COMPARISON OF CR MAMMOGRAPHY, SONOMAMMOGRAPHY AND REAL-TIME ELASTOGRAPHY IN EVALUATING BREAST LESIONS

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ABSTRACT

BACKGROUND

Breast cancer is the most common cause of cancer deaths in women worldwide. As early detection can decrease the deaths due to breast cancer, high sensitive and specific tests are necessary to evaluate breast lesions.

MATERIALS AND METHODS

80 patients with complaint of pain or lump in the breast or nipple discharge were evaluated by mammography, sonomammography and real-time elastography. Imaging studies were compared with the FNAC/biopsy of lesions.

RESULTS

Mammography has sensitivity, specificity, PPV, NPV as 80%, 95.5%, 93.3%, 86%, respectively. Sonomammography has sensitivity, specificity, PPV, NPV as 74.2%, 91%, 86%, 82%, respectively. Real-time elastography has sensitivity, specificity, PPV, NPV as 91.4%, 94.4%, 94.1%, 91.8%, respectively. Combined mammography and sonomammography has sensitivity, specificity, PPV, NPV as 82.8%, 93.3%, 90.6%, 87.5%, respectively. Combined sonomammography and elastography has sensitivity, specificity, PPV, NPV as 91.4%, 97.2%, 96.96%, 92.1%, respectively.

CONCLUSIONS

Combination of CR mammography, sonomammography and real-time elastography has high diagnostic sensitivity and specificity in the diagnosis of benign and malignant breast masses obviating the use of higher modalities like MRI, CAD and digital tomosynthesis, which is very useful in resource poor countries like India.

KEYWORDS

CR Mammography, Sonomammography, Real-Time Elastography, Benign and Malignant Breast Lesions.

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BACKGROUND

Breast cancer is the most common of all cancers and is the leading cause of cancer deaths in women worldwide accounting for >1.6% of deaths and case fatality rates are highest in low-resource countries.[1]

A recent study of breast cancer risk in India revealed that 1 in 28 women develop breast cancer during her lifetime. This is higher in urban areas being 1 in 22 in a lifetime compared to rural areas where this risk is relatively much lower being 1 in 60 women developing breast cancer in their lifetime.[1]

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In India, the average age of the high-risk group is 43-46 years unlike in the west where women aged 53-57 years are more prone to breast cancer.[1]

Mammography and Ultrasonography (US) 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 often yield false-negative results.[2] US is sensitive in the detection of lesions, but specificity is poor as most solid lesions are benign. Unfortunately, the BIRADS criteria generate a significant number of false-positive results.[3] This limitation leads to an increase in biopsies with a cancer "detection rate" of only 10%-30%.[4,5]

Many biopsies are performed in benign lesions causing discomfort to the patients and increased costs. To overcome these limitations and obtain a more accurate characterisation of breast lesions, US elastography was introduced. This technique combines US technology with the basic physical principles of elastography. US elastography is noninvasive and assesses tissue deformability by providing information on the elasticity.[6,7]

AIMS AND OBJECTIVES

a) Comparison of real-time elastography, greyscale sonomammography and CR mammography.
b) The effectiveness of real-time elastography to differentiate benign and malignant lesions.
c) Advantages of elastography over other imaging modalities (ultrasound/mammography).
d) To decrease invasive procedures (FNAC/biopsy).

MATERIALS AND METHODS

Source of Data

All patients with complaint of pain or lump in the breast or nipple discharge, attending OPD/admitted to Government General Hospital, Kurnool, during July 2013 - June 2015.

Method of Collection of Data

A proforma drafted for the study of all patients with pain or lump in the breast, nipple discharge. Evaluation was done by mammography, sonomammography, elastography, MRI and correlated with FNAC/biopsy.

Sample size: 80 patients.

Sampling method: Simple random sampling.

Study involves: Humans only.

Type of study: Prospective study.

Mammography

Mammography was performed with GE alpha ST machine. Both craniocaudal and mediolateral views are taken and the image was assessed and scored using the BIRADS criteria.

Sonomammography and Ultrasound Real-Time Elastography

Sonomammography and ultrasound real-time elastography examination was performed with Esaote MyLab Class 3, which has real-time elastography (stress-strain technique) with 5-10 MHz linear transducer. Greyscale ultrasound of both breasts were done by radial and grid scanning technique. The results were analysed and categorised according to BIRADS (Breast Imaging Reporting and Data System) score.

RTE was performed by compression technique and score was given according to Italian Multicenter Team of Study Colour Grading.[8] Colour coding in one Esaote machine was blue, green and red indicating hard, intermediate and soft areas, respectively (as in classification), and in other machine was red, green, blue indicating hard, intermediate and soft areas, respectively.

Score 1 lesions show a typical triple layer feature (blue-green-red from the surface to the bottom) that indicates cystic lesions. Score 2 shows almost entirely green with random blue points that indicates benignity. A score 3 shows predominantly green showing some blue spots consistent with probable benignity. Score 4 shows almost entirely blue lesion with minimal green points at the periphery that indicates suspicion for malignancy. Score 5 shows entirely blue lesion surrounded by a blue halo that indicates malignancy.

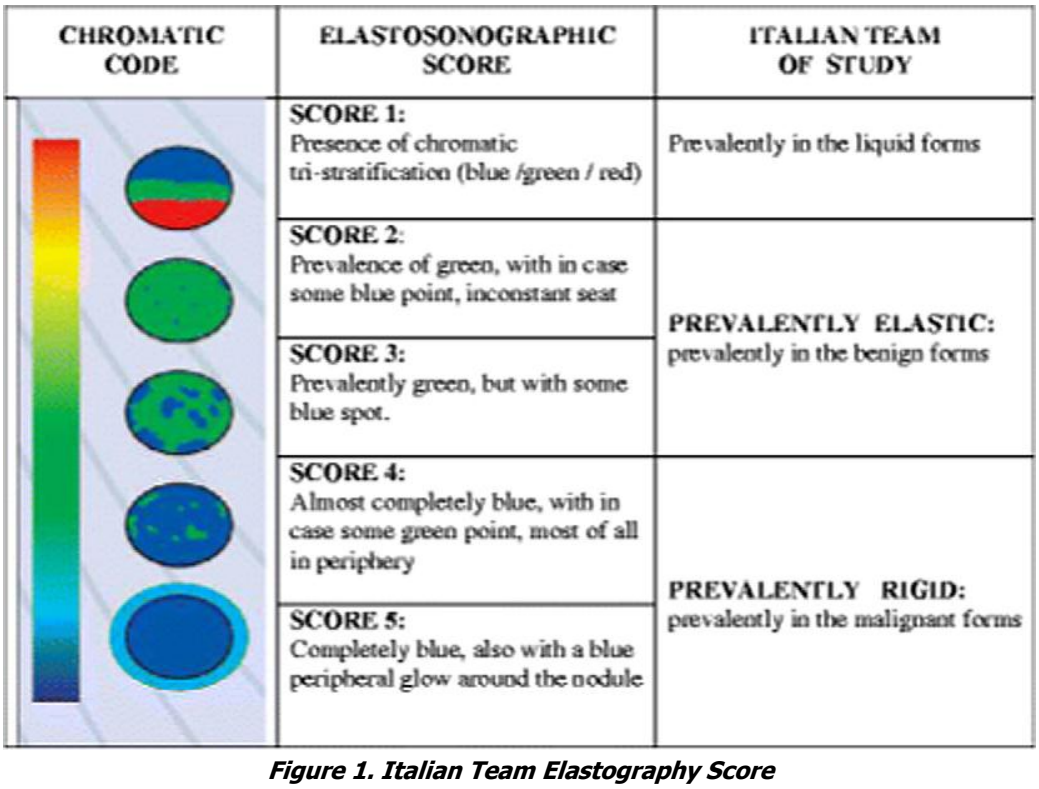


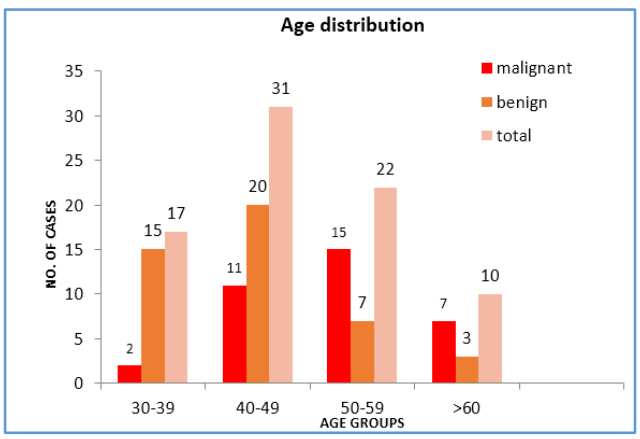
Figure 1. Italian Team Elastography Score

FNACs were performed in the most suspicious lesions in ultrasound guidance. When FNAC was inconclusive, core biopsy/excision biopsy was done. All imaging studies were done before doing FNAC.

RESULTS

Sl. No.	Age Groups (in Years)	Number of Malignant Lesions	Number of Benign Lesions	Number of Cases	%
1.	30-39	02	15	17	21.25%
2.	40-49	11	20	31	38.75%
3.	50-59	15	07	22	27.5%
4.	>60	07	03	10	12.5%
Total		**35**	**45**	**80**	**100**

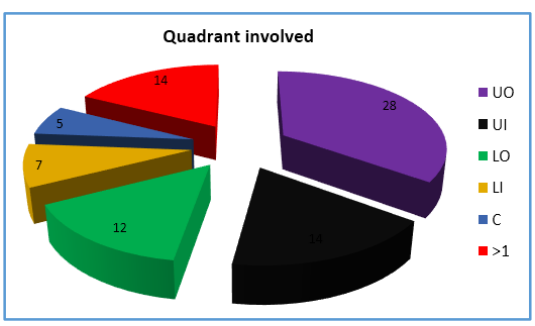
Table 1. Age Distribution of Breast Lesions



Graph 1. Age Distribution of Breast Lesions

Sl. No.	Quadrant Involved	Number of Cases	Percentage
1.	Upper Outer (UO)	28	35%
2.	Upper Inner (UI)	14	17.5%
3.	Lower Outer (LO)	12	15%
4.	Lower Inner (LI)	7	8.75%
5.	Central (C)	5	6.25%
6.	>1 quadrant	14	17.5%
Total		**80**	**100**

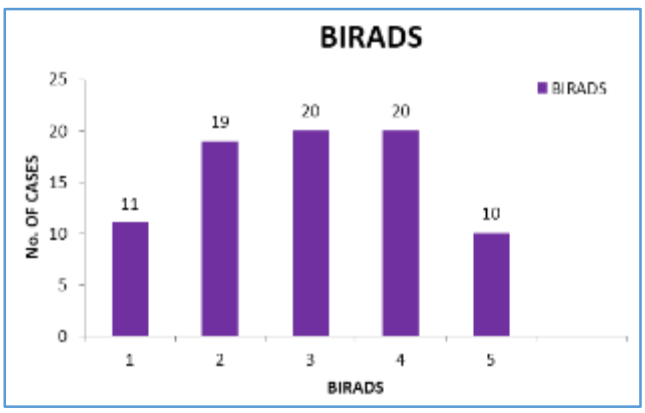
Table 2. Distribution of Breast Lesions According to Quadrant Involved



Graph 2. Distribution of Breast Lesions According to Quadrant Involved

Sl. No.	Mammographic Diagnosis (BIRADS)	Number of Cases
1.	1	11
2.	2	19
3.	3	20
4.	4	20
5.	5	10
Total		**80**

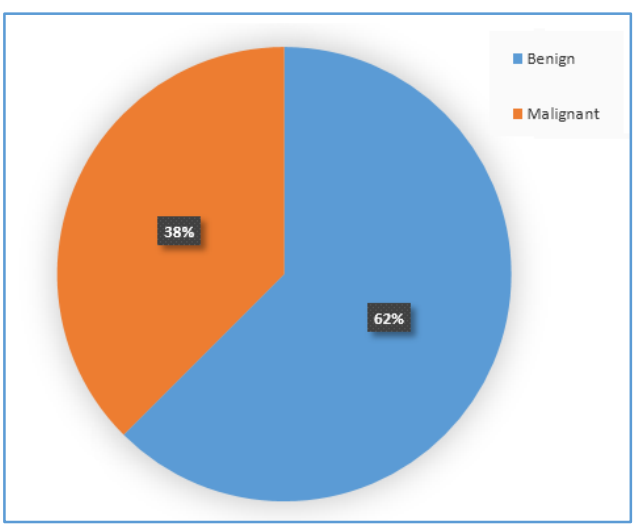
Table 3. Distribution of Cases Diagnosed by Mammography According to BIRADS Classification



Graph 3. Distribution of Cases Diagnosed by Mammography According to BIRADS Classification

Sl. No.	Lesions	Number of Cases	Percentage
1.	Benign	50	62%
2.	Malignant	30	38%
Total		**80**	**100**

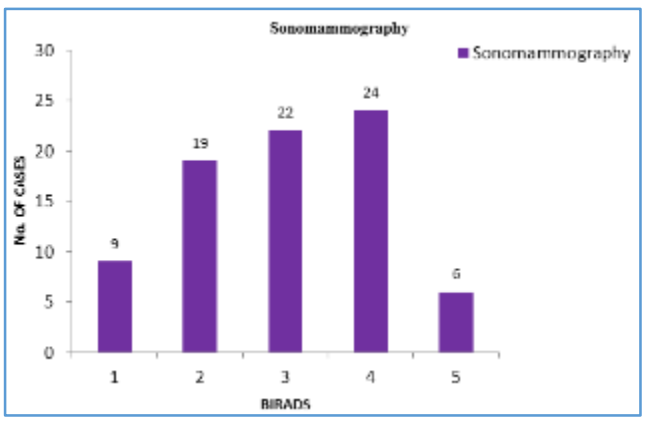
Table 4. Distribution of Benign and Malignant Cases on Mammography



Graph 4. Distribution of Benign and Malignant Cases on Mammography

Sl. No.	USG BIRADS	Number of Cases
1.	1	9
2.	2	19
3.	3	22
4.	4	24
5.	5	6
TOTAL		**80**

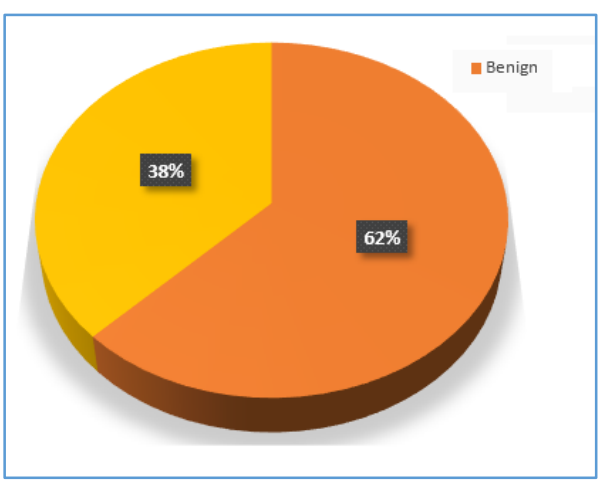
Table 5. Distribution of Cases in Sonomammography According to BIRADS Classification



Graph 5. Distribution of Cases in Sonomammography According to BIRADS Classification

Sl. No.	Lesions	Number of Cases	Percentage
1.	Benign	50	62%
2.	Malignant	30	38%
Total		**80**	**100**

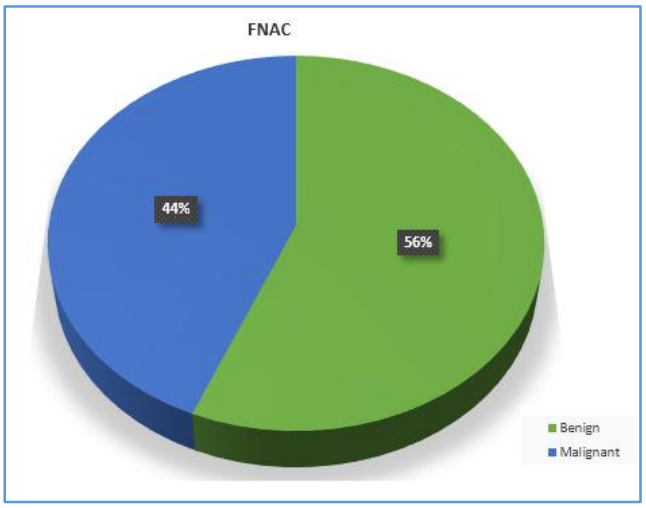
Table 6. Distribution of Benign and Malignant Cases in Sonomammography



Graph 6. Distribution of Benign and Malignant Cases in Sonomammography

Sl. No.	Lesions	Number of Cases	Percentage
1.	Benign	45	56.25%
2.	Malignant	35	43.75%
	Total	**80**	**100**

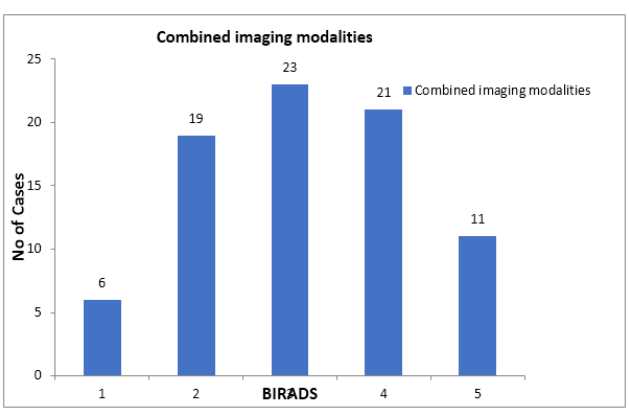
Table 7. Distribution of Benign and Malignant Cases in FNAC



Graph 7. Distribution of Benign and Malignant Cases in FNAC

Sl. No.	BIRADS	Number of Cases
1.	1	6
2.	2	19
3.	3	23
4.	4	21
5.	5	11
		80

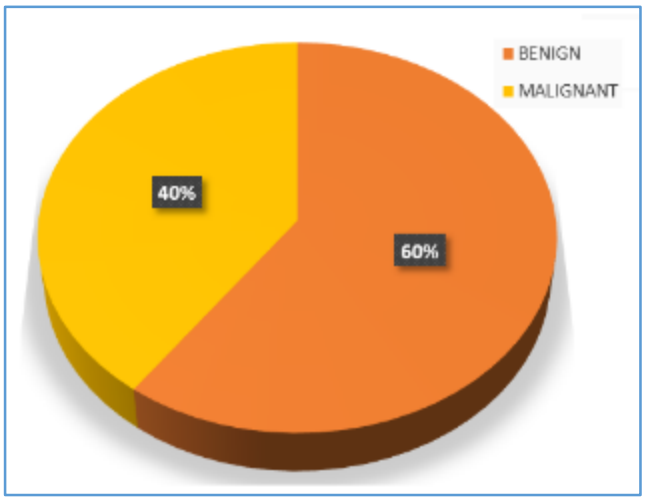
Table 8. Distribution of Cases Diagnosed by Combined Mammography and Sonomammography According to BIRADS Classification



Graph 8. Distribution of Cases Diagnosed by Combined Mammography and Sonomammography

Sl. No.	Lesions	No. of Cases	Percentage
1.	Benign	48	51.25%
2.	Malignant	32	48.75%
		80	**100**

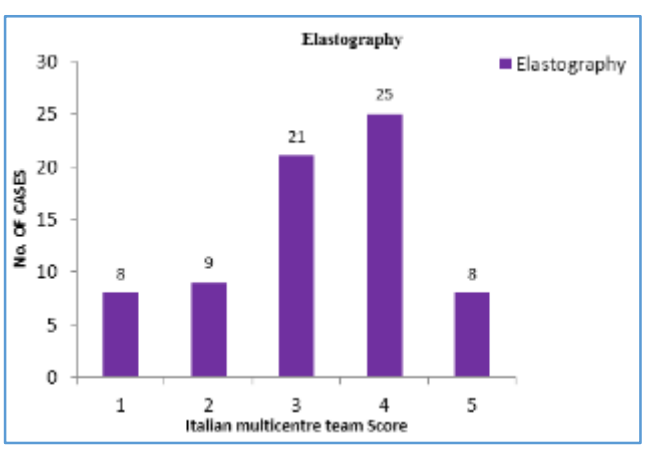
Table 9. Distribution of Benign and Malignant Cases in Combined Mammography and Sonomammography



Graph 9. Distribution of Benign and Malignant Cases in Combined Mammography and Sonomammography

Sl. No.	Score	Number of Cases
1.	1	8
2.	2	9
3.	3	21
4.	4	25
5.	5	8
TOTAL		**71**

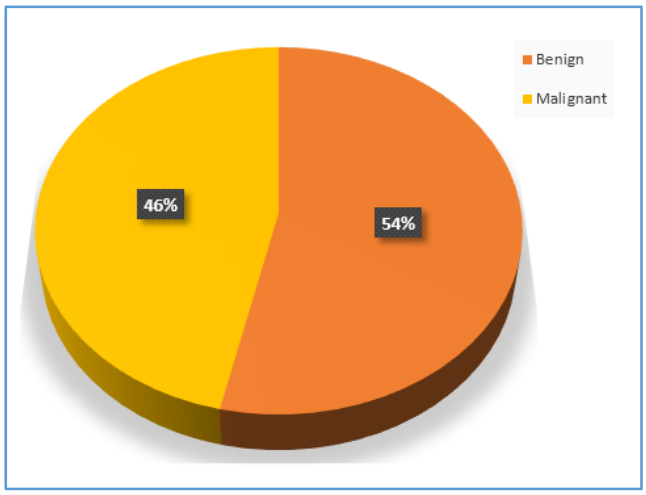
Table 10. Distribution of Cases in Elastography According to Italian Multicentre Team Study Score Classification



Graph 10. Distribution of Cases in Elastography According to Italian Multicentre Team Study Score Classification

Sl. No.	Lesions	Number of Cases
1.	Benign	38
2.	Malignant	33
Total		**71**

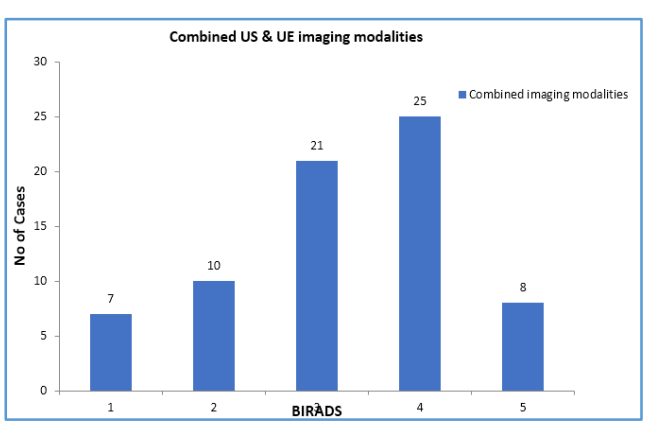
Table 11. Distribution of Benign and Malignant Cases in Elastography



Graph 11. Distribution of Benign and Malignant Cases in Elastography

Sl. No.	BIRADS	No. of cases
1.	1	07
2.	2	10
3.	3	21
4.	4	25
5.	5	08
		80

Table 12. Distribution of Cases Diagnosed by Combined Sonomammography and Elastography According to BIRADS Classification



Graph 12. Distribution of Cases Diagnosed by Combined Sonomammography and Elastography According to BIRADS Classification

Sl. No.	Mammography Diagnosis	FNAC Diagnosis		Total
		Malignant	Benign	
1.	Malignant	28	2	30
2.	Benign	7	43	50
		35	**45**	**80**

Table 13. Comparison of Mammographic Diagnosis with FNAC

Sensitivity - 80%.
Specificity - 95.5%.
Positive predictive value - 93.3%.
Negative predictive value - 86%.

Number of observed agreements- 71 (88.75% of the observations).
Number of agreements expected by chance- 41.3 (51.56% of the observations).
Kappa = 0.768.
SE of kappa = 0.07295%.
Confidence interval- From 0.626 to 0.909.
The strength of agreement is considered to be 'good.'

Sl. No.	Sonomammography Diagnosis	FNAC Diagnosis		Total
		Malignant	Benign	
1.	Malignant	26	4	30
2.	Benign	9	41	50
		35	**45**	**80**

Table 14. Comparison of Sonomammography Diagnosis with FNAC

Sensitivity - 74.2%.
Specificity - 91%.
Positive predictive value - 86%.
Negative predictive value - 82%.

Number of observed agreements- 67 (83.75% of the observations).
Number of agreements expected by chance- 41.3 (51.56% of the observations).
Kappa = 0.665.
SE of kappa = 0.084.
95% confidence interval- From 0.499 to 0.830.
The strength of agreement is considered to be 'good.'

Sl. No.	Elastography Diagnosis	FNAC Diagnosis		Total
		Malignant	Benign	
1.	Malignant	31	2	33
2.	Benign	4	34	38
		35	**36**	**71**

Table 15. Comparison of Diagnosis by Elastography with FNAC

Sensitivity - 88.5%.
Specificity - 94.4%.
Positive predictive value - 93.9%.
Negative predictive value - 89.4%.

Number of observed agreements- 65 (91.55% of the observations).
Number of agreements expected by chance- 35.5 (50.05% of the observations).
Kappa = 0.831.
SE of kappa = 0.066.
95% confidence interval- From 0.701 to 0.960.
The strength of agreement is considered to be 'very good.'

Sl. No.	Combined sonomammography and Elastography Diagnosis	FNAC diagnosis		Total
		Malignant	Benign	
1.	Malignant	32	1	33
2.	Benign	03	35	38
		35	**36**	**71**

Table 16. Comparison of Diagnosis by Combined Sonomammography and Elastography with FNAC

Sensitivity - 91.4%.
Specificity - 97.2%.
Positive predictive value - 96.96%.
Negative predictive value - 92.1%.

Number of observed agreements- 67 (94.37% of the observations).
Number of agreements expected by chance- 35.5 (50.05% of the observations).
Kappa = 0.887.
SE of kappa = 0.055.
95% confidence interval- From 0.780 to 0.994.
The strength of agreement is considered to be 'very good.'

Sl. No.	Combined Mammography and Sonomammography Diagnosis	FNAC Diagnosis		Total
		Malignant	Benign	
1.	Malignant	29	3	32
2.	Benign	06	42	48
		35	**45**	**80**

Table 17. Comparison of Diagnosis by Combined Mammography and Sonomammography with FNAC

Sensitivity - 82.8%.
Specificity - 93.3%.
Positive predictive value - 90.6%.
Negative predictive value - 87.5%.

Number of observed agreements- 71 (88.75% of the observations).
Number of agreements expected by chance- 41.0 (51.25% of the observations).
Kappa=0.769.
SE of kappa = 0.072.
95% confidence interval- From 0.628 to 0.911.
The strength of agreement is considered to be 'good.'

Modality	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Mammography	80%	95.5%	93.3%	86%
Sonomammography	74.2%	91%	86%	82%
Elastography	91.4%	94.4%	94.1%	91.8%
Combined Mammography and Sonomammography	82.8%	93.3%	90.6%	87.5%
Combined Sonomammography and Elastography	91.4%	97.2%	96.96%	92.1%

Table 18. Comparison of Mammography, Sonomammography, Elastography, Combined Mammography and Sonomammography, Combined Sonomammography and Elastography

CASES

Case 1- Intraductal Carcinoma

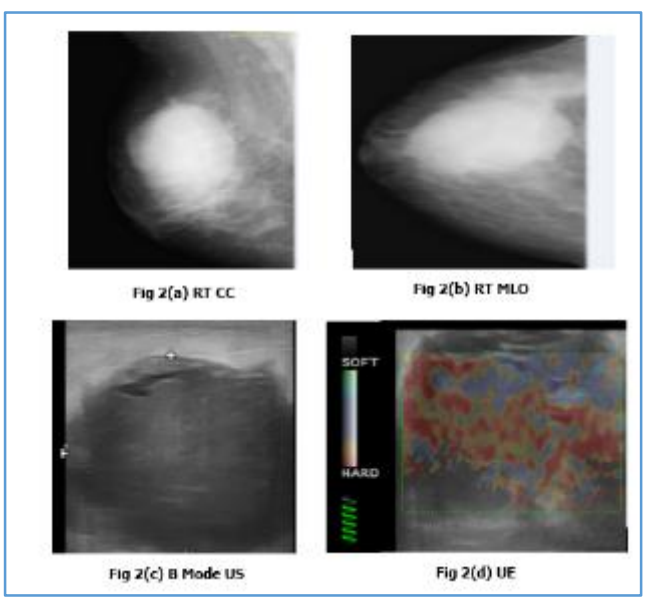


Figure 2. Female Patient of Age 40 Yrs. Came with Chief Complaint Lump in Upper Outer Quadrant of Right Breast.

a and b - Mammogram of rt. breast showing well-circumscribed high-density mass noted in upper outer quadrant rt. breast s/o BIRADS 3.
c - On u/s large hypoechogenic well-circumscribed mass noted in upper outer quadrant of rt. breast s/o BIRADS 3.
d - on UE showing red area (stiff) in the whole mass s/o score 4.

Final Diagnosis- Intraductal carcinoma.

CASE 2- Papillary Carcinoma

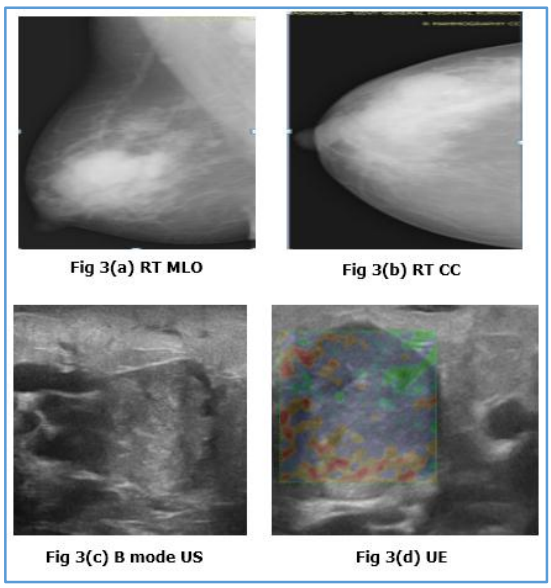


Figure 3. A Female Patient Came with Chief Complaint of Lump and Serosanguineous Nipple Discharge in Right Breast.

a and b - On mammography, heterogeneously dense right breast noted.
b - Round well-defined hyperdense lesion noted in upper outer quadrant of rt. breast- BIRADS 3.
c - On US dilation of ducts noted. An irregular hypoechoic mass with papillae like projections noted within a large cystic dilated space (BIRADS 3).
d - On UE, mosaic appearance of blue red noted (soft) in the solid lesion - SCORE 3.

FNAC Final Diagnosis- Papillary carcinoma.

CASE 3- Chronic Abscess

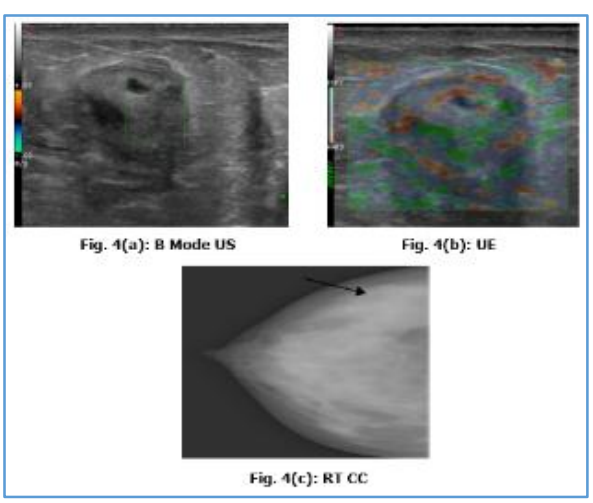


Figure 4. A Female Patient Came with Lump and Pain in the Right Breast in the Upper Outer Quadrant for the Past 4 Months.

a - On US, a mixed echogenic lesion with irregular margins noted (BIRADS 4).
b - On UE, mosaic pattern of blue red (soft lesion) noted (score 3).

c - On mammography (cc), an isodense well-circumscribed lesion (arrow) noted in upper outer quadrant (BIRADS 3).

FNAC Final Diagnosis- Thick pus - chronic abscess.

Case 4- Sclerosing Adenosis

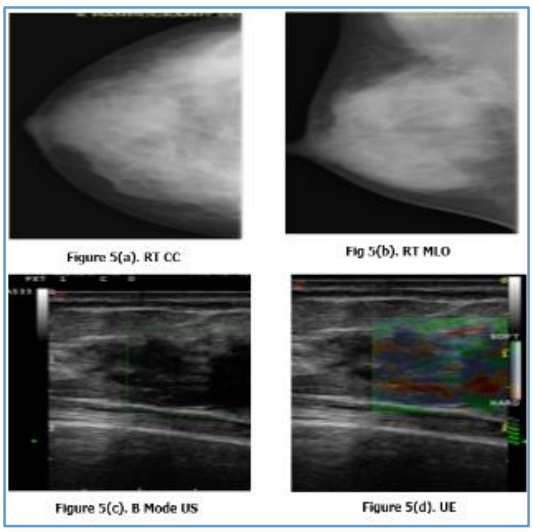


Figure 5. A Female Patient of Age 49 Yrs. Came with Chief Complaints of Lump in the Upper Inner Quadrant in the Right Breast.

a and b - On mammography, an isodense lesion with central hypodensity and long and thin spicules noted radiating from it with benign coarse calcification in upper inner quadrant noted (BIRADS 4).
c - On US, a hypoechoic lesion with speculated borders, wider than taller, noted in upper outer quadrant (BIRADS 4).
d - On UE, predominant blue areas indicating soft tissue noted - score 2.

FNAC Diagnosis- Sclerosing adenosis.

Case 5- Giant Fibroadenoma

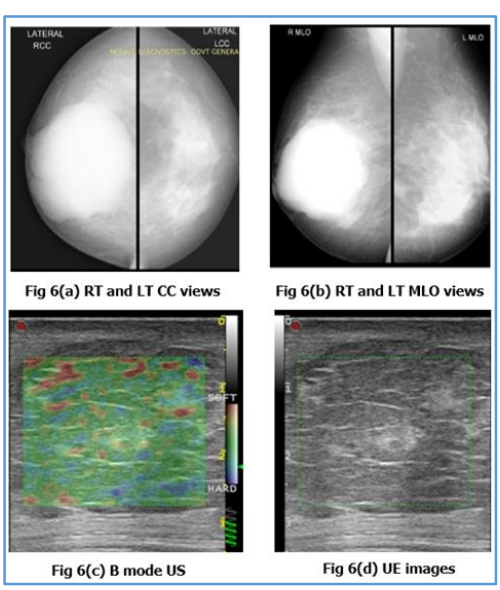


Figure 6. A Female Patient of Age 33 Yrs. Came with a Palpable Lump and Pain in Upper Outer Quadrant in Right Breast.

a and b - Mammogram showing b/l heterogenously dense breasts. A round well-defined hyperdense lesion noted in superolateral quadrant extending upto retroareolar region in anterior and middle one-third of the right breast - BIRADS 3.
c - On US, iso to hypoechoic, large, well-defined round lesion with posterior enhancement is seen - BIRADS 3.
d - On UE, total green colour indicating predominant elasticity of the mass - score 2.

FNAC Diagnosis- Fibroadenoma

Case 6- Oil Cyst

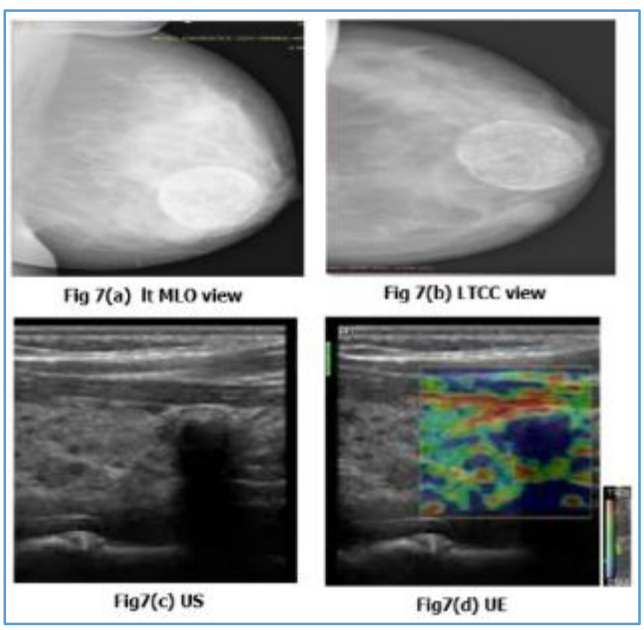


Figure 7. A 35 Yrs. Female Came with Chief Complaint Lump in the Left Breast in Lower Inner Quadrant h/o Previous Trauma is Present.

a and b - Mammagram of left breast both cc and MLO views showing well-defined round calcifed lesion with hypodensities within it in lowerinner quadrant (BIRADS 2).
c - On US, a hyperechogenicty with posterior acoustic shadowing noted (BIRADS 3).
d - On UE, blue colour indicating stiff lesion noted (score 4), misdiagnosed as malignant lesion (false positive).

FNAC Final Diagnosis- Oil cyst/fat necrosis.

Case 7- DCIS

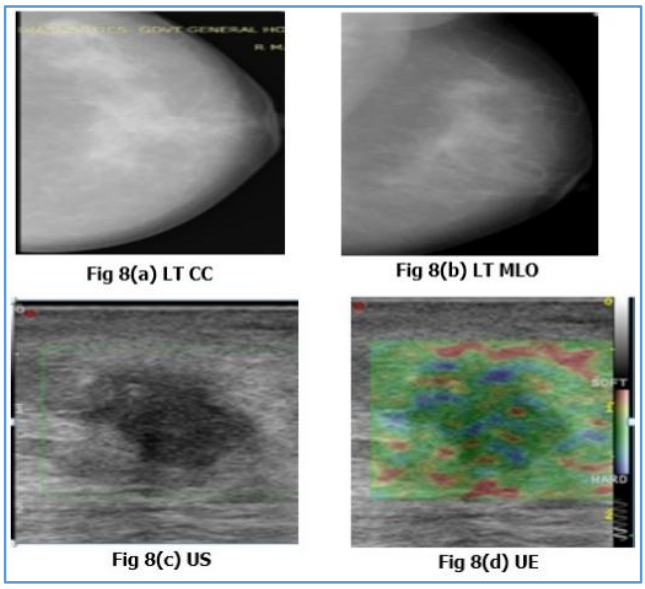


Figure 8. A Female Patient of 39 Yrs. Came with Chief Complaint of Palpable Lump in Upper Outer Quadrant of Left Breast.

a and b - On mammogram- both breasts show scattered areas of fibroglandular density. Both CC and MLO views showing ill-defined, dense lesion in upper outer quadrant in middle third of the lt. breast - BIRADS 4.
c - On US, a hypoechoic lesion with irregular margins noted in upper outer quadrant without posterior enhancement - BIRADS 4.
d - On UE, lesion showing mosaic pattern of green blue areas (predominant green) score 3 (false negative).

FNAC Final Diagnosis- DCIS

Case 8- Fibrocystic Disease

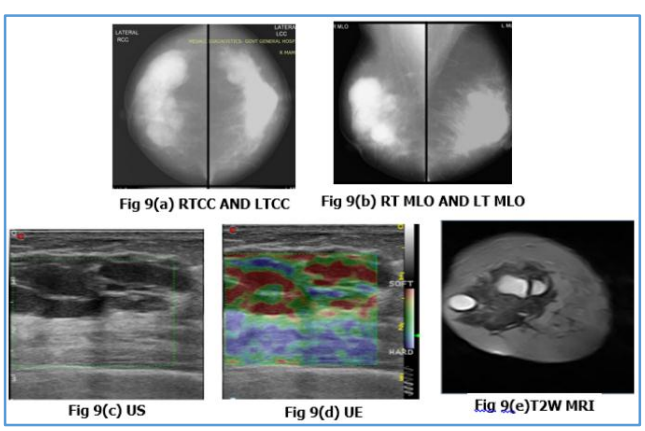


Figure 9. A Female of 45 Yrs. Old Came with Chief Complaints of Multiple Palpable Lumps and Pain in Both Breasts.

a and b - Mammogram - both breasts showing heterogeneously dense breasts. Both breasts showing diffuse involvement of multiple well-defined round dense lesions - BIRADS 2.
c - On US showing multiple cystic lesions involving both breasts (all quadrants) BIRADS 2.
d - On UE showing typical triple layer pattern (blue-green-red) indicating cystic lesion SCORE 1.
e - On MRI, multiple T2 hyperintense well-defined round lesions noted involving both breasts.

FNAC Diagnosis- Fibrocystic disease of breast.

Case 9- B/l Multiple Fibroadenomas

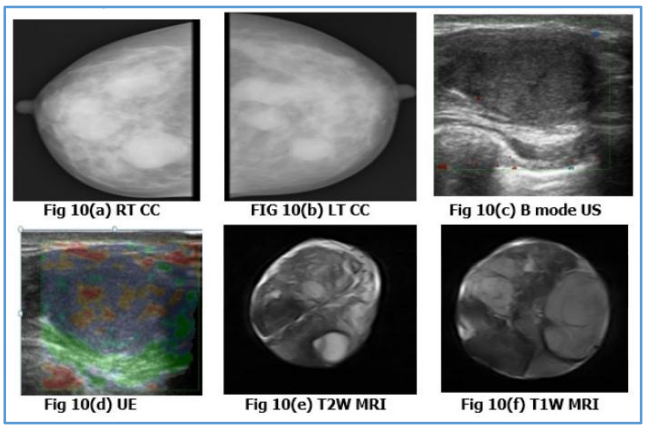


Figure 10. A Female Patient of 34 Yrs. Came with Chief Complaints of Multiple Palpable Lumps and Pain in Both Breasts.

a and b - On mammogram - both breasts are heterogeneously dense. Both breasts showing multiple round, well-defined smooth bordered lesions involving all quadrants of the breasts - BIRADS 3.
c - On US, both breasts showing hypoechoic lesion showing lobulated borders - BIRADS 3.
d - On UE, lesion showing mosaic pattern of blue-red (predominantly blue) indicating soft tissue - score 3.
e and f - MRI - Multiple T1 hypo to iso,T2 iso to hyperintense round well-defined lesions and masses noted in both breasts.

FNAC Diagnosis- Fibroadenomas (FNAC from multiple lesions).

Case 10- Medullary Carcinoma

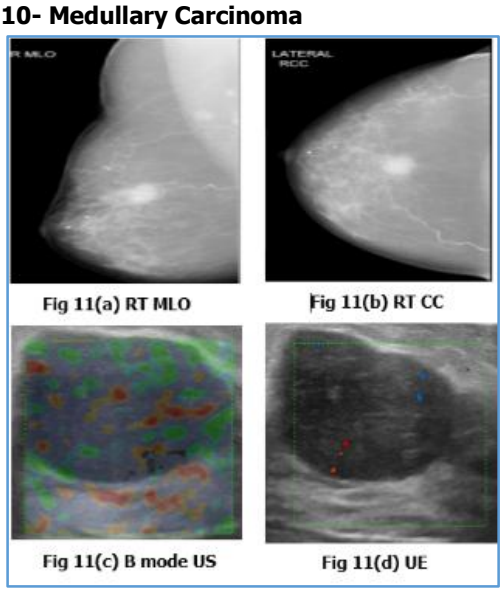


Figure 11. A Female Patient of Age 49 Yrs. Came with Chief Complaint of Palpable Lump in Superior Middle Portion of the Rt. Breast.

a and b - Mammogram of rt. breast showing scattered areas of fibroglandular density. A well-defined, round, smooth bordered, hyperdense lesion noted in superior middle portion of the breast in middle third of the breast - BIRADS 3.
c - On US, well-defined smooth bordered, hypoechogenic lesion with posterior enhancement is seen - BIRADS 3.
d - On UE, lesion showing red-blue pattern (predominant blue) indicating soft tissue - score 3 (false negative).

FNAC Diagnosis- Medullary carcinoma.

Case 11- Intraductal Carcinoma

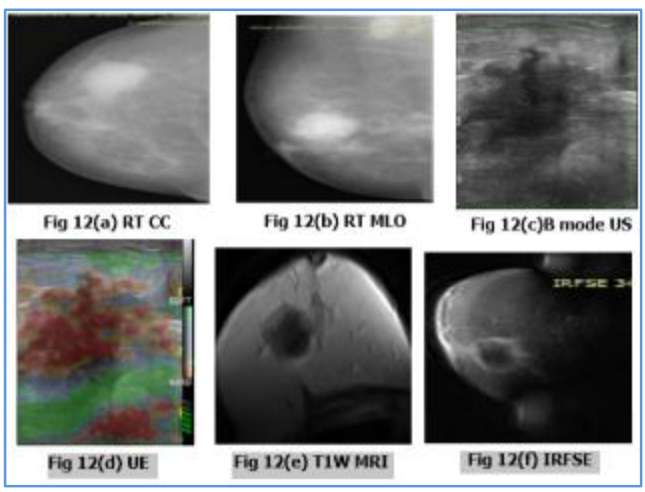


Figure 12. A Female of Age 51 Yrs. Came with Chief Complaints of Lump and Pain in Upper Outer Quadrant of Right Breast.

a and b - On mammogram, Rt. breast composition is almost entirely fatty. Speculated hyperdense lesion noted in upper outer quadrant in middle third of the breast with enlarged axillary lymph nodes - BIRADS 4.
c - On US, hypoechogenic irregular speculated mass noted - BIRADS 5.
d - On UE, red colour (hard tissue) noted within and adjacent to the lesion - SCORE 5.
e and f - T1W and IRFSE MRI showing ill-defined hypodense lesion.

FNAC Diagnosis- Intraductal carcinoma.

DISCUSSION

For the United States, for the year 2012- 2,32,714 women were newly detected with breast cancer; 43,909 women died of breast cancer. So, roughly in the US for every 5 or 6 women newly diagnosed with breast cancer, one lady is dying of it.

For India, for the year 2012- 1,44,937 women were newly detected with breast cancer; 70,218 women died of breast cancer. So roughly, in India, for every 2 women newly diagnosed with breast cancer, one lady is dying of it.[9]

In India, the overall incidence of breast cancer is less as compared to the US. But, if you see the actual number of cases, India is not far behind. In the year 2012, there were about 2,32,000 breast cancer cases reported in the US, whereas in India, 1,45,000 new cases were diagnosed. This implies that because of India's population, the percentage of total women affected seems less, but the breast cancer burden in India has almost reached about two-thirds of that of the US and is steadily rising.[9]

If you compare these countries, you can easily make out that India has the maximum number of women dying of breast cancer and that number is huge. Since, more patients (in India) turn up in later stages, they do not survive long irrespective of the best treatment they may get and hence the mortality is fairly high. There are lots of reasons for late presentations including lack of awareness, shyness on part of patients, social stigma, ignorance of doctors (patients present on time, but doctors are not aware and they delay treatment) and many other causes.[10]

A recent study of breast cancer risk in India revealed that 1 in 28 women develop breast cancer during her lifetime. This is higher in urban areas being 1 in 22 in a lifetime compared to rural areas where this risk is relatively much lower being 1 in 60 women developing breast cancer in their lifetime.[1]

In India, the average age of the high-risk group in India is 43-46 years unlike in the west where women aged 53-57 years are more prone to breast cancer.[1]

For decades together, cervical cancer was the most common cancer in women in India and more deaths in women in India were attributed to cervical cancer than any other cancer. But, over last ten years or so, breast cancer has been rising steadily and breast cancer is the most common cancer in women in India and also most common cancer causing death in women in India.[10]

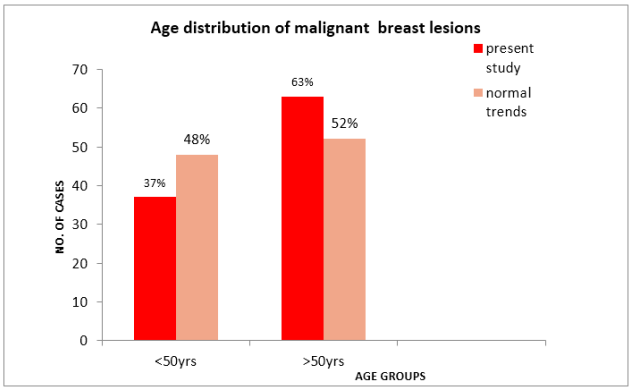
25 years back, out of every 100 breast cancer patients, 2% were in 20 to 30 years age group, 7% were in 30 to 40 and so on. 69% of the patients were above 50 years of age. Presently, 4% are in 20 to 30 yrs. age group, 16% are in 30 to 40, 28% are in 40 to 50 age group. So, almost 48% patients are below 50. An increasing numbers of patients are in the 25 to 40 years of age and this definitely is a very disturbing trend.[10]

In present study, out of 35 malignant cases, 2 (5.7%) were in 30-39 yrs., 11 (31.5%) were in 40-49 yrs., 15 (42.8%) were in 50-59 yrs., 7 (20%) were in 50-59 yrs. Only 5.7% cases are below 40 yrs. and 37.2% were below 50 yrs. Highest incidence was seen in 50-59 yrs. This may be due to late presentation of patients. As more patients came from rural areas, lack of awareness, social and economic factors, not much development of cosmopolitan culture in this area, changing trends were not demonstrated in the present study.

Below 50 yrs. out of 48 cases, 13 (37%) were malignant and 35 were benign and above 50 yrs. out of 32 cases 22 (63%) were malignant and 10 were benign indicating increased incidence of malignancy with increasing age.

Sl. No.	Age Group	Present Study	Normal Trends
1	<50 yrs.	37%	48%
2	>50 yrs.	63%	52%

Table 19. Age Distribution of Malignant Breast Lesions



Graph 13. Age Distribution of Malignant Breast Lesions

The most common symptom of presentation was lump in the breast seen in 77 patients and the second most common symptom was pain seen in 37 patients. Other symptoms were nipple discharge, areolar retraction and haemorrhage.

Lesions were most commonly located in the upper outer quadrant 28 cases (35%), 14 cases (17.5%) in upper inner quadrant, 12 cases (15%) in lower outer quadrant, 7 cases (8.75%) in lower inner quadrant, 5 cases (6.25%) in central area and 14 cases (17.5%) in >1 quadrant.

Marshall et al suggested that 60% of their cases had the tumour in the upper outer quadrant while Sen and Dasgupta had 49% of the cases in same quadrant. About 35% cases were located in upper outer quadrant in present study.

There is no way to prevent breast cancer, but it can be definitely detected early and treated adequately. Only with early detection, a longer survival can be achieved. To make people aware of this early detection, it is going to need a lot of efforts especially since Indian society is so deep rooted in myths and alternative treatment and unusual illogical beliefs.

It will take a lot of time to reverse this and get people on track. So, awareness and education about breast cancer is very essential. Imaging plays a crucial role in early detection of breast cancer, so that early treatment can be given.

Breast carcinoma has been reported in only 4% of patients with breast symptoms and even among palpable lesions undergoing biopsy. A large number of lesions turned out to be benign.[11,12]

The role of mammography in patients with palpable breast lumps, nipple discharge is to show a benign cause for the palpable abnormality, which although uncommon, avoids further intervention (calcified involuting fibroadenoma, lipoma, oil cyst, galactocele and haematoma) to support earlier intervention for a mass with malignant features to screen the remainder of the ipsilateral and contralateral breast for additional lesions and to assess the extent of malignancy when cancer is diagnosed.[13]

Of the benign lesions, fibroadenoma was the most common histopathological diagnosis in the present study. Of the malignant lesions, intraductal carcinoma was the most common histopathological diagnosis in the present study.

Mammography is the only screening modality, which has been proven to reduce mortality from breast cancer through early detection.[14] Sensitivity of mammography in detection of breast cancers in the screening setup ranges from 83 to 95 percent.[15] Sabine Malur et al showed sensitivity, specificity, PPV, NPV 83.7%, 68.5%, 67.8%, 84.1%, respectively.

In a study by Nesreen Mohey et al, mammography has sensitivity 72.7% and specificity 86.4%. In the present study, mammography has a sensitivity of 80%, specificity of 95.5%, positive predictive value of 93.3%, negative predictive value of 86%, which are higher than previous studies.

However, the false-negative rate of mammography for breast cancer in patients with palpable abnormalities of the breasts has been reported to be as high as 16.5%.[16]

Mammographic sensitivity for breast cancer declines significantly with increasing breast density and is independently higher in older women with dense breasts. It decreases to as low as 30 to 48 percent in patients with mammographically dense and glandular breasts.[17]

Even though, present study got more sensitivity, it had false-positive rate of 4.4% and false-negative rate of 20%. We did not see any lesions in 5 cases, which are seen in ultrasound. This is mainly due to the breast density obscuring the lesions, this is main disadvantage of mammography as women with 35 to 45 yrs. of age mostly have dense breasts.

Sl. No.	Histopathology Diagnosis	Number of Patients
1.	Fibrocystic disease	8
2.	Fibroadenoma	24
3.	Sclerosing adenosis	1
4.	Abscess	2
5.	Lipoma	1
6.	Duct ectasia	1
7.	Galactocele	1
8.	Oil cyst	1
9.	Intramammary lymph node	1
10.	DCIS	13
11.	Intraductal carcinoma	19
12.	Papillary carcinoma	1
13.	Medullary carcinoma	1
14.	Cystosarcoma phyllodes	1

Table 20. Distribution of Histopathology Diagnoses of the Patients Studied

Further density of breasts increases depending upon the menstrual cycle. In India, the average age of the high-risk group in India is 43-46 years unlike in the west where women aged 53-57 years are more prone to breast cancer. So, the lesions maybe missed or misdiagnosed decreasing its sensitivity and increasing false-negative rate. Further, it cannot be diagnosed whether the lesion is solid or cystic and any tumours within the cystic lesion in mammograms.

Sl. No.	Study	Present Study	Sabine Malur et al	Nesreen Mohey et al
1.	Sensitivity	80%	83.7%	72.7%
2.	Specificity	95.5%	68.5%	86.4%
3.	PPV	93.3%	67.8%	---
4.	NPV	86%	84.1%	---

Table 21. Comparison of Mammography Results with Other Studies

Ultrasound is adjunct to the mammogram. It can differentiate cystic and solid lesions that appear as iso/high dense lesions on mammograms and also as problem solving tool for nonspecific finding on mammograms. It can also detect any tumours within the cyst.

The advances in ultrasound technology over the past two decades have transformed this diagnostic modality into a diagnostic tool that allows the exclusion of malignant breast tumours and identification of definitely benign lesions.

In the present study, sensitivity, specificity, PPV, NPV were 74.2%, 91%, 86% and 82%, respectively. When compared to Sabine Malur et al study, which had sensitivity, specificity, PPV, NPV 89.1%, 79.1%, 65.7% and 90.9%, respectively. Present study has higher specificity and PPV when compared to Marwa A Shaaban et al study that had sensitivity, specificity, PPV, NPV 85%, 94%, 92.5% and 88%, respectively. All the values are lower in the present study.

Sl. No.	Study	Present Study	Sabine Malur et al	Marwa A Shaaban et al
1.	Sensitivity	74.2%	89.1%	85%
2.	Specificity	91%	79.1%	94%
3.	PPV	86%	65.7%	92.5%
4.	NPV	82%	90.9%	88%

Table 22. Comparison of Sonomammography Results with Other Studies

All solid masses may not be visible in the sonomammography even in dense breasts. A palpable mass that is invisible in both mammography and sonography strongly needs biopsy histology. When compared to mammography, sonomammography has lower sensitivity, specificity, PPV, NPV. In 11 cases, no lesion was detected in mammogram and in 9 cases no lesion was detected in sonomammogram. In 5 cases, lesion was found in sonomammogram that were not detected in mammogram.

Of these 5 cases, 2 were fibroadenomas, 2 were fibrocystic disease, 1 duct ectasia. These patients were below 50 yrs. and have dense breasts, so lesions could not be made out separately, but readily identified in sonomammography as fibroadenoma appears hypoechoic, cysts appear anechoic and duct ectasia appears as dilated ducts communicating with each other with serous discharge through the nipple. So, sonomammography is very useful in dense breasts and can be used as screening for the breast lesions in younger women and women with dense breasts.

In 3 cases, lesions were found in mammogram that were not detected in sonomammogram. These three were fibroadenomas. This may be due to isoechoic appearance of fibroadenoma with adjacent breast tissue.

In 6 cases, no lesion was detected in both sonomammography and mammography. FNAC was done, which showed 1 fibroadenoma, 3 fibroadenosis changes and 2 normal breast tissue.

Ultrasound elastography is a new imaging modality in addition to sonography used to detect and identify breast lesions. It uses another characteristic, i.e. stiffness of the lesion. By compressing of the target lesion lightly, UE can noninvasively determine strain and elasticity of the lesion by using a standardised color scale.

Itoh et al first used UE to detect breast lesions and proposed the 5-point scoring system. They had higher sensitivity of UE than that of B-mode sonography. It had a sensitivity, specificity and accuracy of 86.5%, 89.8% and 88.3%, respectively and US achieved 71.2%, 96.6% and 84.7%, respectively.[8]

Navarro et al[18] who stated that B-mode sonography had a sensitivity of 96.6%, specificity of 76.9%, positive predictive value of 79.2% and a negative predictive value of 96.2% compared with a sensitivity of 69.5%, specificity of 83.1%, positive predictive value of 78.9% and negative predictive value of 75.0% for elastography.

Thomas et al[19] evaluated this new modality in 108 patients and found that specificity was improved from 78% for conventional sonography to 91.5% for UE. For Thomas et al, sensitivity and specificity in the differentiation of benign and malignant lesions were 94% and 83%, respectively for B-mode US while elastography had a sensitivity of 82% and a specificity of 87%; while for Leong et al sensitivity and specificity were 88.5% and 42.9%, respectively; for conventional ultrasound, 100% and 73.8%, respectively; for elastography, 88.5% and 78.6%, respectively for combined imaging.

In the present study, sensitivity, specificity, PPV and NPV of elastography are 88.5%, 94.4%, 93.9%and 89.4%. When compared to sonomammography, elastography had higher sensitivity in Itoh et al study, but higher specificity in many other studies. As in several studies, elastography showed higher specificity than sonomammography in the present study.

But, many studies showed lower sensitivity. In the present study, both sensitivity and specificity were higher than sonomammography, which is consistent with Leong et al study in which sensitivity and specificity were 88.5% and 42.9%, respectively. For conventional ultrasound, 100% and 73.8%, respectively for elastography.

In present study, sensitivity, specificity, PPV and NPV for the combination of sonomammography and UE were higher than those of sonomammography alone. When compared to previous studies, sensitivity, specificity, PPV for the combination of sonomammography and UE were higher.

Sl. No.	Study	Present Study	Navarro et al	Thomas et al	Leong et al	Itoh et al
1.	Sensitivity	88.5%	69.5%	82%	88.5%	86.5%
2.	Specificity	94.4%	83.1%	87%	78.6%	89.8%
3.	PPV	93.9%	78.9%	__	__	__
4.	NPV	89.4%	75%	__	__	__

Table 23. Comparison of Elastography Results with Other Studies

Sl. No.	Study	Present Study	Zhi et al	Nesreen Mohey et al	Leong et al
1.	Sensitivity	91.4%	89.7%	90.9%	88.5%
2.	Specificity	97.2%	95.7%	95.1%	78.6%
3.	PPV	96.96%	89.7%	__	__
4.	NPV	92.1%	__	__	__

Table 24. Comparison of Combined Sonomammography and Elastography Results with Other Studies

Compared with mammography, UE has higher sensitivity and NPV, but slightly lower specificity. But, combined UE and sonomammography has higher sensitivity, specificity, PPV and NPV than mammography alone or combined mammography and sonomammography.

The median age of patients with breast cancer in the present study was 53 years, which was younger than in Western women, but older than in women in India.

Younger age, limits the use of mammography due to radiation and most patients below 50 yrs. have dense breasts. As sonomammography with elastography has more sensitivity and specificity than mammogram, it is better to use it in dense breasts and women below 50 yrs. Further, mammography uses ionising radiation, which itself is a potential carcinogen and this limits the age and frequency with which it can be used.

Conversely, there is no such risk to patients when using ultrasound with UE. In addition, UE and sonomammography are less expensive than mammography.

There is an overlap of the elasticity between benign and malignant lesions in the breast, which limits the use of UE. In the present study, 4 out of 35 cancers were missed (false-negative) by UE. False-negative findings on UE were DCIS, medullary carcinoma, papillary carcinoma and large intraductal carcinoma with necrosis. Two (large IDC with necrosis and DCIS) of the four were detected as malignant by mammography and two (including 1 medullary carcinoma and 1 papillary carcinoma) were missed by all 3 modalities.

Sl. No.	False-Negative in Elastography
1.	DCIS
2.	Medullary carcinoma
3.	Papillary carcinoma
4.	Large intraductal carcinoma with necrosis

Table 25. False-Negatives in Elastography

2 out of 36 benign lesions were misdiagnosed by UE. Among the false positive diagnoses, one was an oil cyst with calcification that increased the stiffness and one was an involuting fibroadenoma with calcifications, which increased the hardness of the lesion. Therefore, when using UE, one should pay attention to all the factors that would affect the stiffness of lesions and cause misleading results. In these cases, mammography was very useful as it can detect benign calcifications easily and down staged to BIRADS II (i.e. benign).

Sl. No.	False-Positive in Elastography
1.	Oil cyst
2.	Involuting fibroadenoma

Table 26. False-Positives in Elastography

In addition, elastography can be applied only to the lesions that were visible on grey scale ultrasound. In the present study, 9 lesions were not identified in grey scale ultrasound (BIRADS 1), so elastography could not be applied to those cases. This is a limitation to the elastography.

In mammography, 7 out of 35 cancers were false negative. Of these, two were DCIS, two were IDC, one medullary CA, one papillary CA, one cystosarcoma phyllodes. Combined sonomammography and elastography correctly identified malignancy in 5 cases whereas 2 cases (medullary and papillary CA) were missed in all the three modalities.

In mammography, 2 out of 45 benign lesions were misdiagnosed as malignant (false positive), one was sclerosing adenosis, which on sonomammography also misdiagnosed as malignant, but elastography correctly identified it as benign soft lesion. Another one was fibroadenoma, which on sonomammography and elastography correctly identified as benign lesion.

Sl. No.	False-Negative in Mammography	Number of Cases
1.	DCIS	2
2.	IDC	2
3.	Papillary carcinoma	1
4.	Cystosarcoma phylloides	1
5.	Medullary carcinoma	1

Table 27. False-Negatives in Mammography

Sl. No.	False-Positive in Mammography
1.	Sclerosing adenosis
2.	Fibroadenoma

Table 28. False-Positives in Mammography

In sonomammography, 9 out of 35 (false negatives) malignant lesions were missed. Four were correctly identified in mammography, but by using elastography, three more lesions were diagnosed as malignant. So, by combining all the three modalities, only two lesions were missed.

In sonomammography, 4 out of 45 benign lesions were misdiagnosed as malignant (false positive). These are 1 sclerosing adenosis, 2 fibroadenomas and 1 chronic abscess. Both, mammography and sonomammography misdiagnosed sclerosing adenosis as malignant, but elastography showed score 2, thus differentiating it as a benign lesion. Of 2 cases of fibroadenomas, one was correctly identified as benign by elastography and mammography and other was correctly

identified by elastography, but mammography misdiagnosed it as malignant. Chronic abscess was correctly identified as benign by elastography and mammography.

Sl. No.	False-Negative in Sonomammography	Number of Cases
1.	DCIS	4
2.	IDC	2
3.	Papillary carcinoma	1
4.	Cystosarcoma phyllodes	1
5.	Medullary carcinoma	1

Table 29. False-Negatives in Sonomammography

Sl. No.	False-Positive in Sonomammography	Number of Cases
1.	Sclerosing adenosis	1
2.	Fibroadenoma	2
3.	Chronic abscess	1

Table 30. False-Positives in Sonomammography

MRI was also performed wherever necessary to know how the lesion appears in MRI. Cystic lesions appeared as T2 and fat sat hyperintense, T1 hypointense lesions, fibroadenomas appear as well-defined T2 iso to hyperintense (but less than fluid signal) and T1 hypointense lesion. Malignant lesions have nonspecific findings. As dynamic imaging was not performed and lower strength magnet, it was not significant in distinguishing benign and malignant lesions.

On comparison of CR mammography, greyscale sonomammography and real-time elastography, CR mammography has highest specificity, whereas real-time elastography has highest sensitivity, PPV and NPV.

By combining all three modalities, CR mammography, grey scale sonomammography and real-time elastography, only two malignant lesions were misdiagnosed as benign and all benign lesions were correctly identified as benign. So, multimodality imaging approach can increase sensitivity, specificity, PPV and NPV. So, by identifying benign lesions correctly, unnecessary FNACs/biopsies can be avoided.

UE has advantages of using no radiation, simple to use, it can be overlapped on the greyscale ultrasound image, identifies cyst with more specificity (three layer pattern), able to differentiate BIRADS 3 and 4 lesions. In the present study, UE is superior or equal to mammography, but superior to conventional sonography. Combined UE and sonography evaluation of the lesion can improve the detection accuracy, so that the combination potentially could reduce unnecessary biopsy.

CONCLUSION

- Real-time elastography, which is cheap, easier to operate and has no radiation is an useful adjunct technique to ultrasound for the characterisation of benign and malignant solid lesions as it increases the diagnostic sensitivity and specificity comparable to sonomammography or mammography alone.
- So, combination of sonomammography and real-time elastography can be used as a screening procedure to differentiate benign and malignant lesions in young women and women with dense breasts where mammography cannot be used or less sensitive.
- Sonomammography is better to identify cystic lesions. Further specificity can be increased by using real-time elastography.
- Further real-time elastography is useful to obtain representative samples from the suspicious areas within the lesion, thus reducing unnecessary tissue injury and increases the specificity of diagnostic sampling.
- As real-time elastography is qualitative technique and operator dependent, accuracy can be increased by using quantification techniques like shear wave elastography, Acoustic Radiation Force Impulse (ARFI) techniques.
- Combination of CR mammography, sonomammography and real-time elastography has high diagnostic sensitivity and specificity in the diagnosis of benign and malignant breast masses obviating the use of higher modalities like MRI, CAD and digital tomosynthesis, which is very useful in resource poor countries like India.
- But, major limitation is combination of CR mammography, sonomammography and real-time elastography cannot quantify the disease burden (number of lesions) correctly and is inferior to dynamic MRI.

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