Impact of Using Digital Breast Tomosynthesis on the Interpretation of Dense Breasts

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Abstract:

Background

Dense breasts represent a risk factor for breast cancer, but unfortunately, they represent a weak point in conventional digital mammography (DM) interpretation due to tissue overlapping and increased conspicuity of the lesion; hence, the development of digital tomosynthesis (DBT) came to overcome this obstacle, allowing better characterization of lesions, reducing patient recall and medical costs.

Objectives: To assess the impact of DBT on the interpretation of dense breasts and its advantages and disadvantages over DM, hence estimate its role in dense breast screening.

Method: Eighty-three patients with dense breasts (ACR C or D) were included in our study, either having detectable lesions or indeterminate findings by Ultrasound (US) and DM, over 12 months between November 2022 and October 2023.

All patients underwent DM and DBT, which were correlated to histopathology and/ or follow-up. **Results:** DBT exhibited a higher sensitivity, specificity, accuracy, PPV, and NPV than DM, with moderate kappa agreement (*k=0.4115).*

Conclusions: DBT improved the identification and characterization of diverse dense breast abnormalities with much higher sensitivity and specificity, so that it can be considered as an essential tool for screening in dense breasts

Keywords: DM; DBT; Dense breasts.

Introduction:

Mammography is a well-established tool in breast cancer screening. However, it is deficient in dense breasts where tissue overlap masks some lesions, making their accurate characterization difficult(1).

As stated in a previous meta-analysis, cancer risk increases up to 6-fold in extremely dense breasts, and the need for improving dense breast evaluation in mammography becomes essential (2).

Digital breast tomosynthesis (DBT), by offering 3D imaging capabilities, enhances lesion visibility and diagnostic confidence. It has been shown to lower false positives and reduce recall rates by 15–37% (3) while boosting cancer detection by 1.2–2.7 cases per 1,000 screenings while boosting cancer detection by 1.2–2.7 cases per 1,000 screenings (4).

Given these advantages, our study seeks to determine whether DBT offers greater diagnostic accuracy than DM in dense breast evaluations and whether it could be a reliable screening tool.

Methods

This cross-sectional prospective study was performed over 24 months between

October 2021 and October 2023 at the radiology departments of Assiut University Hospital and South Egypt Oncology Institute.

The research and ethical committee number approved the study:17101525 dated 16-9-2021, and informed consent was obtained from each patient before the examination.

The study included patients with ACR density C&D with indeterminate or abnormal findings in digital mammography (BIRADS 0, II, III, IV, and V), even if it was done as screening, for high-risk women (operated breast cancer, family history) or for diagnosis of symptomatic patients.

Patients with ACR A or B and patients with breast implants were excluded.

All participants underwent a standard full-field digital mammographic (DM) examination. For breasts presenting abnormalities, digital breast tomosynthesis (DBT) was subsequently performed using one or both standard views (craniocaudal [CC] and mediolateral oblique [MLO]) based on where the lesion was best visualized. Imaging was conducted using Siemens Mammomat Revelation and Fujifilm systems equipped with 3D tomosynthesis capabilities.

During DBT acquisition, the x-ray tube rotated from +25° to -25°, capturing 25 projection images, which were then reconstructed into thin sections parallel to the detector plane.

DM and DBT images were reviewed on high-resolution liquid crystal display (LCD) monitors. Image manipulation, including zoom, contrast adjustment, and background inversion, improved visualization without requiring additional mammographic views.

The breast image data are sent from the acquisition Workstation to the reading workstation, and images are reconstructed using a mathematical algorithm like those used in CT reconstructions to generate a set of thin image sections parallel to the breast platform. The DM and DBT images were separated for interpretation.

Two experienced radiologists, blinded to clinical information and each other's assessments, independently reviewed the DM and DBT images. Lesions were classified according to the BI-RADS 5th edition (2013), resulting in separate BI-RADS scores for DM and DBT for each lesion.

The results of DM and DBT for each patient were compared in terms of the main BIRADS classification and diagnostic performance in correlation to the gold standard histopathology or follow-up, as follows.

a. BIRADS IV&V lesions underwent either US-guided TCNB or Excisional biopsy.
b. BIRADS II lesions were subject to annual follow-up by ultrasound.
c. BIRADS III lesions were subjected to follow-up every 6 months up to a year and a half or 2 years, then annual follow-up by ultrasound.

Statistical Analysis:

Statistical analysis was done using SPSS software version 29. Data were presented in tables, and continuous data were presented as mean, standard deviation, and range. Qualitative data were presented as frequencies and proportions. All numerical variables were tested before evaluation to determine the normality of the data.

Test of significance: Chi-square/Fisher's exact Test was used to compare the difference in distribution of frequencies among different groups.

Cohen's kappa and Test for validity statistics (Sensitivity, Specificity, Positive predictive value, Negative predictive value, and Accuracy were calculated to validate the mammography and tomosynthesis against histopathological findings. A p-value of ≤ 0.05 was accepted as a statistically significant difference, and a p-value of < 0.001 was accepted as a highly statistically significant difference.

Results

Eighty-three women were included in our study; the mean age of the study population was (42.8±11.5) years, ranging from (23-76) years. The majority (40.96%) ranged from 23 to less than 40, as shown in **Table 1**.

ACR C was 46.98% while 53.01% were with ACR D.

Table 1: Age distribution among the study population.

Age distribution	Number (n=83)	Percentage
23- <40	34	40.96%
40 - <50	33	39.75%
50 - <60	7	8.43%
>60	9	10.84%
Mean ± SD (range)	42.8±11.5 (23-76)	

*Data were expressed as frequency and percentage or mean ±SD

- **As regards the final diagnosis**

Of all detected lesions, 36 were subjected to biopsy; 30 of these biopsies were TCNB, while 6 lesions underwent excisional biopsy.

Their histopathological examination revealed 27 malignant lesions, most of which were IDC, and 9 benign lesions, 3 of which were fibroadenoma. As shown in **Table (2).**

Table 2: Histopathology of benign and malignant mass lesions.

Malignant	N=27
Invasive ductal carcinoma	20
Invasive lobular carcinoma	3
Papillary carcinoma	1
Mixed invasive ductal and lobular carcinoma	2
Mixed invasive ductal and mucinous carcinoma	1
Benign	**N=9**
Granulomatous mastitis	2
Benign proliferative disease without atypia	2
Fibroepithelial polyp	1
Sclerosing adenosis	1
Intracanalicular fibroadenoma	3

- **Follow up: (47 lesions)**

Benign lesions, which were interpreted as BIRADS II, III by DBT, were subjected to follow-up as follows:

- ✓ BIRADS II 39 lesions (fibrocystic, fibro adenosis, chronic abscess, duct ectasia, fat necrosis, hamartoma, seroma, intramammary lymph nodes) were subjected to annual follow-up by US.
- ✓ BIRADS III 8 lesions (fibroadenoma) were subjected to follow-up every 6 months up to a year and a half or 2 years, then annual follow-up by US.

Benign nature was confirmed during follow-up.

Regarding the different lesions detected in our study:

By DM 37 mass (44.6%), 5 focal asymmetries without mass (6.1%), 7 micro-calcifications without mass (8.4%), 24 indeterminate lesions (28.9%),1 architecture distortion (1.2%).

While DBT detected 45 masses (54.21%), 7 focal asymmetries without mass

(8.43%), 6 micro-calcifications without mass (7.22%), 4 architecture distortions (4.81%), and 21 overlapped glandular tissue (25.30%). As shown in Table (3) below

Table 3: Detectable lesions by DM and DBT

DM lesions	Number (n=83)
lass	37 (44.6%)
ocal asymmetry without mass	5 (6.1%)
rchitectural distortion	1 (1.2%)
icrocalcification without mass	7 (8.4%)
determinate lesions	24 (28.9%)
ot seen	9 (10.8%)
DBT lesions	**Number (n=83)**
lass	45 (54.21%)
ocal asymmetry without mass	7 (8.43%)
rchitectural distortion	4 (4.81%)
icro-calcification without mass	6 (7.22%)
Overlapped glandular tissue (BIRA	21 (25.30%)

BIRADS category by DM & DBT (upgrading and downgrading):

Nine lesions that DM missed were detected by DBT and interpreted as 5 lesions BIRADS II and 4 lesions BIRADS IV (upgrading).

All indeterminate lesions by DM (24 lesions) were upgraded to different BIRADS categories: six lesions to BIRADS I, 16 to BIRADS II, one to BIRADS III, and another to BIRADS IV.

Five lesions were upgraded from BIRADS IV to V (Figures 1 and 2), while 2 lesions were upgraded from BIRADS II to III, 5 lesions from III to IV, and one lesion was upgraded from III to V.

Collectively, from a total of 83 lesions, 46 were upgraded by DBT, 12 were downgraded (figure 3), while 25 lesions (30.12%) remained at the same category, so mild agreement was detected between DBT and DM in BIRADS categorization (Kappa agreement = 0.342) and a statistically significant difference between them (P-value <0.001), as shown in table (4).

Table 4: Upgrading and downgrading of DM BIRADS category by DBT.

		DM BI-RADS							Total
		Not seen	B0	BI	BII	BIII	BIV	BV	
	Not seen	0	0	0	0	0	0	0	0
DBT BI-RADS	**B0**	0	0	0	0	0	0	0	0
	BI	0	6	0	0	1	0	0	7
	BII	5	16	0	6	3	3	0	33
	BIII	0	1	0	2	6	4	0	13
	BIV	4	1	0	0	5	3	1	14
	BV	0	0	0	0	1	5	10	16
Total		9	24	0	8	16	15	11	83

Downgrading
Upgrading
the same grade

P- value	**<0.001**
Kappa agreement	**0.342**

Validity measures and diagnostic indices of DM and DBT:

When comparing validity measures of DM and DBT, it was found that DBT had higher sensitivity and specificity than DM in the detection and characterization of different lesions in dense breasts, as shown in Table (5), with a statistically significant difference (P-value < 0.001).

Table 5: Comparison between DM and DBT in detecting and characterizing dense breast lesions.

Validity measures	DM	DBT
True positive	34 (40.69%	46(55.42%)
False positive	3(3.6%)	1 (1.2%)
True negative	24(28.91%)	32(38.55%)
False negative	22 (26.50%	4(4.81%)
Sensitivity	60.71 %	92%
Specificity	88.88 %	96.96%
Accuracy	62.38 %	92.15%
PPV	91.89 %	97.87%
NPV	52.17 %	88.88%

A chi-square test was used to compare the proportion of differences between groups. *Significant test results were considered when p-value was <0.05, p-value <0.001 indicating high significance.

Discussion

Digital breast tomosynthesis is an exciting development for breast cancer screening and diagnostic applications (5).

Increased breast density is a challenging issue in detecting lesions in mammography, decreasing its sensitivity and giving tomosynthesis the upper hand (6); hence, we paid patients with prominent fibro-glandular breast tissue (ACR C and ACR D) great attention.

In our study, we specifically focused on patients with dense breasts—classified as ACR C and D—to assess DBT's efficacy. Among 83 women with dense breasts (46.98% ACR C & 53.01% ACR D) with age ranged from 23 to 76 years, having a complaint (problem solving) or a symptomatic (screening) which was more inclusive and different from Romieh et al (7) who conducted their study on 90 symptomatic females with dense breasts (80% ACR C & 20% ACR D) with near equivalent age group (30-75). And much different and far away from Bian et al (8), who conducted their study on 631 symptomatic women with dense breasts having breast masses, and their ages ranged from 35 to 82 years with near equivalent breast density percentages (48.8% ACR C and 51.2% ACR D).

From 83 lesions in the current study, the majority were benign lesions (67.5%), this was different from Bian et al. and Seo et al studies (8)&(6) where most lesions were malignant (52.3% and 73.7% respectively), this can be attributed to inclusion of patients with breasts masses only in the later study while our study conducted on both symptomatic and asymptomatic patients.

DBT in our study provided better detection and characterization of lesions than DM, 24 mammographic findings were interpreted as indeterminate in DM became more obvious to be categorized either to a mass, asymmetry or normal overlapped glandular tissue by DBT, so it was found that 45 mass lesions could be detected by DBT vs only 37 were detected by DM, consequently this participated in change of BIRADS category and helped in improvement of all validity measures of DBT than DM.

The agreement between DM and DBT in BI-RADS classification was modest (Cohen's kappa = 0.342), with 69.88% of cases changing classification when DBT was introduced. Specifically, 46 lesions were upgraded and 12 were downgraded, while 25 remained unchanged.

Our results showed slightly more variation than those of Singla et al. (9), who found 53% of cases were reclassified using DBT, with a greater proportion being downgraded.

These findings align with those of Naeim et al. (10), who reported a 61% reclassification rate with DBT—49% upgrades and 12% downgrades.

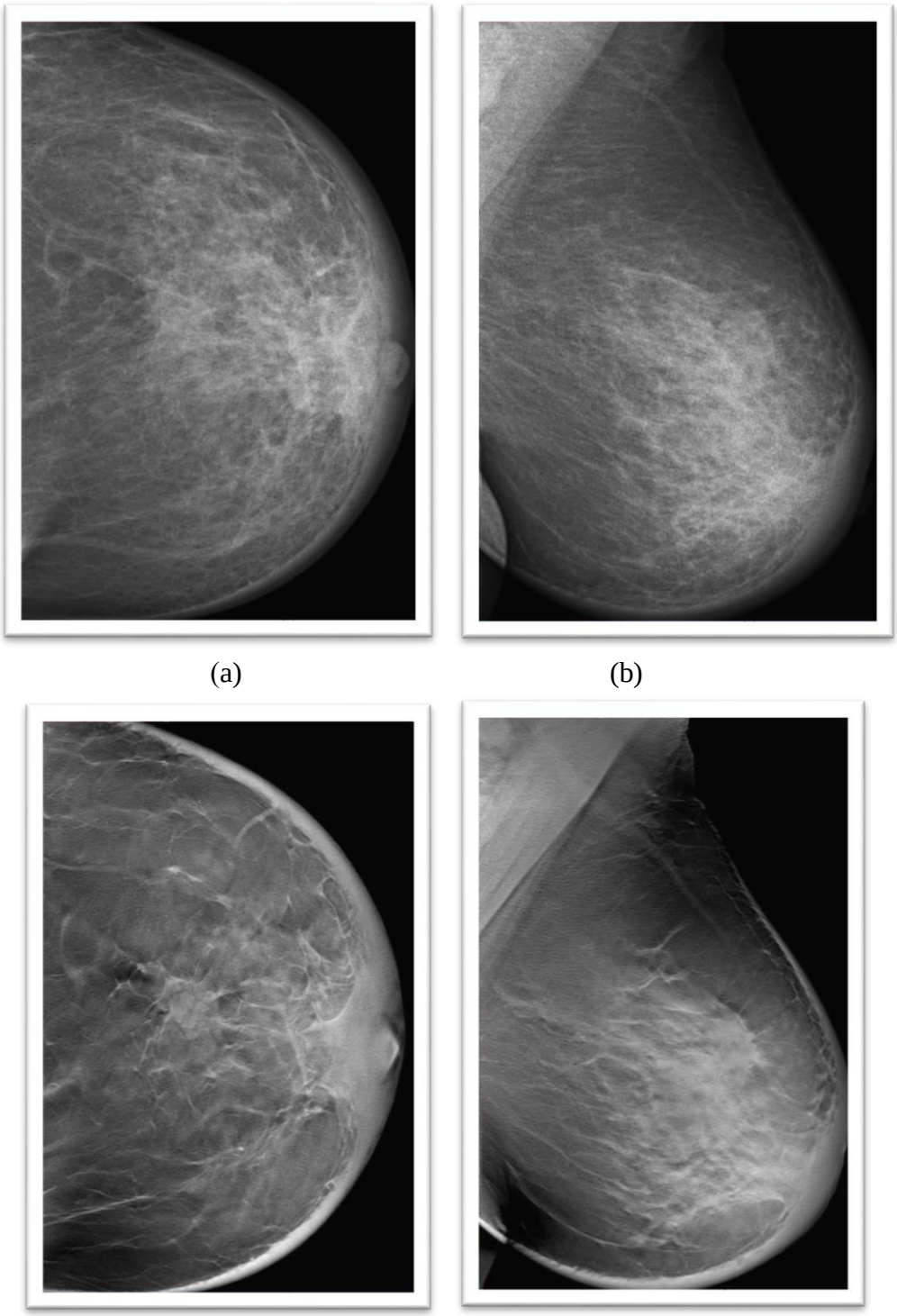
Consequently, and as result of the forementioned enhanced parameters in DBT in comparison to DM, all the validity measures were much better than DM as follows, sensitivity, specificity, accuracy, PPV and NPV were 92%, 96.96%, 92.15%, 97.87% and 88.88% versus 60.71%, 88.88%, 62.38%, 91.89% and 52.17% respectively, with a (P-value<0.001), which was found close to Naeim et al. (10) who reported nearly perfect sensitivity and specificity for DBT and a notable increase in diagnostic accuracy compared to DM. But far from Seo et al. (11) who concluded th there was no statistically significant difference between DBT and FFDM for the characterization of breast lesions (P > 0.0. However, DBT was superior in dense breasts (P = 0.03). The current study's validity measures differ from those of Sudhir et al. (12), who found a statistically significant difference between DBT and FFDM regarding all validity parameters except the sensitivity.

However, a minor limitation of DBT observed in our study was its slightly lower performance in detecting isolated microcalcifications, with DM identifying seven such cases compared to six by DBT. This finding supports prior conclusions by Spangler et al(13) who suggested that DM may retain a marginal advantage over DBT in detecting microcalcifications. However, the overall diagnostic performance between the two remains similar. Naeim et al.(10) also found a 16% reduction in calcification detection sensitivity when using DBT compared to DM.

Conclusion:

Digital breast tomosynthesis (DBT) significantly enhances the detection and diagnostic evaluation of breast abnormalities in women with dense breast tissue. Compared to traditional digital mammography (DM), DBT offers improved sensitivity, specificity, and overall diagnostic accuracy. The technology provides clearer lesion visualization, minimizes overlapping tissue artifacts, and reduces false negatives, making it a valuable adjunct in breast cancer screening protocols, particularly for high-risk populations with dense breasts.

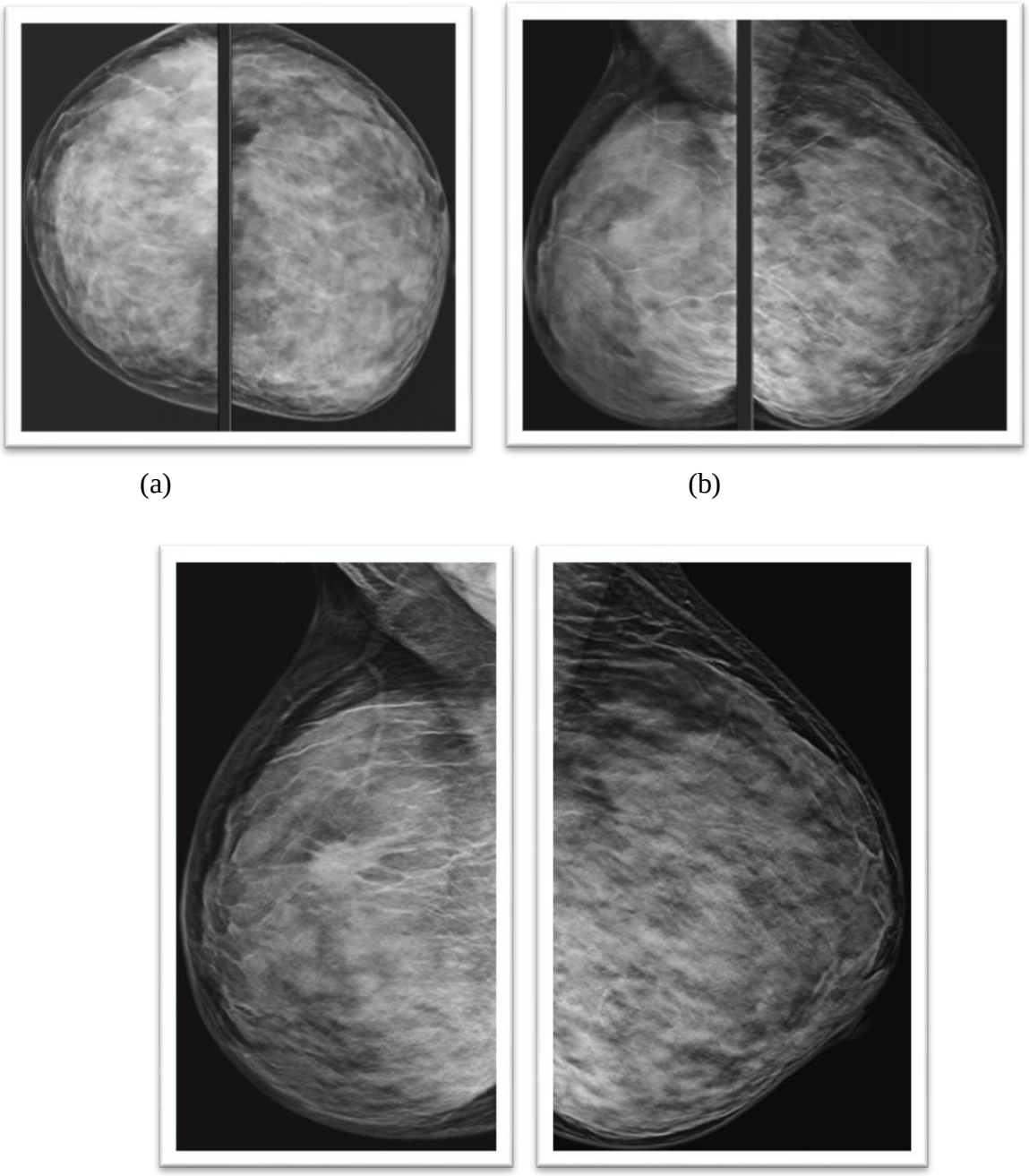
Given these advantages, incorporating DBT into routine breast imaging, especially for patients with ACR C and D density, should be strongly considered to reduce missed diagnoses and improve patient outcomes.



(a) (b)

(c) (d)

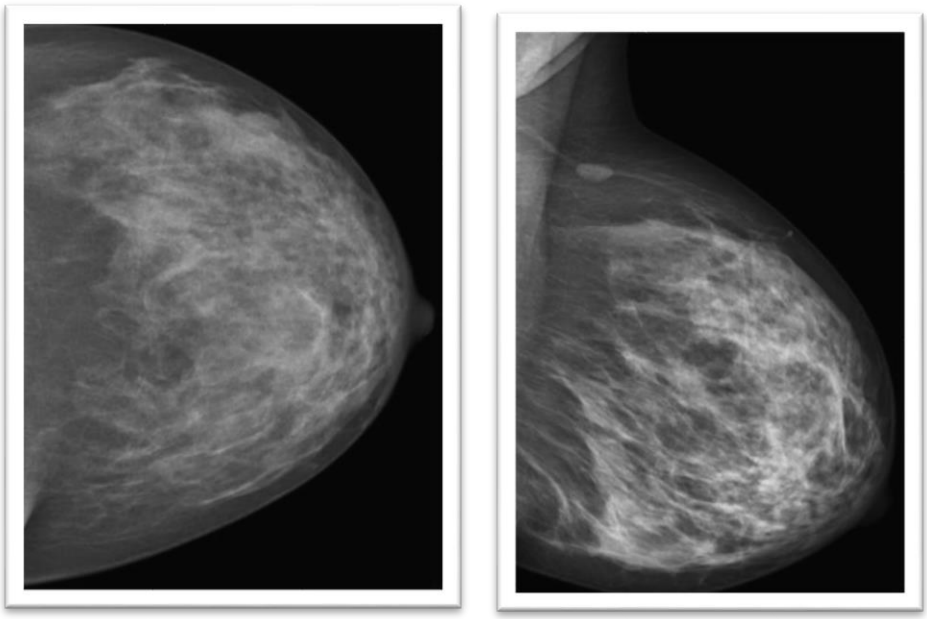
Figure (1) Fifty -four years female patient presented with left breast lump, (a) and (b) DM CC and MLO views of the left breast shows retro-areolar increase density, diffuse skin thickening more at nipple-areola complex with pathological axillary lymph nodes, interpreted as BIRADS IV a. (c) and (d) Tomosynthesis shows hyperdense mass, irregular shape, speculated margins, upgraded to BIRADS IV. Tru-cut needle biopsy revealed: invasive ductal carcinoma grade II.



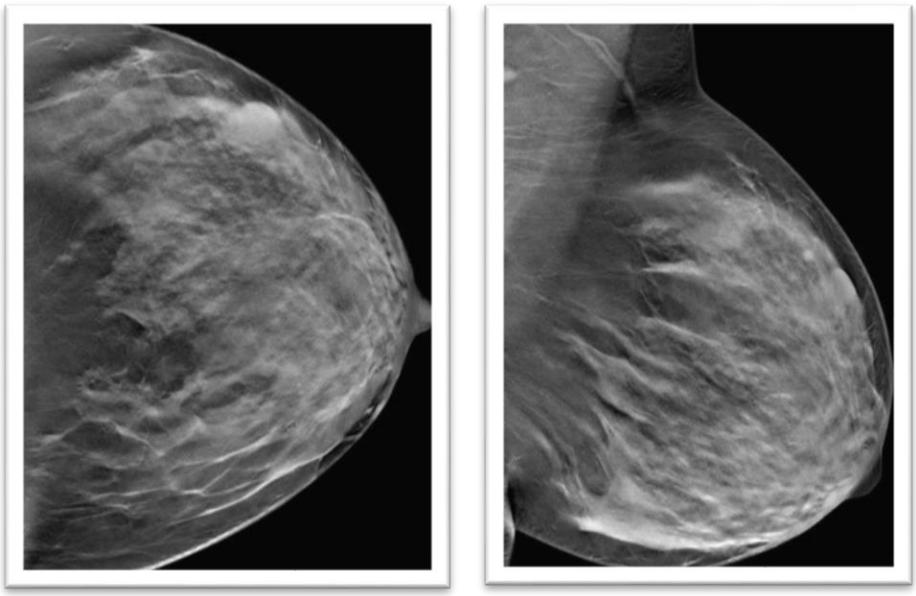
(a) (b)

(c)

- **Figure (2):** A 28-year-old female patient referred for screening as she has a positive family history of breast cancer.DM examination CC (a) and MLO (b) views of both breasts show extremely dense breast parenchyma (ACR D), obscured hyperdense mass at right MLO view (BIRADS IV). (c) **DBT of MLO view of both breasts** shows a right breast hyperdense mass at the upper outer quadrant, a rounded shape, speculated margins, and no calcification. Upgraded to BIRADS V. Tru cut needle Biopsy revealed right breast infiltrating duct carcinoma grade II.



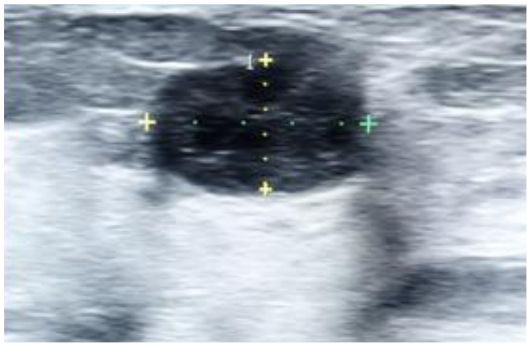
(a) (b)



(c) (d)

- **Figure (3):** A thirty-five-year-old female patient presented with a left breast lump. (a) & (b) DM, CC & MLO views of the left breast show heterogeneous breast density, ACR C hyperdense mass at the upper outer quadrant, obscured margins, oval shape, not seen at MLO view, interpreted as BIRADS IVa. (c) & (d) Tomosynthesis examination shows a circumscribed oval-shaped mass in the upper outer quadrant of the left breast (arrow), with no calcification. Interpreted as BIRADS III. (downgrading).

(e)



Ultrasound examination (e) showed a well-circumscribed oval-shaped hypo-echoic soft tissue capsulated mass lesion at the 2 o'clock position of the left breast measuring 10x14 mm, with no calcification within. These findings suggest a benign lesion (fibro adenoma), BIRADS III for short interval follow-up.

The lesion was subjected to regular short-interval follow-up by US every 6 months for one and a half years, revealing the same findings and hence was given a BIRADS II).

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