can be very useful for clinical practice.

Tozaki et al,[42] in their study investigated 30 mass lesions of breast (13 benign & 17 malignant). They noticed that mean SWV of malignant lesions was significantly higher than that of benign lesions (4.49 versus 2.68 m/s) with $p<0.01$, which is partly congruent with our results. However, we found higher SWVs, which can be explained, as we obviously used a different approach to perform the measurements. Tozaki et al performed two measurements in each lesion: the "internal" value assessed SWV in the center of the lesion, and the "marginal" value assessed the SWV at the margin of the lesion. When measuring the internal value, they experienced a failure (indicated as X.XX m/s) rate of 82.4%, which is quite close to that in our study. Furthermore, the failure rate for measurement of the marginal value was 25.5%. The significant differences between the benign and malignant lesions in their study were based on the marginal values.

Jin et al,[45] reported the SWV of 56 malignant and 66 benign breast masses categorized as BI-RADS-IV in B-mode ultrasound. The authors calculated the SWV ratio of the mass and the surrounding parenchyma and concluded that the mean SWV ratio of benign lesions (2.44 ± 1.27) was lower than that of malignant lesions (5.74 ± 1.68) with p<0.001). Jin et al further reported an overall failure rate of 16.4% in benign and malignant masses, calculated as the rate of obtaining X.XXm/s on repeated attempts. But in our study, the results obtained with the shear wave elastography were more accurate than this study.

The results of our study are similar to the study by Bai et al, in which it was reported that during SWV of 102 benign lesions and carcinomas,[41,44] a failure rate of 63.4% for malignant lesions was found. Bai et al postulated that a result of X.XXm/s indicates that the SWV is too fast and exceeds the upper limit of possible measurement (9.10 m/s). Therefore, the authors replaced X.XXm/s by a value of 9.10 m/s, and in this way, the SWVs of the malignant masses were represented by a range of values from 1.17 to 9.10 m/s (mean = 5.96 ± 2.96 m/s), which was significantly higher than the SWV in the benign masses (mean = 2.25 ± 0.59 m/s) with p< 0.001.

In the study by Kim et al,46 it was demonstrated that qualitative and quantitative elasticity is clinically relevant. The modified BI-RADS scores improved with SM specificity, accuracy and PPV with no statistical differences observed in test sensitivity or NPV in differentiation of benign and malignant breast lesions. This result may mean that a combination of SM & SE could assist in decision-making process regarding possible invasive procedures, such as biopsy.

The literature shows that the only radiological technique that has significant impact on diagnosis, staging and patient follow-up in case of screening asymptomatic breasts for cancer is low-dose XRM, hence the only reliable screening test proven in breast imaging. Although it is an effective screening tool, it does have limitations, particularly in women with dense breasts. Recent studies show that computer-aided detection, SM and breast MRI are frequently used adjuncts to XRM in today's clinical practice and these techniques enhance the radiologist's ability to detect cancer and assess disease extent, which is crucial in treatment planning and staging.

Though VTTQ values of SE obtains the elastic value by measuring SWV directly is more direct and objective44 yet there are still some limitations of VTTQ as it cannot be completely separated from SM and sensitivity of VTTQ for lesion <10mm is lower. Also VTTQ is associated with some misdiagnosis related to pathological types of lesion. When there is calcification, sclerosis or hyalinization in benign lesions, SWV tends to be higher. Last but not the least, as external pressure could also bias the results, and it could not be standardized at present,43 the VTTQ may be less objective as we think.

Limitations of the Study:

1. The study was observer-biased as while analysing SE, the observer was not blinded with XRM findings.
2. Results of the SE were not correlated with size of the lesion.
3. Since sample size of our study is small, results of our study cannot be extrapolated to a larger population.
4. Another limitation is the use of ARFI VTTQ in our study which is a relatively new technology with its inherent shortcomings that can be listed as follows:
   a. Limited data is available about impact of tumor size, optimal measurement point within the lesion, influence of density of surrounding tissue, the distance from skin on the SWV measurement and the variance of SWV when repeatedly measuring the same region.
   b. Pre-compression seems to have a significant effect on measurements, and a major bias may result if different degrees of pre-compression applied to the tissue.41,43
   c. The Acuson S2000 system displays SWV >9 m/s as X.XXm/s, consequently the difference in SWV between different lesions may be underestimated.
   d. The larger ROI on Virtual Touch Tissue quantification results in volume averaging which may hamper the ability to reveal the actual stiffness of small target tissues.
   e. Last but not the least, breast ARFI is only available with a 4–9-MHz linear probe, which is lower than that used for SM.
5. We have not correlated sonoelastography with histopathologic type of benign / malignant lesion.
6. Last but not the least, the sizes of malignant and benign lesions in our study were relatively larger, which may have resulted in higher sensitivity in our study population.

CONCLUSION

Based on the findings in our study we can conclude

1. Benign palpable lesions of breast are commoner in younger age group while malignant lesions are common in middle-aged to elderly females.
2. Among the palpable breast lesions, benign lesions outnumber the malignant lesions
3. Sonomammography can differentiate solid and cystic lesions of the breast.
4. Sonomammography is superior to x-ray mammography in differentiating benign and malignant lesions.
5. Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value & Accuracy of sonomammography revealed improvement when sonoelastography was included in imaging protocol.

6. Sensitivity & Specificity of elastography in detecting benign & malignant lesions is nearly similar however the NPV for malignant lesions is higher.
7. Accuracy of sonomammography with addition of sonoelastography was noted to be significantly higher than x ray mammography and sonomammography alone.
8. Clinically palpable breast lesion is the commonest indication for x-ray mammography in addition to the screening of breast for carcinoma however with the advent of modern USG scanners; growing concern over radiation exposure and relative inability of x-ray mammography to pick up malignant lesions with confidence, sonomammography has become popular. Sonoelastography has added another dimension to sonomammography. However, sonoelastography is limited by its availability and operator expertise.

Summary

Though MR mammography is a gold standard imaging tool for differentiating benign from malignant lesions of breast yet its higher scan time, need for contrast injection, limited availability and expensive nature are major deterrent factors in its utilization. Sonoelastography along with sonomammography in the expert hands when performed on a USG scanner of good quality can yield results of higher accuracy than X-ray mammography and sonomammography guiding appropriate management in day-to-day clinical practice.

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