Section: Radiology

Original Research Article

TO COMPARE DIFFERENT METHODS FOR DETECTING BREAST ABNORMALITIES

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Abstract

Background: To compare different methods for detecting breast abnormalities. **Materials and Methods:** Prospective study was done in the department of radiology, Continental Hospitals, Nanakaramguda, Hyderabad. 50 women presenting with breast swelling and confirmed by ultrasonography were included in this study. Patients with a breast mass on ultrasonography and which are subsequently confirmed by FNAC / BIOPSY was included in the study. **Results:** Based on USG 26 patients [52%] showed benign features, corresponding elastography performed on these 26 patients 21[80.7%] of them showed benign features, comparing the USG findings and corresponding elastography features on this 50 patients sensitivity and specificity of malignant lesions was 82% and 95% respectively with accuracy rate of 88%. Based on ultrasound 26 patients [52%] showed benign features, and corresponding FNAC performed on these 26 patients, 22[84.6%] of them showed benign features, so comparing the ultrasound findings and corresponding FNAC on these 50 patients' sensitivity and specificity were 85.7% and 100 % respectively with an accuracy rate of 92%. Based on elastography 22 [44%] patients showed benign features and corresponding FNAC performed on them 17 [77.2%] patients showed benign features, so comparing the ultrasound findings and corresponding FNAC on these patients Sensitivity and Specificity was 82.1% and 77.3% respectively with an accuracy rate of 80%. Based on strain ratio 22 [44%] patients showed benign features and corresponding FNAC performed on them 18 [81.8 %] patients showed benign features, so comparing the ultrasound findings and corresponding FNAC on these patients Sensitivity and Specificity was 85.7 % and 81.8 % respectively with an accuracy rate of 84%. **Conclusion:** We believe that the combined use of elastography and strain ratio can complement conventional B mode ultrasound with improving its diagnostic performance in distinguishing benign form malignant lesions of breast with considerable decrease in the rate of unnecessary biopsies in benign lesions.

INTRODUCTION

Elastography-based imaging techniques have received substantial attention in recent years for non-invasive assessment of tissue mechanical properties. These techniques take advantage of changed soft tissue elasticity in various pathologies to yield qualitative and quantitative information that can be used for diagnostic purposes.[1-3] Mammography and ultrasound are often used in conjunction to characterize breast masses and assess the risk of malignancy. Ultrasound elastography has been introduced as a complementary modality for improving lesion characterization. Elastography may assess the stiffness of a lesion by mapping the strain in tissue elements subjected to an external compression Today two technical solutions are available for clinical use, Strain Elastography and Shear Wave Elastography. Mammography and Ultrasonography are the diagnostic methods which have shown the highest sensitivity in the detection of breast cancer. However, both methods present some limitations. Mammography performed in dense breasts may yield false negative results. USG is sensitive in the detection of lesions but specificity is poor and most solid lesions are benign. In order to obtain an acceptable specificity various characteristic of the lesions must be evaluated according to BIRADS Criteria defined by American College of Radiology. Unfortunately, BIRADS Criteria generated significant false positive results. These limitations lead to an increase in biopsies with a

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cancer detection rate of 10% to 30%. Many biopsies are performed in benign lesions causing discomfort to the patients and are highly expensive. To overcome these limitations and to obtain a more accurate characterization of breast lesions, USG Elastography was introduced. USG Elastography is noninvasive and assesses the tissue deformity by providing information on the elasticity. It is based on the premise that they are significant differences in mechanical properties of the tissue that can be detected by applying an external mechanical force. Elastography has been proved to be highly specific in evaluating the lesions situated in various organs. However, this technique is still new and considering that there are several solutions in clinical practice. Elasticity is the property of a body or a substance that enables it to be deformed when it is subjected to an external force and resume its original shape or size when the external force is removed. Different tissues are expected to respond differently according to the specific elastic modulus. Tissue deformity is inversely proportional to stiffness of the material and responds time. In general adipose tissue is more easily deformed than other tissues, whereas the fibrous tissue returns to its original state more slowly when compared to the adipose and muscle tissues.[2-6]

MATERIALS AND METHODS

Prospective study was done in the department of radiology, Continental Hospitals, Nanakaramguda, Hyderabad. 50 women presenting with breast swelling and confirmed by ultrasonography were included in this study.

Inclusion Criteria

Patients who presenting in the Department of Radio Diagnosis Continental Hospitals, Hyderabad with a breast mass on ultrasonography and which are subsequently confirmed by FNAC / BIOPSY was included in the study.

Exclusion Criteria

Patients who have already been diagnosed.

Methodology

Conventional B-mode US, ultrasound elastography and strain ratios were performed for all patients in the same session by using a 3-12 MHZ linear array transducer connected to a real time USG machine (Samsung medison RS80A). After an informed consent from the patient, the patient was positioned in a supine position with the arms placed behind the head over a pillow. Both breasts were examined in all patients by conventional B – mode US and images of the target lesions were primarily obtained.

A radial – ductal examination was done by placing the transducer perpendicularly to the skin but radially on the breast ,with one end overlapping the areola and the other end directed peripherally away from the areola .The transducer was then rotated around the areola .When a duct was recognized ,the rotation of the transducer was paused and it was moved back and forth laterally for detailed evaluation of the duct and its branches as well as the lobules. The transducer was then rotated again to reach the next ducto-lobular complex.

This procedure was repeated until all ductal structures were evaluated. A second rotating sweep was performed over the upper outer peripheral part of each breast. After recognition of a target lesion on a B – mode US image, and ultrasound elastography were performed for the lesion.

The US features of the identified breast masses were classified according to the ACR BI- RADS US lexicon, based on the analysis of US descriptors of six morphologic features including the shape, orientation, margin, lesion boundary, internal echo pattern and posterior acoustic features.[7] Lesions with BI- RADS categories 1 and 2 were considered as benign, BIRADS category 3 as indeterminate, and those with BIRADS 4 and 5 as malignant.[8]

Features suggestive for malignancy were speculation, unparallel orientation (taller than wider), angular margins, shadowing, branching pattern, hypoechogenecity, calcifications, duct extension, and microlobulations.[9] Features suggestive of benign breast masses include smooth and well circumscribed hyperechoiec ,isoechoiec or mildly hyperechoiec masses with thin echogenic capsule ,oval shape ,with paralleled orientation(maximum diameter being in the transverse plane), three or fewer gentle lobulations and absence of any malignant findings.[9]

No additional pressure in terms of free hand compressions was used during scanning of USG elastographic images. Although elastographic machine uses “strain” technology, physiological stimuli, such as patient respiration, caused the required strain in tissue deformation.

The elasticity images were obtained with the elasticity color map, superimposed on the B- mode images, and displayed on the left side of a dual–display image while the corresponding B – mode was on the right in order to maintain continuous real – time visualization. The region of interest (ROI) was set with in a box highlighted manually. Each ROI included the breast mass and sufficient adjacent tissue up to 0.5 cms with inclusion of the subcutaneous layers and pectoralis muscle but without involvement of costal cartilages.

Each lesion were assessed using 256- level color mapping (red-green-blue) elastography: green indicated average stiffness of the tissue ,blue indicated hard tissue ,and red indicated soft tissue which was described by ITOH et al.[10] The elasticity color scale by ITOH et al[10] was as follows: On the basis of the overall pattern, we assigned each image an elasticity score on a five-point scale with the score of 0 lesions having a unique red-green-blue signature that is seen with simple cystic lesions. A score of 1 indicated even strain for the entire hypoechoiec lesion (i.e., the entire lesion was evenly shaded in green). A score of 2 indicated strain in most of the hypoechoiec lesion, with some areas of no strain (i.e., the hypoechoiec lesion had a mosaic pattern of green

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and blue). A score 3 indicated strain at the periphery of the hypoechoiec lesion, with sparing of the centre of the lesion (i.e., the peripheral part of the lesion was green, and the central part was blue). A score of 4 indicated no strain in the entire hypoechoiec lesion (i.e., the entire lesion was blue, but its surrounding area was not included). A score of 5 indicated no strain in the entire hypoechoiec lesion or in the surrounding area (i.e., both the entire hypoechoiec lesion and its surrounding area were blue) based on the criteria by ITOH etal. For comparison of techniques, elastography scores were matched with the BIRADS categories, with a BIRADS II lesion corresponding to elastography scores of 1 and 2, and one to one correspondence for the other categories.

In our study, the SR value was calculated automatically based on the average strain measured in the lesion compared to adjacent adipose tissue in the breast. The average strain of the lesion was determined by selecting a representative ROI from the centre of the lesion, and this was expressed as *ST-ave LESION*.A corresponding ROI of adjacent adipose tissue was then selected and expressed as *ST – ave FAT*. The resultant SR value was expressed as a ratio according to the equation *ST – ave FAT/ST – ave LESION = SR*. The ratio value increases as a function of the relative stiffness of the target lesion. As the SR increases, the likelihood of invasive breast cancer increases.[11]

In our present study based on the strain ratio, we took a cut off of 4 and lesions above the SR value of 4 were considered malignant and below 4 were considered benign.

Cytological examination – FNAC was performed and cytological results were classified based on the most commonly used categorization which is a five tier system, with categories ranging from insufficient materials (C1), benign (C2), atypical (C3), suspicious for malignancy(C4) or frankly malignant (C5).[35]

RESULTS

Out of 50 patients of the present study most of the patients are between the age groups of 41-50[28%] followed by the patients between 31-40 and 51-60 [22%] respectively and above age groups of 60 [18%] and below age group of 30 [10%] respectively.

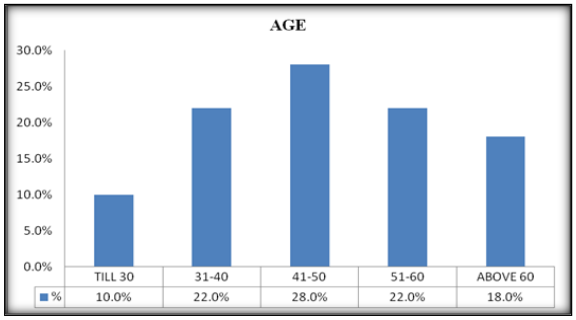

Figure 1: Diagram -1 Bar diagram representing different age groups

In the present study out of 50 patients, 27 patients were presented on left side [54.0%] and 23 patients presented on right side [46.0%]

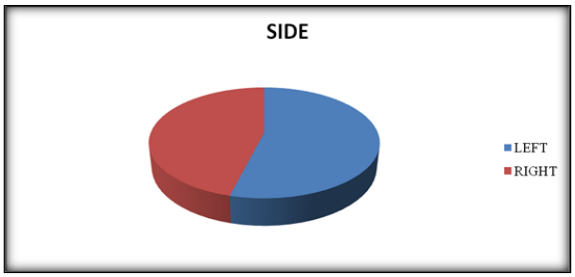

Figure 2: Pie chart representing laterality of breast

In the present study 26 patients [52%] showed benign features and about 24 patients [48%] showed malignant features

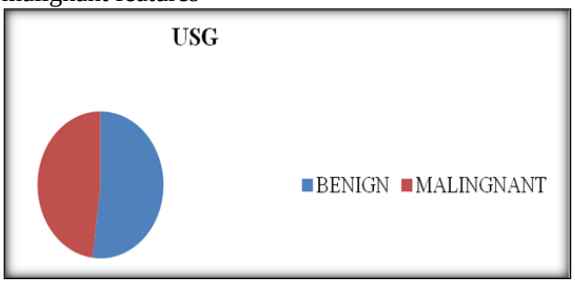

Figure 3: Pie chart representing the frequency of benign and malignant lesions in respect to ultrasound features of breast

In the present study 22 patients [44%] showed benign features and 28 patients [56%] showed malignant features according to elastography.

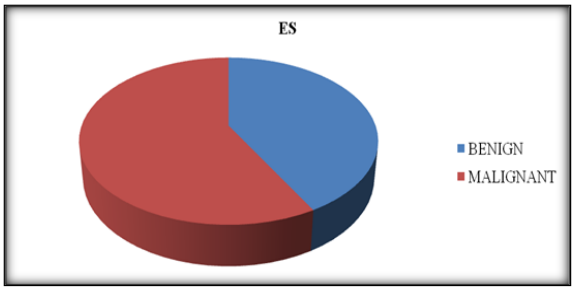

Figure 4: Pie chart representing the frequency of benign and malignant lesions in respect to elastography

In the present study out of 50 patients 22 patients showed benign features and 28 patients showed malignant features according to histopathology. [Table 1]

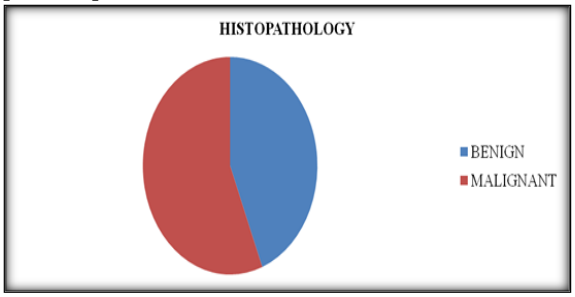

Figure 5: Pie chart representing the frequency of benign and malignant lesions in respect to histopathology

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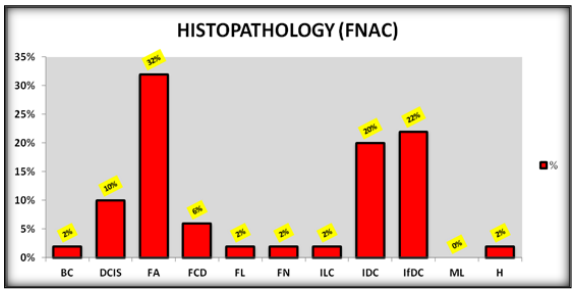


Figure 6: Bar diagram showing Various Fnac / Histopathology findings

In the present study of 50 patients based on ultrasound 24 patients [48%] showed features of malignancy and corresponding elastography performed on this 24 patients ,23[95.8%] of them showed malignant features

Based on USG 26 patients [52%] showed benign features, corresponding elastography performed on these 26 patients 21[80.7%] of them showed benign features, comparing the USG findings and corresponding elastography features on this 50 patients sensitivity and specificity of malignant lesions was 82% and 95% respectively with accuracy rate of 88%. [Table 3]

In the present study of total 50 patients, based on ultrasound 24 patients [48%] showed features of malignancy and corresponding FNAC performed on these 24 patients, all 24[100%] of them showed malignant features

Based on ultrasound 26 patients [52%] showed benign features, and corresponding FNAC performed on these 26 patients, 22[84.6%] of them showed benign features, so comparing the ultrasound findings and corresponding FNAC on these 50 patients' sensitivity and specificity were 85.7% and 100 % respectively with an accuracy rate of 92%. [Table 4]

In our present study out of total 50 patients, based on elastography 28[56%] patients showed features of malignancy, and corresponding performed on these 28 patients ,23[82.1%] patients showed malignant features

Based on elastography 22 [44%] patients showed benign features and corresponding FNAC performed on them 17 [77.2%] patients showed benign features, so comparing the ultrasound findings and corresponding FNAC on these patients Sensitivity and Specificity was 82.1% and 77.3% respectively with an accuracy rate of 80%. [Table 5]

In our present study out of 50 patients, based on strain ratio 28 patients [56%] are malignant and corresponding FNAC performed on these 28 patients, 24 patients [85.7 %] were malignant.

Based on strain ratio 22 [44%] patients showed benign features and corresponding FNAC performed on them 18 [81.8 %] patients showed benign features, so comparing the ultrasound findings and corresponding FNAC on these patients Sensitivity and Specificity was 85.7 % and 81.8 % respectively with an accuracy rate of 84%. [Table 6]

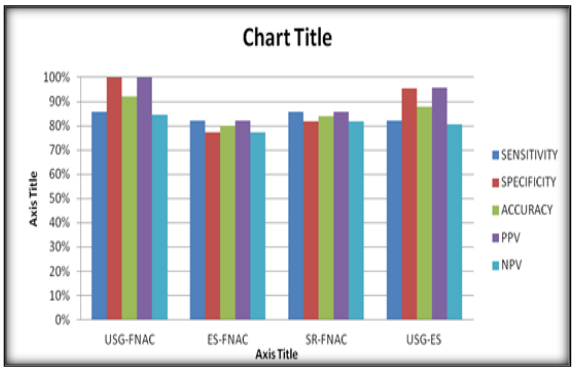
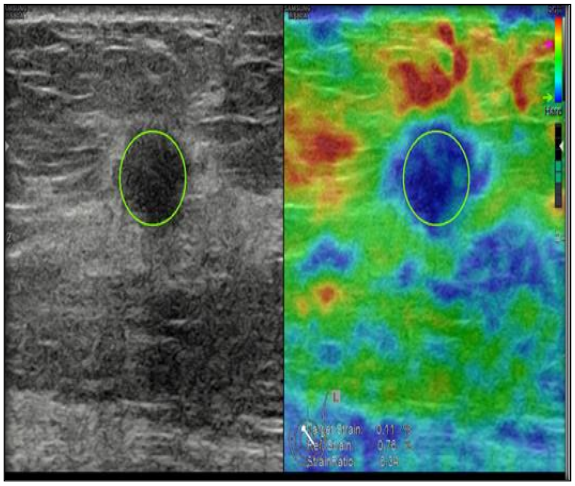
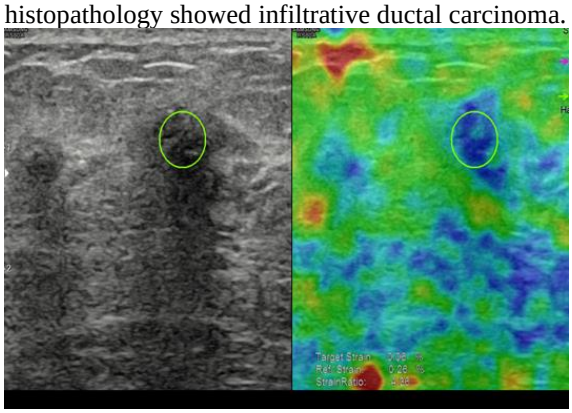


Figure 7: Bar diagram showing the comparison of various techniques used in present study in detection of breast lesions



CASE -1

Ultrasound shows an ill-defined hypoechoiec lesion with irregular margins. Elastography shows low strain pattern of the lesion and adjacent tissues [score 5 blue colours in the lesion and adjacent surrounding tissue given by Itoh etal corresponding stain ratio is 6.3 which is suggestive of malignancy, on subsequent histopathology showed infiltrative ductal carcinoma.



CASE - 2

Ultrasound shows a irregular hypoechoiec lesion with irregular margins. Elastography shows low strain pattern of the lesion [score 4 blue colour in the lesion given by Itoh etal corresponding stain ratio is 4.3 which is suggestive of malignancy, on subsequent histopathology showed infiltrative ductal carcinoma.

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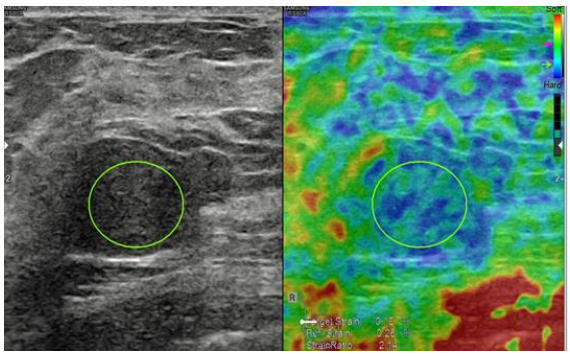
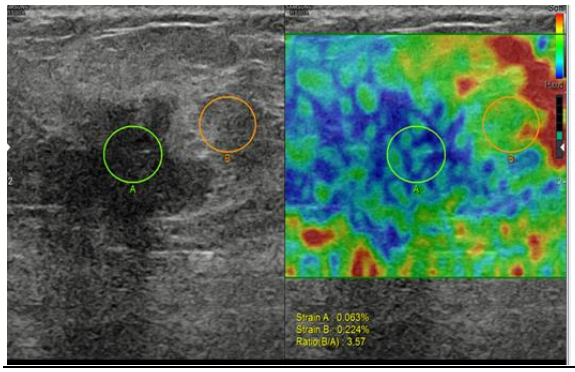


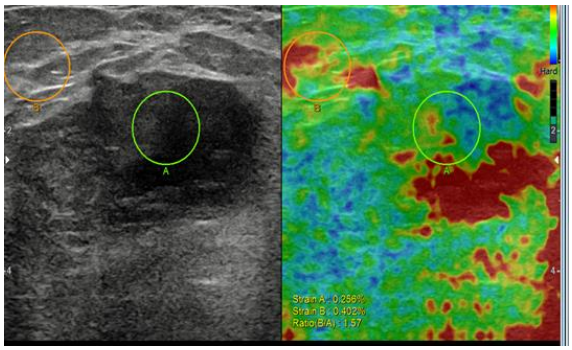
CASE - 3

Ultrasound shows a well circumscribed hypoechoiec lesion with regular margins. Elastography shows mostly intermediate stiffness and a score of,[3] (peripheral; central blue area that is surrounded by green peripheral colour was given according to Itoh et al corresponding stain ratio of 2.1 which is significant of benign lesion, subsequent histopathology confirmed as fibro adenoma.



Case – 4

Ultrasound shows an ill-defined hypoechoiec lesion with irregular margins. Elastography shows low strain pattern of the lesion in the centre and high strain pattern in the periphery [score 3 blue colour in the lesion in the centre with peripheral green colour pattern] given by Itoh etal corresponding stain ratio is 3.5 which is suggestive of benign, on subsequent histopathology showed infiltrative ductal carcinoma.



CASE -5

Ultrasound shows an ill-defined hypoechoiec lesion with irregular margins. Elastography shows high strain pattern in most of the lesion [score 2 shows mosaic pattern of green & blue colours] given by Itoh etal corresponding strain ratio is 1.5 which is suggestive of benign, on subsequent histopathology showed infiltrative ductal carcinoma.

Table 1: Number of Benign and malignant lesions in respect to histopathology

HISTOPATHOLOGY	FREQ	%
BENIGN	22	44%
MALINGNANT	28	56%
TOTAL	**50**	**100%**

Table 2: Tables showing various FNAC [Histopathological] findings

HISTO	FREQ	%
Benign Cyst (BC)	1	2%
Ductal Carcinoma insitu (DCIS)	5	10%
Fibro Adenoma (FA)	16	32%
Fibro Cystic Disease (FCD)	3	6%
Fibro Lipoma (FL)	1	2%
Fat Necrosis (FN)	1	2%
Invasive Lobular Carcinoma (ILC)	1	2%
Invasive Ductal Carcinoma (IDC)	10	20%
Infiltrating Ductal Carcinoma (IfDC)	11	22%
Hamartoma	1	2%
TOTAL	50	100%

Table 3: Sensitivity and Specificity of Ultrasound vs. Elastography

	Elastography score		
	Malignant	Benign	
USG	M	B	TOTAL
Malignant	23	1	24
Benign	5	21	26
TOTAL	28	22	50

Sensitivity = 23 / 28 x 100 = 82% Specificity = 21 / 22 x 100 = 95%
PPV = 23 / 24 x 100 = 96% NPV= 21 / 26 x 100 = 81%

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Table 4: Table representing detection of lesions by USG Vs histopathology

	Histo pathology [FNAC]	Histopathology [FNAC]	
	Malignant	Benign	Total
USG Malignant	24	0	24
USG Benign	4	22	26
TOT	28	22	50

Sensitivity = 24 / 28 x 100 = 86% Specificity = 22 / 22 x 100 = 100%
PPV = 24 / 24 x 100 = 100% NPV = 22 / 26 x 100 = 85%

Table 5: Table representing detection of lesions by elastography vs. FNAC

	Histopathology [FNAC]	Histopathology [FNAC]	
	Malignant	**Benign**	**Total**
Elastography Malignant	23	5	28
Elastography Benign	5	17	22
Total	28	22	50

Sensitivity = 23 / 28 x 100 =82 % Specificity = 17 / 22 x 100 = 77%
PPV = 23 /28 x100 = 82 % NPV = 17 / 22 x 100 = 77%

Table 6: Table representing detection of lesions by Strain ratio vs. FNAC

	Histopathology FNAC	Histopathology (FNAC)	
	Malignant	**Benign**	**Total**
Strain ratio Malignant	24	4	28
Strain ratio Benign	4	18	22
Total	28	22	50

Sensitivity - 24 / 28 x 100 = 86 % Specificity - 18 / 22 x 100 = 82%
PPV – 24 / 28 x 100 = 86 % NPV – 18 / 22 X 100 = 82%

Table 7: Comparison of various techniques used in our study in detection of breast lesions

	USG-Elasto graphy	USG-Histo pathology	Elastography –Histo pathology	Strain ratio – Histo Pathology
ACCURACY	88%	92%	80%	84%
SENSITIVITY	82%	86%	82%	86%
SPECIFITY	95%	100%	77%	82%
NPV	81%	85%	77%	82%
PPV	96%	100%	82%	86%

DISCUSSION

Ultrasonographic elastography is a non-invasive medical imaging technique that discriminates masses based on their hardness.[12] The interpretation of breast nodules detected on B-mode US relies mainly on morphological criteria. To improve the accuracy of USG, additional techniques can be used, including Doppler and harmonic imaging. Over the last decade, there has been increasing interest in imaging the elasticity of biological tissues to complement information from standard anatomical imaging. SE can differentiate between benign and malignant lesions on the basis of their firmness. The lesion's contours, dimensions, color, SR, and appearance on elastography are some of the criteria used for differentiating benign from malignant lesions. The SR represents the relative compliance stiffness of lesions compared with surrounding tissues. Malignant lesions, which are very stiff, deform less and are displayed in blue on the elastography images, whereas benign lesions deform much more easily and are depicted in green color.[13] Results of the clinical use of SE were initially published in 1997–2001 but it was only in 2003–2004 that US equipment was developed that had incorporated software for real-time processing of elastography images and routine US examinations. For characterization of breast lesions, two elasticity scoring systems have been proposed: the Tsukuba score developed by Itoh and Ueno and another designed by the Italian Research Group after Locatelli, Rizzatto et al.[13]

This prospective study was carried out in 50 patients who were referred to the department of radio diagnosis with palpable mass in the breast and few of them were associated with pain.

Females with age group of more than 17 years were included in the study most of the patients in our study belong to the age group of 41-50 years [28%], and of [22%] of patients were between 31 to 40 and 51 to 60 years of age group. And remaining, 18 % of the patients were above 60 years of age, with mean age of 45 years [SD-14.23]

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Out of 50 patients, 27 [54%] patients were presented with left side breast lesion and 23 [46%] of them were presented with right side breast lesion.

Out of 50 patients 26 patients [52%] showed benign features and 24 patients [48%] showed malignant features in respect to ultrasound

According to elastography out of 50 patients 23 patients [46%] showed benign characteristics and 27 patients [54%] showed malignant characteristics.

According to histopathology out of 50 patients 23 [46%] were benign,1 patient [2%] had benign cyst , 16 patients [32%] had fibro adenoma 3 patients [6%] had fibrocystic disease 1 patient [2%] had fibro Lipoma , 1 patient [2%] had fat necrosis and 1 patient [2%] had hamartoma 27 [54%] were malignant out of which 5 patients [10%] showed ductal carcinoma insitu and 10 patients [20%] showed invasive ductal carcinoma and 11 patients [22%] infiltrating ductal carcinoma and 1 patient [2%] with invasive lobular carcinoma

In the present study of 50 patients based on ultrasound 24 patients [48%] showed features of malignancy and corresponding elastography performed on these 24 patients ,23[95.8%] of them showed malignant features

Based on USG 26 patients [52%] showed benign features, corresponding elastography performed on these 26 patients 21[80.7%] of them showed benign features, comparing the USG findings and corresponding elastography features on this 50 patients' sensitivity and specificity of malignant lesions was 82% and 95% respectively with accuracy rate of 88%.

In the present study of total 50 patients, based on ultrasound 24 patients [48%] showed features of malignancy and corresponding FNAC performed on these 24 patients, all 24[100%] of them showed malignant features

Based on ultrasound 26 patients [52%] showed benign features, and corresponding FNAC performed on these 26 patients, 22[84.6%] of them showed benign features, so comparing the ultrasound findings and corresponding FNAC on these 50 patients' sensitivity and specificity were 86% and 100 % respectively with an accuracy rate of 92%.

This is in close conformity with results reported by Itoh et al who found that B –mode ultrasound based on criteria of BI-RADS had the sensitivity of 71%, specificity of 96.6% and accuracy rate of 84% of all breast lesions.[10]

In our present study out of total 50 patients, based on elastography 28 [56%] patients showed features of malignancy, and corresponding performed on these 28 patients, 23 [82.1%] patients showed malignant features.

Based on elastography 22 [44%] patients showed benign features and corresponding FNAC performed on them 17 [77.2%] patients showed benign features, so comparing the ultrasound findings and corresponding FNAC on these patients Sensitivity and Specificity was 82% and 77% respectively with an accuracy rate of 80%.

The mean elasticity score is significantly higher in malignant [4.5+_ 0.5] than benign 2.4 +_0.5] with P value of < 0.05, this is in close conformity with results reported by Itoh et al who found that when a cutoff point of between 3and 4 was used elastography had 86.5 % sensitivity, 89.8% specificity and 88.3 % accuracy.[10]

These slight differences may be probably attributed to different prevalence of breast cancer, different patient criteria as well as differences in number of study lesions and differences in the used equipment.

In our present study out of 50 patients, based on strain ratio [cut off value of 4]28 patients [56%] are malignant and corresponding FNAC performed on these 28 patients, 24 patients [85.7 %] were malignant.

Based on strain ratio 22 [44%] patients showed benign features and corresponding FNAC performed on them 18 [81.8 %] patients showed benign features, so comparing the ultrasound findings and corresponding FNAC on these patients Sensitivity and Specificity was 86 %and 82% respectively with an accuracy rate of 84%. respectively.

The mean strain ratio was significantly higher for malignant lesions [4.9+_0.9] than for benign lesions [2.1 +_0.7] with P value of <0.05

This is in close conformity of the results reported by Gheonea et al who had a sensitivity of 93.3% and specificity of 92.9% [when a cut-off points of 3.67 was used.[13]

The limitations to this study were with the sonoelastography images, as there were intra observer and Interobserver variability for acquisition of the strain index. Comparing all the above techniques of ultrasound, elastography and strain ratio the sensitivity of USG and elastography are almost similar all though the specificity of ultrasound is little bit more, when strain ratio is combined to the study it increases the sensitivity to 86% and specificity of 82%.

CONCLUSION

We believe that the combined use of elastography and strain ratio can complement conventional B mode ultrasound with improving its diagnostic performance in distinguishing benign form malignant lesions of breast with considerable decrease in the rate of unnecessary biopsies in benign lesions.

REFERENCES

1. Rosa. S, Joy.L, Ahmed.K, Maria.C, et al. Ultrasound Elastography: Review of techniques and clinical applications Theranostics .2017; 7(5):1303-1329
2. Goddi.A, Bonardi.M, Alessi.S. Breast Elastography: A literature review J Ultrasound .2012; 15(3):192-198.
3. Gennison.L, Deffieux.T, Fink.M ,Tanter.M Ultrasound Elastography: Principles and techniques , Diagnostic and Interventional Imaging 2013;94(5) :487-495
4. Cournane.S, FeganAJ, Browne JE. Review of Ultrasound Elastography quality control and training test phantoms D.I.T 2012; 20: 1-2.

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5. Mousa A E, Aboelatta M, et al. Combined sonoelastography scoring and strain ratio in evaluation of breast masses. The Egyptian Journal of Radiology and Nuclear Medicine 2012; 43: 647-656.
6. Burnside E S, Hall T J , Sommer AM et al . Differentiating benign from malignant solid breast masses with US strain imaging Radiology 2007 ;245(2):401-10.
7. Raza. S, Goldkamp. AL, Chikarmane.SA .US of breast masses categorized as BIRADS 3, 4, and 5: pictorial review of factors influencing clinical management. Radio graphics 2010; 30(5):199-213.
8. Reston.VA Breast imaging reporting & data system American College of Radiology 5th edition 2003.
9. Thomas Stavros.A, Thick man.D , Rapp.CL , et al .Solid breast nodules: use of sonography to distinguish benign and malignant lesions .NCBI 1995; 1969(1):123-34.
10. Itoh A, Ueno E, Tohno E, et al. Breast Disease: Clinical Application of Ultrasound Elastography for Diagnosis. Radiology .2006 ;239(2):341-350
11. Todd. R, Margaret.M Elastography for the characterisation of breast lesions :Initial clinical experience Cancer Control Journal of Moffitt 2010;17(3):156-61
12. Mehmet.Y , Eren .T,Ciodem.O ,The role of Ultrasonographic elastography in the differential diagnosis of breast masses and its contribution to classical Ultrasonographic evaluation J Breast health 2014;10(3):141-146.
13. Gheonea.I, Stoica.Z, Bondari.S. Differential diagnosis of breast lesions using ultrasound elastography Indian Journal of Radiological Imaging 2011; 21(4): 301-305.

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