Original Article

A Comparative Study of Digital Mammography and Digital Tomosynthesis for Detection of Breast Lesions With Pathological Correlation

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ABSTRACT

Background: Breast cancer remains the most common malignancy among women worldwide. Accurate imaging is essential for early detection, especially in women with dense breast tissue. Digital mammography (DM) is the standard screening tool, but its limitations have led to the development of digital breast tomosynthesis (DBT), which reduces tissue overlap and improves lesion visualisation.
Aim: To compare the diagnostic performance of digital mammography and digital breast tomosynthesis in detecting breast lesions, using histopathology as the reference standard.
Materials and Methods: A prospective observational study was conducted on 50 women aged >40 years who underwent both DM and DBT using the SIEMENS MAMMOMAT REVELATION VC20 system. Lesions were evaluated according to BI-RADS criteria, and histopathological examination (HPE) or cytology served as the gold standard. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy were calculated and compared.
Results: DBT outperformed DM in detecting architectural distortion (34% vs 18%) and microcalcifications (30% vs 12%). DBT showed higher sensitivity (95.24% vs 80.95%), higher NPV (95.45% vs 84.00%), and greater diagnostic accuracy (82% vs 76%), while specificity remained equal (72.41%). DBT also increased the number of lesions categorized as BI-RADS 4, improving the identification of suspicious findings.
Conclusion: Digital breast tomosynthesis provides superior diagnostic performance compared to digital mammography, particularly in dense breasts. Its enhanced ability to detect and characterize breast lesions supports its routine use in breast cancer screening and diagnostic evaluation.

Keywords: Digital mammography, digital breast tomosynthesis, breast lesions, BI-RADS, histopathology, breast cancer detection.

INTRODUCTION

Breast cancer is the most common malignancy among women worldwide and remains a leading cause of cancer-related morbidity and mortality despite significant advances in diagnostic and therapeutic strategies [1]. Early detection through appropriate imaging plays a crucial role in reducing mortality, improving treatment outcomes, and enhancing patient survival [2]. Mammography has long been established as the primary imaging modality for breast cancer screening and diagnostic evaluation, owing to its accessibility, low radiation dose, and proven effectiveness in detecting early breast lesions [3].

However, conventional 2D digital mammography (DM) has limitations, particularly in women with dense breast tissue, where tissue overlap may obscure lesions and reduce diagnostic accuracy [4]. Dense breasts not only lower mammographic sensitivity but also increase the risk of developing breast cancer, necessitating more advanced imaging technologies for reliable assessment [5]. In this context, Digital Breast Tomosynthesis (DBT), also known as 3D

mammography, has emerged as a promising innovation. DBT acquires multiple projection images across an arc and reconstructs them into thin slices, thereby minimizing overlapping tissue and improving the detection of small masses, architectural distortions, and asymmetries [6].

Several studies have demonstrated that DBT enhances lesion conspicuity, increases cancer detection rates, reduces recall rates, and improves overall diagnostic performance compared to DM alone [7–9]. DBT is especially beneficial in dense breasts, where it significantly improves sensitivity without compromising specificity [10]. Despite these advantages, the utility of DBT varies depending on patient demographics, breast density, lesion characteristics, and institutional expertise. Therefore, comparative studies using both imaging modalities with pathological correlation are essential to establish their relative diagnostic performance in routine clinical practice.

This study aims to compare the effectiveness of digital mammography and digital breast tomosynthesis in detecting various breast lesions, with histopathology serving as the reference standard. By evaluating diagnostic indices such as sensitivity, specificity, PPV, NPV, and accuracy, this study provides evidence to support the optimal use of DBT and DM in breast cancer screening and diagnosis.

MATERIALS AND METHODS
Study Design and Setting
This study was designed as a **prospective observational study** and was conducted in the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre (VIMS & RC), Bangalore. The study period extended from **May 2023 to December 2024**.

Study Population
The study enrolled female patients aged **above 40 years** who were referred to the Department of Radiodiagnosis for routine breast cancer screening or for diagnostic evaluation of suspicious breast lesions.

Inclusion Criteria
- Female patients aged >40 years.
- Patients referred for screening mammography or evaluation of questionable breast lesions.

Exclusion Criteria
4. Pregnant or lactating women.
5. Women with open breast wounds or recent breast trauma.
6. Male patients presenting with gynecomastia or other breast-related symptoms.
7. Patients unwilling or unable to provide informed written consent.

Sample Size Calculation
Sample size estimation was based on the sensitivity reported by Abdelattef SA et al., where sensitivity of **3D digital breast tomosynthesis (DBT)** was 100%, and that of **digital mammography (DM)** was 77.8%.
the The formula used was:

$$n = \frac{Z_\alpha^2 \times Sn(100 - Sn)}{d^2}$$

Where:
- $Z\alpha$ = 1.96 (95% confidence level),
- Sn = 77.8%,
- $100 - Sn$ = 22.2%,
- d = 15% (absolute precision).

$$n = \frac{(1.96)^2 \times 77.8 \times 22.2}{15^2} = 29.48$$

Allowing for a **10% attrition rate**, the final required sample size was **33 patients**.

Method of Evaluation
Imaging Protocol
All participants underwent both Full-Field Digital Mammography (FFDM) and Digital Breast Tomosynthesis (DBT).

Equipment
All imaging was performed on the SIEMENS MAMMOMAT REVELATION VC20 system equipped with FFDM and 3D tomosynthesis technology.

Patient Preparation

Patients were scheduled during a period of minimal breast tenderness (approximately one week after menstruation). On the day of examination, they were instructed to avoid deodorants, talcum powder, lotions, or creams that may create artifacts resembling calcifications.

Digital Mammography Technique

- Standard Mediolateral Oblique (MLO) and Craniocaudal (CC) views were obtained for both breasts.
- Adequate compression was applied to reduce motion and overlapping tissue.
- The MLO view provided visualization of the upper outer quadrant and axillary tail (tail of Spence).
- The CC view improved evaluation of the central and medial breast.

Digital Breast Tomosynthesis Technique

- DBT was performed immediately following the 2D examination without repositioning the patient.
- The X-ray tube rotated in an arc (15°–60°) over the immobilized breast, acquiring 11–15 low-dose projection images.
- Images were reconstructed into 1-mm slices, generating a pseudo-3D dataset for improved lesion visibility.
- Standard DBT MLO and CC views were obtained and interpreted on high-resolution diagnostic workstations.

Image Interpretation

- All images were reviewed by experienced radiologists with breast imaging expertise.
- DBT slice-by-slice review was performed to identify masses, architectural distortion, asymmetries, and microcalcifications.
- Lesions were categorized as per American College of Radiology (ACR) BI-RADS assessment categories.
- BI-RADS 4 and 5 lesions underwent tissue sampling.

Tissue Sampling

Histopathological or cytological confirmation was obtained through:
- Image-guided core needle biopsy,
- Fine-needle aspiration cytology (FNAC), or
- Surgical excision, whenever clinically indicated.

Clinical Correlation

Final diagnosis was established through histopathology, cytology, or imaging follow-up at 6-month intervals for indeterminate lesions.

Outcome Measures

The diagnostic performance of FFDM and DBT was compared using:
- Sensitivity
- Specificity
- Positive Predictive Value (PPV)
- Negative Predictive Value (NPV)
- Diagnostic accuracy

Ethical Considerations

The study protocol received approval from the Institutional Ethics Committee (IEC) of VIMS & RC. Participation was voluntary, and written informed consent was obtained from all participants. Confidentiality was ensured through anonymization and secure data handling, following institutional and international ethical guidelines.

Statistical Analysis

Data entry was performed using Microsoft Excel, and statistical analysis was conducted using **SPSS version 22**.
- Categorical variables were expressed as frequencies and percentages.
- The **Chi-square test** or **Fisher's exact test** (for small samples) assessed associations between imaging findings and histopathology.
- Diagnostic indices were calculated using standard formulas:

$$Sensitivity = \frac{a}{a + c} \times 100$$
$$Specificity = \frac{d}{b + d} \times 100$$
$$PPV = \frac{a}{a + b} \times 100$$
$$NPV = \frac{d}{c + d} \times 100$$

$$Accuracy = \frac{a + d}{a + b + c + d} \times 100$$

A **p-value < 0.05** was considered statistically significant.

RESULTS AND OBSERVATIONS;

Table 1: Distribution of subjects according to age group

	Number	Percentage
30-39yrs	3	6.0
40-49yrs	17	34.0
50-59yrs	16	32.0
60-69yrs	11	22.0
70-79yrs	3	6.0
Total	50	100.0

Table 2: Breast Composition according to digital mammography and digital breast tomosynthesis.

	Digital mammography		Digital breast tomosynthesis	
	N	%	N	%
A	5	9.8	5	9.8
B	28	54.9	28	54.9
C	16	31.4	16	31.4
D	2	3.9	2	3.9
Total	50	100	50	100

Table 3:- Architectural distortion according to diital mammography and digital breast tomosynthesis

Architectural distortion	Digital mammography		Digital breast tomosynthesis	
	N	%	N	%
Absent	41	82.0	28	56.0
Present	9	18.0	17	34.0
Total	50	100.0	50	100.0

Table 4: Density According to Digital Mammography and Digital Breast Tomosynthesis

Density	Digital Mammography (n=50)	Digital Breast Tomosynthesis (n=50)
	N	%
Low	7	14.0
Iso	15	30.0
High	28	56.0
Total	**50**	**100**

Table 5: Margins According to Digital Mammography and Digital Breast Tomosynthesis

Margins	Digital Mammography (n=50)	Digital Breast Tomosynthesis (n=50)
	N	%
Regular	28	56.0
Irregular	21	42.0
Spiculated	1	2.0
Total	**50**	**100**

Table 6: Shape According to Digital Mammography and Digital Breast Tomosynthesis

Shape	Digital Mammography (n=50)	Digital Breast Tomosynthesis (n=50)
	N	%
Regular	34	68.0
Irregular	16	32.0
Total	**50**	**100**

Table 7: Distribution of Lesions According to Digital Mammography and Digital Breast Tomosynthesis

Lesion Distribution	Digital Mammography (n=50)	Digital Breast Tomosynthesis (n=50)
	N	%
Unifocal	39	78.0
Multifocal	11	22.0
Total	**50**	**100**

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Table 8: Calcifications According to Digital Mammography and Digital Breast Tomosynthesis

Calcification Type	Digital Mammography (n=50)	Digital Breast Tomosynthesis (n=50)
	N	%
Macrocalcifications	15	30.0
Microcalcifications	6	12.0
Total	**50**	**100**

Table 9: BIRADS according to digital mammography and digital breast tomosynthesis

BIRADS	Digital mammography		Digital breast tomosynthesis	
	N	%	N	%
0 - Needs additional investigations	2	4.0%	0	0%
1- Benign	6	12.0%	6	12.0%
2 - Probably benign	17	34.0%	16	32.0%
3 - Suspicious	20	40.0%	14	28.0%
4 - High suggestive of malignancy	3	6.0%	12	24.0%
5 - Proven case of malignancy	2	4.0%	2	4.0%

Table 10: Comparison of Digital Mammography and Digital Breast Tomosynthesis With Respect to HPE

Parameter	Digital Mammography	Digital Breast Tomosynthesis (DBT)
Contingency Table (n = 50)	Benign = 21 (TP) Malignant = 4 (FP) Benign = 8 (FN) Malignant = 17 (TN)	Benign = 21 (TP) Malignant = 1 (FP) Benign = 8 (FN) Malignant = 20 (TN)
Sensitivity	80.95% *(95% CI: 58.09–94.55)*	95.24% *(95% CI: 76.18–99.88)*
Specificity	72.41% *(95% CI: 52.76–87.27)*	72.41% *(95% CI: 52.76–87.27)*
Positive Predictive Value (PPV)	68.00% *(95% CI: 53.21–79.88)*	71.43% *(95% CI: 57.91–81.96)*
Negative Predictive Value (NPV)	84.00% *(95% CI: 67.88–92.88)*	95.45% *(95% CI: 75.37–99.31)*
Accuracy	76.00% *(95% CI: 61.83–86.94)*	82.00% *(95% CI: 68.56–91.42)*

ILLUSTRATIVE CASES:
CASE 1:
A 46 year old female diabetic patient presented with pain and swelling in the left breast since 3 months. Clinical examination revealed a lump in the left breast and the patient was subjected to mammography.
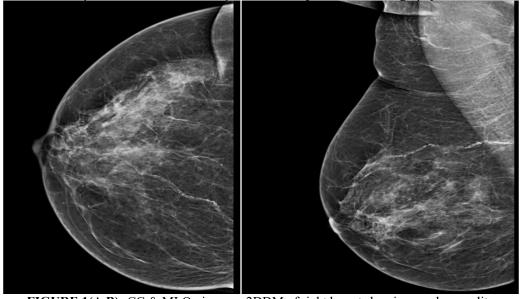

FIGURE 1(A,B): CC & MLO views on 2DDM of right breast showing no abnormality

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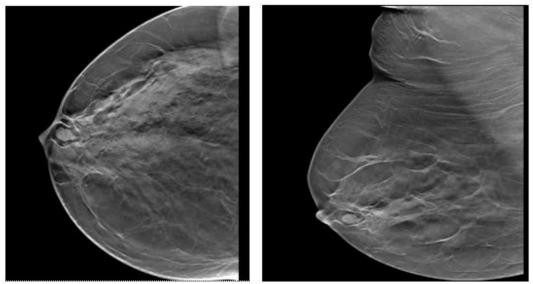
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FIGURE 1(C, D): CC & MLO views on DBT show a well- circumscribed lobulated isodense lesion in the retro areolar region of the right breast.

Mammography Findings:

Breast composition: Scattered areas of fibroglandular density noted - ACR category B.

A well- circumscribed lobulated isodense lesion in the retro areolar region of the right breast measuring~ 10.4 x 8 mm causing adjacent mild architectural distortion.

No calcifications noted within.

Nipple areolar complex appears normal.

No evidence of axillary lymphadenopathy.

HPE FINDINGS: HPE showed proliferative fibrous stroma with compressed and elongated epithelial ducts, suggestive of fibroadenoma.

BIRADS on 2D Digital mammography :1
BIRADS on Digital breast Tomosynthesis : 3

Case 2:

A 44 year old female patient who presented with a lump in the left breast since 12 months. Clinical examination revealed a lump in the left breast and the patient was subjected to mammography.
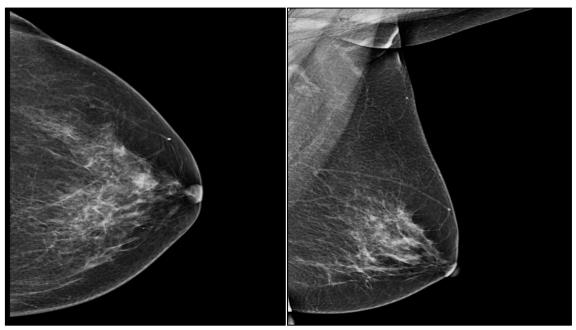

FIGURE 2 (A,B): CC & MLO views of left breast on 2DDM showed scattered fibroglandular densities with focal

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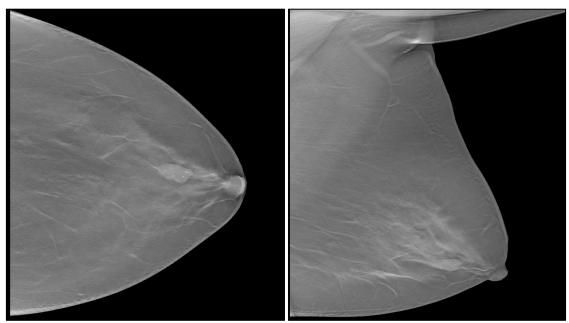**1697**

asymmetry in the lower inner quadrant.

FIGURE 2(C,D): CC & MLO views of left breast on DBT shows a well defined oval high density lesion with lobulated margins noted in the retroareolar region with few specs of calcifications.

MAMMOGRAPHY FINDINGS:
Breast composition: ACR category B, Scattered fibroglandular density.
A well defined oval high density lesion (measuring ~ 14x11 mm) noted in the retroareolar region with few specs of calcifications within it.
Few vascular calcifications noted.
Nipple areola complex appears normal.
Skin appears normal.
Few small volume lymph nodes noted in both axilla.

HPE FINDINGS: a well-circumscribed benign breast tumor with abundant fibrous stroma and compressed, elongated ductal structures arranged in a swirling pattern, suggestive of fibroadenoma.

BIRADS on 2D Digital mammography:1
BIRADS on Digital breast Tomosynthesis : 3
Case: 3:
A 55 year old female patient presented with a lump in the right breast since 2 years which has gradually increased in size in the past 2 months .Clinical examination revealed a lump in the right breast and the patient was subjected to mammography.
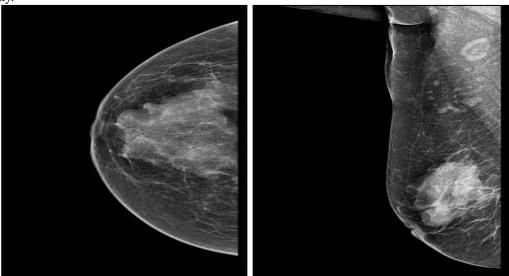

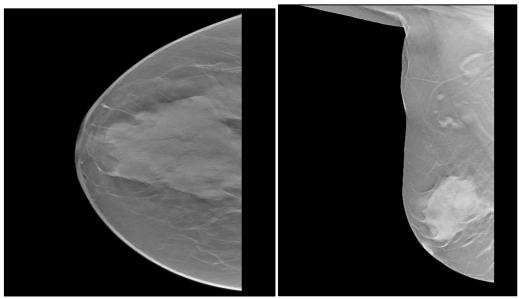**FIGURE 3 (A,B) :**CC & MLO views on 2DDM shows a heterogeneously dense breast showing no abnormality

FIGURE 3(C,D): CC & MLO views on DBT shows a well-defined high density lesion with lobulated margins in the upper outer quadrant of right breast

MAMMOGRAPHY FINDINGS:
Breast composition: ACR category C, heterogeneously dense , which may obscure small lesions.
Nipple areola complex appears normal.
A well defined high-density lesion with lobulated margins seen in the upper outer quadrant of right breast measuring~ 41 x 28 mm.The epicenter of the lesion is located at ~3.4 cm from the nipple areolar complex.

One enlarged and few subcentimetric lymph nodes with lucent hila were noted in the right axilla, largest measuring~ 20 x 17 mm.
Nipple areola complex appears normal.

HPE FINDINGS: HPE showed proliferation of small, uniform, dyscohesive neoplastic cells filling and expanding lobules along with round to oval nuclei with minimal pleomorphism and indistinct nucleoli, features in favor of lobular carcinoma insitu.

BIRADS on 2D Digital mammography: 0
BIRADS on Digital breast Tomosynthesis : 4B

Case 4: A 55 year old female patient presented with a lump in the right breast since 2 months.Clinical examination revealed a lump in the right breast and the patient was subjected to mammography.
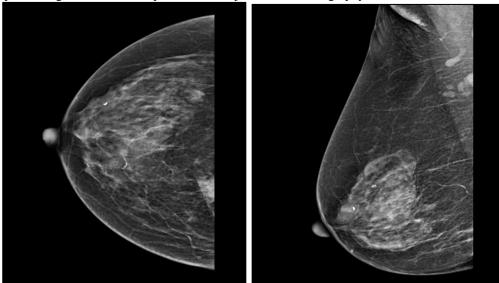

FIGURE 4(A,B): CC & MLO views on 2DDM showed heterogeneously dense breasts which may obscure small lesions.
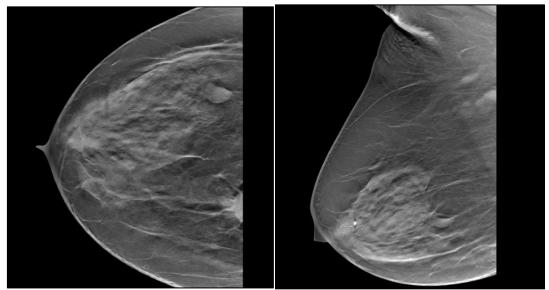
FIGURE 4(C,D): CC & MLO views of the right breast on DBT showed scattered areas of fibroglandular densities in the right breast with partially obscured high density lesion with irregular margins seen in the lower inner quadrant with associated architectural distortion. A well circumscribed oval high density lesion with coarse calcifications noted in the upper outer quadrant.

MAMMOGRAPHY FINDINGS:
Breast composition: ACR category C, heterogeneously dense , which may obscure small lesions.
Partially obscured high-density lesion with irregular margins seen in the lower inner quadrant of right breast.
Nipple areola complex appears normal.

On USG correlation, a taller than wider, hypoechoic lesion with microlobulations measuring ~ 18 x 14mm noted at 5 o' clock position involving the pectoralis muscle.
On doppler interrogation, internal vascularity is noted. No calcifications/posterior acoustic shadowing.

Another well circumscribed oval high-density lesion with coarse calcifications noted in the upper outer quadrant of right breast, measuring ~ 11 x 6 mm seen ~1.3 cm from the nipple areolar complex.Multiple small volume lymph nodes were noted in the right axilla largest measuring ~ 8 x 7.5 mm.

HPE FINDINGS: HPE showed malignant epithelial cells infiltrating the stroma in irregular nests and trabeculae with cells exhibiting pleomorphic, hyperchromatic nuclei and prominent nucleoli along with loss of normal ductal or lobular architecture.Features suggestive of invasive ductal adenocarcinoma.

BIRADS on 2D Digital mammography:0
BIRADS on Digital breast Tomosynthesis : 5
Case 5: A 51 year old female patient presented with a lump in the left breast since 1 month.Clinical examination revealed a lump in the left breast and the patient was subjected to mammography.'
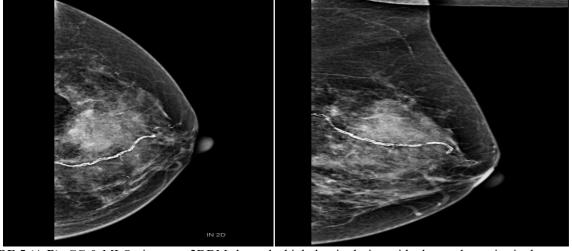

FIGURE 5 (A,B): CC & MLO views on 2DDM showed a high density lesion with obscured margins in the upper outer
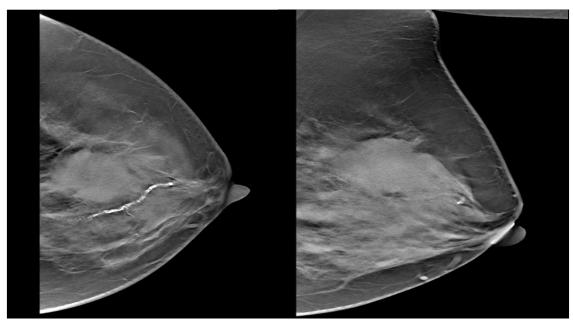
FIGURE 5 (C,D): CC & MLO views of the left breast on DBT showed a high density lesion with ill-defined margins in the upper outer quadrant of left breast.

MAMMOGRAPHY FINDINGS:
Breast composition: Heterogeneously dense, which may obscure masses - ACR category C
A fairly well-defined high-density lesion measuring ~3.5 x 3.2 cm with ill-defined margins noted in upper outer quadrant of left breast. The lesion is seen 2.2 cm from nipple areolar complex.Vascular calcifications noted in the left breast. No obvious enlarged lymph nodes seen in bilateral axilla.

HPE FINDINGS: On HPE the individual tumor cells were moderately pleomorphic with desmoplastic stromal change adjacent to tumor cells, suggestive of infiltrating ductal adenocarcinoma.
BIRADS on 2D Digital mammography:2
BIRADS on Digital breast Tomosynthesis : 5

DISCUSSION
In this prospective observational study, digital mammography (DM) and digital breast tomosynthesis (DBT) were compared for their diagnostic performance in evaluating breast lesions, with histopathology used as the gold standard. The findings of this study demonstrate that DBT outperforms DM in several critical parameters, particularly sensitivity, detection of architectural distortion, lesion margins, microcalcifications, and overall diagnostic accuracy.

The age distribution in our study (predominantly 40–59 years) aligns with the peak incidence of breast cancer reported in Indian and global populations [1]. Breast density plays a crucial role in imaging interpretation, as higher density reduces mammographic sensitivity and may mask underlying lesions. In our study, the majority of participants exhibited ACR type B and C composition, consistent with previous studies indicating that these patterns are common in middle-aged women [2]. Because dense tissue limits DM performance, DBT becomes particularly beneficial, as supported by prior research showing improved visualization through reduction of tissue overlap [3,4].

Architectural distortion—often an early sign of malignancy—was detected more frequently on DBT (34%) than on DM (18%), reflecting DBT's superior capability. Similar findings were reported by Rafferty et al., who demonstrated that DBT significantly enhances detection of subtle distortions not clearly visible on DM [5]. Likewise, margins appeared more often spiculated on DBT than on DM in our study, which is clinically important because spiculation strongly correlates with malignancy. Philpotts et al. also noted that DBT improves assessment of lesion borders and spiculations due to its quasi-3D visualization [6].

Regarding lesion density, DBT identified a higher proportion of high-density lesions (76%) than DM (56%), which reflects improved lesion conspicuity on tomosynthesis. These observations corroborate studies showing that DBT increases contrast and clarity of mass lesions compared to 2D mammography [7]. Shape characterization was comparable between the two modalities, though DBT slightly improved detection of irregular shapes—an important parameter in BI-RADS categorization.

In terms of lesion distribution, DBT identified slightly more multifocal lesions (26% vs 22% with DM), demonstrating better lesion localization. Previous literature confirms that DBT aids in evaluating multifocal and multicentric disease, supporting surgical planning and reducing false negatives [8].

One of the most significant differences in our study was the detection of microcalcifications, which increased from 12% on DM to 30% on DBT. Although DM is traditionally considered superior for evaluating calcifications, several newer studies indicate that synthetic 2D images combined with DBT or high-resolution DBT slabs improve microcalcification visualization [9]. Our results suggest that DBT provided added benefit, likely due to improved contrast resolution in the equipment used.

The BI-RADS distribution further highlights DBT's diagnostic advantages. DBT resulted in a greater number of BI-RADS 4 lesions (24% vs 6% on DM), indicating enhanced recognition of suspicious features warranting biopsy. Similar trends were reported in large multicenter trials where DBT shifted more lesions into actionable BI-RADS categories, reducing ambiguity and unnecessary recalls [10].

When diagnostic indices were compared, DBT demonstrated higher sensitivity (95.24%) than DM (80.95%). This improvement is consistent with studies by Skaane et al. and Ciatto et al., who reported substantial increases in cancer detection rates when DBT was added to or replaced DM [11,12]. Specificity in our study was identical for both modalities (72.41%), aligning with literature suggesting that DBT improves sensitivity without compromising specificity [13]. DBT also showed superior NPV (95.45% vs 84%) and overall accuracy (82% vs 76%), reaffirming its value for ruling out malignancy.

Overall, the findings of this study strongly support the use of digital breast tomosynthesis as a superior modality to digital mammography for evaluating breast lesions. DBT reduces tissue overlap, improves lesion characterization, and enhances diagnostic confidence—particularly in women with dense breasts. Incorporating DBT into routine breast imaging protocols may significantly improve early cancer detection and reduce false-negative diagnoses.

CONCLUSION

Digital breast tomosynthesis (DBT) demonstrated superior diagnostic performance compared to digital mammography (DM) in the evaluation of breast lesions. DBT showed higher sensitivity, improved detection of architectural distortion, clearer visualization of lesion margins, better identification of microcalcifications, and greater overall diagnostic accuracy. Its ability to reduce tissue overlap and enhance lesion conspicuity was especially valuable in women with dense breasts. While specificity remained comparable between both modalities, DBT provided a markedly higher negative predictive value, increasing confidence in ruling out malignancy.

Overall, DBT proved to be a more reliable imaging modality than DM for the early and accurate detection of breast lesions, supporting its integration into routine breast cancer screening and diagnostic workflows.

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