ORIGINAL ARTICLE

Comparative Study Between Digital Tomosynthesis and Dynamic Contrast Enhanced MRI in Diagnosis of Malignant Breast Cancer

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Abstract

Background: ***All throughout the globe, people are dealing with the devastating effects of breast cancer (BC). It ranks first among female cancers in both industrialized and underdeveloped nations.***

Aim of the study: ***To assess the efficacy of DCT and SPECT/MRI in the diagnosis and localization of breast cancer.***

Subjects and methods: ***In this study, 34 female patients with suspected breast cancer who were referred to the radiology departments of two hospitals—Almana General Hospital in Khobar, Kingdom of Saudi Arabia KSA, and the National Cancer Institute (NCI) Cairo—from surgical departments and outpatient clinics were included. The study ran from March 2018 to February 2023. Digital tomography (DBT) and dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) were administered to all patients.***

Results: ***Comparing DBT with DCE-MRI for BIRAD category assessment yields a highly significant difference (P-value=0.001). Our study found that 73.3% of breast lesion BIRAD scores were upgraded and 2.96 percent were downgraded when using DCE-MRI instead of DBT. This study found no statistically significant distinction between BDT and DCE-MRI in terms of site, shape, margin, and focality (all with p-values>0.05).***

Conclusion: ***Significantly higher diagnostic performance of DCE-MRI using qualitative and quantitative assessment in diagnosis and Bi-RAD categorization of breast carcinoma with high sensitivity, specificity, accuracy, PPV, and NPV as compared to DBT. DCE-MRI Bi-RAD categorization was essential for management of breast carcinoma. Dynamic MRI was more sensitive for detection of axillary adenopathy as compared to Tomosynthesis.***

Keywords: Malignant Breast Cancer; Digital Tomosynthesis; Enhanced MRI

1. Introduction

Out of all cancers diagnosed, 2.3 million are breast cancers, making it one out of every eight cancers. It was the most often diagnosed cancer in women in 2020, accounting for 25% of all cancer cases in females.[1]

It is the most prevalent malignancy in females globally. Metastasis affects almost half of all patients, and some individuals present with advanced stages when they are first diagnosed.[2]

With an anticipated mortality rate of about 11% in 2020, BC is currently the second leading cause of cancer mortality in Egypt, behind only hepatocellular carcinoma. Compared to other emerging nations, such as China (age-standardized death rate: 6.3/105), this rate is significantly higher.[3]

In 2011, the FDA initially authorized DBT for clinical use. Digital breast tomography (DBT) involves taking a number of short exposures at various angles relative to the digital detector in order to create a number of slices at various depths inside the breast. By removing some of the tissue from the slices, the superimposition of images can be reduced, resulting in clearer individual images.[4]

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So far, DCE-MRI has proven to be the most sensitive method for detecting breast cancer. In addition to evaluating the number of diseases and screening high-risk women, MRI can also evaluate the response of neoadjuvant treatment. On the other hand, it's relatively pricey and scarce, especially in less developed nations and rural areas. Furthermore, gadolinium's potential adverse effects and unidentified long-term consequences are causes for caution. So, it's interesting to look at other imaging methods that use various contrast agents.[5]

This study set out to assess how well digital Tomosynthesis and dynamic contrast enhanced magnetic resonance imaging (MRI) work for the diagnosis and localization of breast cancer.

2. Patients and methods

This comparative study included 34 female patients with suspicious breast carcinoma, referred to radiology departments at Almana General Hospital (Khobar, Kingdom of Saudi Arabia, KSA) and National Cancer Institute (NCI), Cairo, from the surgical department and outpatient clinics from March 2018 to February 2023.

Ethical approval:

The Radiology Department's Ethical Research Committee at Al-Azhar University's Faculty of Medicine reviewed and approved the study's updated protocol. Following a comprehensive description of the study's goal and method, all patients under investigation provided signed informed consent.

The patients were classified into two major categories: the first category included 11 patients who are referred to radiology department for screening; the second category included 33 patients who are referred for assessment of abnormal clinical findings in breast.

Inclusion criteria:

Women coming for screening, with questionable breast findings by clinical, Ultrasound, or Digital Mammography, and no age predilection.

Exclusion criteria

Patients who are not suitable for entry into a magnetic field, such as those with a pacemaker, cochlear implant, or other metallic prosthesis that disrupts the examination, as well as pregnant or breastfeeding women, those with impaired kidney functions, and patients with other contraindications to entering a magnetic field.

All patients were subjected to:

Full history taking: personal history, family history of breast cancer and oral contraceptives or birth control pills use, past history of breast cancer, performing any breast imaging modality, and any available images or report, past history of previous breast surgery, biopsy, or intervention, and history of the patient's lifestyle, and routine laboratory tests.

Digital Tomosynthesis:

The DBT was carried out using a specialized FFDM system, which includes a Senographe PristinaTM mammography machine and Fujifilm's third-generation ASPIRE Cristalle.

A sequence of low-dose radiography exposures was used to get quasi-three-dimensional images of the compressed breast tissue. All patients underwent bilateral craniocaudal (CC) and mediolateral-opaque (MLO) imaging. In order to generate sections that run parallel to the breast support, the filtered back-projection algorithm was used for image reconstruction. The usual mode sweep angle was 15-25 degrees, and the tube voltage was approximately 38 kilovolts. A specialized workstation was used to assess DBT reconstructions with a section thickness of 1 mm using either automated or manual scroll modes.

Dynamic contrast-enhanced MRI:

The 1.5 T scanners used for the breast MRIs were the PHILIPS ACHIEVA 1.5T XR, the PHILIPS Ingenia Prodiva 1.5T CS, and the Siemens Healthineers Debuts Magnetom Altea 1.5T MRI Scanner. The patients were positioned in a prone posture during the exams.

MRI protocol performed in Almana General Hospital:

The TR4950 TE71 sequence, which is fat-suppressed-free, uses axial rapid spin echo imaging with a 3 mm slice thickness. Axial pre-contrast diffusion-weighted echo-planar imaging (DWI-EPI) sequences (b-value 0, 50, and 850s/mm). Automatic calculation of ADC maps was performed. Transverse axial T1 (TR567 TE10, 3 mm thickness) without fat suppression. Because of the higher T1-weighting and the natural fat suppression, the imaging contrast is improved using axial turbo inversion recovery magnitude (TIRM) sequences that have short T1 relaxation and long TE (echo duration; TR3740 TE60 Slice Thickness 3mm).

T1 fat-suppression images (T1-tse-tra-fs-pre) before and after axial, coronal, and sagittal contrast. The images were captured using a 256×256 matrix, a slice thickness of 3mm, no gap, and a field of view (FOV) of 36-37 cm, using the following parameters: TR630, TE9.9, and a thickness of 3mm.

A peripheral venous access was used to automatically administer 0.2mmol/kg Omniscan (gadodiamide) at a rate of 3mL/sec, followed by a 20-mL saline flush at the same rate. The injection was performed using a power injector. Each serial phase lasted between 52 and 55 seconds after a 10-second waiting period. The two breasts were imaged using 3D T1gradient thrive (TR 6.5, TE 2.3, flip angle 45°) in both axial and sagittal planes. The following axial 3D fat-suppressed gradient-echo T1-weighted sequences were obtained: slice thickness 3mm, TR 3.9, TE 1.6, and a flip angle of 45°. Roughly eighteen minutes elapsed during processing.

MRI protocol performed in NCI :

Straightforward T2-weighted axial fast spin echo sequences (TR4500, TE110, Slice) that do not reduce fat. Dimensions: 4 mm thick, 0.4 mm interslice gap, 384 x 36 cm matrix, field of view (FOV).Horizontal T1 without adipose tissue reduction. THER550 TE14. With fat suppression, axial and sagittal T2 WI scans. Axial pre-contrast diffusion-weighted echo-planar imaging (DWI-EPI) sequences with b-values of 0, 50, 400, and 800. Automatic calculation of ADC maps was performed. Fat suppression in T1 precontrast gradient imaging (TR 6.5, TE 2.3, flip angle 45°) with axial, coronal, and sagittal views.

A power injector was used to automatically inject 0.2mmol/kg of Magnevist (gadopentetate dimeglumine)/Dotarem (gadoterate meglumine) into a peripheral venous access at a rate of 3mL/sec. Following this, a 20mL saline flush was administered at the same rate. Each of the six subsequent phases lasted between 52 and 57 seconds, after a waiting period of 10-15 seconds. The two breasts were imaged using 3D T1gradient thrive (TR 6.5, TE 2.3, flip angle 45°) in both axial and sagittal planes. Twenty minutes was the whole acquisition duration.

Post-processing and image analysis:

Placing the ROI in the most improved section of the lesion allowed for quantitative analysis, which immediately yielded a time/signal intensity curve. The improving elements in the photos were highlighted by acquiring post-processing subtraction images after each series using the software subtraction that was provided at the work station. throughout addition, maximum intensity projection (MIP) was used to show how the disease was distributed throughout the breast in respect to the skin, nipple, chest wall, and major arteries.

Using morphological, enhancement, and kinetic curve KC analysis, as well as correlation with pathological findings, the results of DCE-MRI were reported and rated according to the Breast Imaging-Reporting and Data System BI-RADS category.

Imaging Evaluation:

The tumor size evaluation, shape, and margins for masses, distribution for non-melanoma endometriosis (NME), and internal enhancement characteristics were evaluated on post-contrast fat-suppressed T1-weighted sequences, and all suspicious lesions were quantified and reported. A statistical study was conducted by collecting, tabulating, and analyzing the data.

Histopathological Analysis:

Using established protocols, a pathologist conducted the histopathological analyses.

Using the Nottingham Histologic Score and the World Health Organization Classification, tumors were assessed.

Subtypes of tumors can be determined using ImmunoHistoChemistry (IHC) features, which include things like HER2 expression, tumor subtypes, and the Ki-67 proliferation index. The St. Gallen International Breast Cancer Conference (2013) used the following criteria to categorize invasive tumors: luminal A-like, luminal B-like, HER2-positive, and triple negative.

Statistical Analysis:

We used the statistical package SPSS (version 22.0; IBM Corp, Armonk, NY) to analyze the data and create the graphs. Binary logistic regression was used to assess associations between continuous factors and BC, while x2 tests were used to compare associations between categorical variables and BC. In order to evaluate the impact of risk factors that were shown to be statistically significant in the univariate analysis, a logistic regression model was employed in the multivariate analysis.

Statistical significance was determined by two-tailed P-values less than 0.05. In order to assess the agreement and dependence of DCE-MRI and DBT measurements with regard to the histological results, we computed their sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. We then fitted Spearman's correlation coefficient and regression analyses to the positive cases.

3. Results

Table 1 show : The most common clinical presentation was breast Lump(32.35%), followed by mastalgia(8.82 %).

Table 1. Clinical presentation of 34 female patients.

CLINICAL PRESENTATION	NUMBER	%
BEAST LUMP	11	32.35%
LUMP WITH ENLARGED AXILLARY LYMPH NODE	1	2.94%
AXILLARY LUMP	1	2.94%
NIPPLE LESION	2	5.88%
MASTALGIA	3	8.82%

The histology subtype of breast carcinoma in our study was IDC(50%), followed by DCIS(35.29%), then ILC and DCIS+Paget's(5.88% for each),(table 2).

Table 2. Histopathology finding in 34 female patients included in this study.

Pathological type			Number	%
DCIS			12	5.29
PATHOLOGICAL GRAD	NUMBER	%		
DCIS GRAD-I	0	0		
DCIS GRAD-II	1	8.33		

DCIS GRAD-III	1	8.33		
UNDETERMINED NUCLEAR GRAD	10	83.33		
IDC			17	50
PATHOLOGICAL GRAD	NUMBER	%		
IDC GRAD-I	1	5.88		
IDC GRAD-II	11	64.7		
IDC GRAD-III	5	29.4		
ILC			2	5.88
PATHOLOGICAL GRAD	NUMBER	%		
ILC GRAD-I	2	100		
ILC GRAD-II	0	0		
ILC GRAD-III	0	0		
DCIS +Paget			2	5.88
Metastatic carcinoma			1	2.94

In regards to axillary adenopathy, there was a highly significant difference between the two methods (<0.001), but in regards to other associated aspects, there was no significant difference (p>0.05),(table 3;figure 1).

Table 3. Comparison between DBT and DCE-MRI regarding associated features.

	TOMOSYNTHESIS		DYNAMIC MRI		CHI-SQUARE TEST	
ASSOCIATED FEATURE	number	%	number	%	X2	- value
SKIN THICKENING	2	5.88	2	5.88	0.266	0.606
SKIN LESION	0	0	0	0	NA	NA
NIPPLE RETRACTION ALONE	0	0	0	0	NA	NA
CHEST WALL INVASION	1	2.94	2	5.88	0.00	0.999
AXILLARY ADENOPATHY	8	23.52	29	85.29	23.71	<0.001
NIPPLE RETRACTION + AXILLARY ADENOPATHY	2	5.88	1	2.94	0.00	0.999

p≤0.05 is statistically significant, p≤0.01 is high statistically significant, *:Chi-Square Test

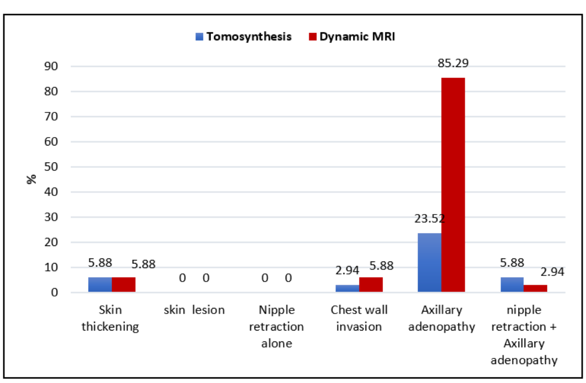


Figure 1. Comparison between DBT and DCE-MRI regarding associated features.

Bi-RAD 4 was commonest by Tomosynthesis(22) as compared to dynamic MRI(11), while Bi-RAD 5 was commonest by dynamic MRI(22) as compared to Tomosynthesis(7). There was highly statistically significant difference between DBT and DCE-MRI in assessing Bi-RAD category(p=0.001), (table 4; figure 2).

Table 4. Bi-RAD category assessment by DBT and DCE-MRI.

BI-RAD CATEGORY	TOMOSYNTHESIS		DYNAMIC MRI		CHI-SQUARE TEST	
	Number	%	Number	%	X2	- value
BI-RAD 3	4	11.76	0	0	15.43	0.001
BI-RAD 4	22	64.7	11	32.35		
BI-RAD 5	7	20.58	22	64.7		
BI-RAD 6	1	2.94	1	2.94		

p≤0.05 is statistically significant, p≤0.01 is high statistically significant, *:Chi-Square Test

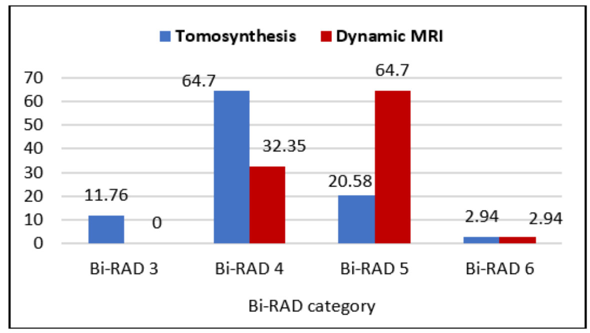


Figure 2. Comparison between DBT and DCE-MRI regarding Bi-RAD category.

In our study 25(25/34, 73.5 %) lesions BDT Bi-RAD were upgraded after using DCE-MRI. (table 5; figure 3).

Table 5. DCE-MRI Bi-RAD upgrading in 25 cases in this study.

DBT BI-RAD	NO. OF UPGRADED CASES		DCE-MRI BI-RAD
3	3	12%	4b
3	1	4%	5
4 (A,B,C)	15	60%	5
4A	3	12%	4b
4A	3	12%	4c

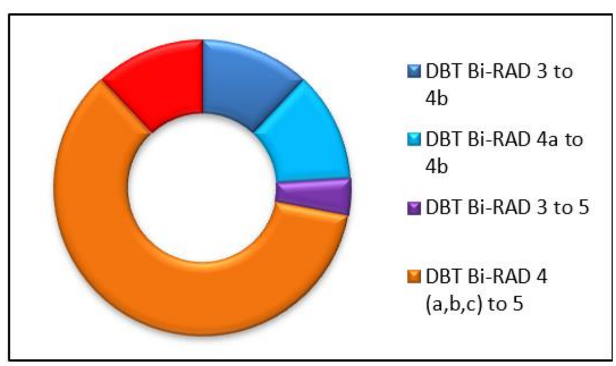
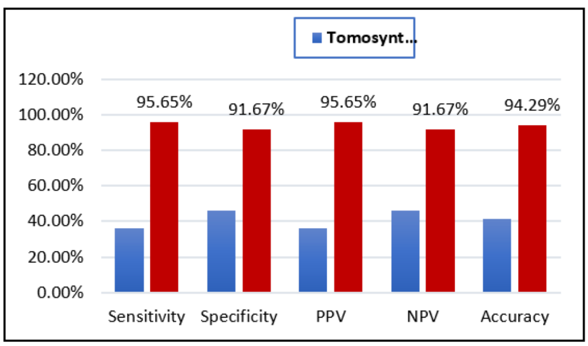


Figure 3. DCE-MRI Bi-RAD upgrading in 25 cases in this study.

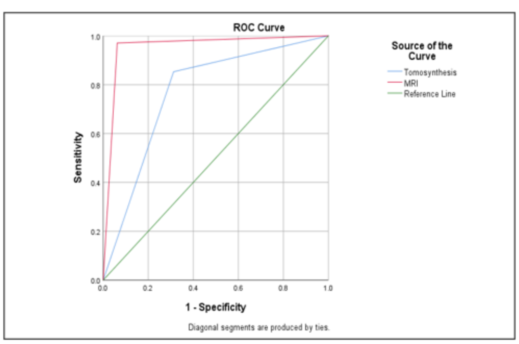
Tomosynthesis was determined to have an overall diagnostic accuracy, specificity, and sensitivity of 41.67%, 46.15%, and 36.36%, respectively, when compared to histological diagnosis, which served as the reference standard. Although tomosynthesis had an area under the curve (AUC) of 0.45 and dynamic magnetic resonance imaging (DMRI) had a sensitivity of 95.63%, specificity of 91.67%, and diagnostic accuracy of 94.29% overall, respectively,(table 6; figure 4).

Table 6. Comparison between accuracy measures of DBT and DCE-MRI.

	TOMOSYNTHESIS		DYNAMIC MRI	
	value	95%CI	value	95%CI
SENSITIVITY	36.36%	17.20% to 59.34%	95.65%	78.05% to 99.89%
SPECIFICITY	46.15%	26.59% to 66.63%	91.67%	61.52% to 99.79%
PPV	36.36%	22.85% to 52.44%	95.65%	77.07% to 99.31%
NPV	46.15%	33.72% to 59.09%	91.67%	61.62% to 98.69%
ACCURACY	41.67%	27.61% to 56.79%	94.29%	80.84% to 99.30%



(a)



(b)

Figure 4. (a)Comparison between accuracy measures of digital Tomosynthesis and dynamic contrast enhanced MRI, and (b AUC for DCE-MRI and DBT.

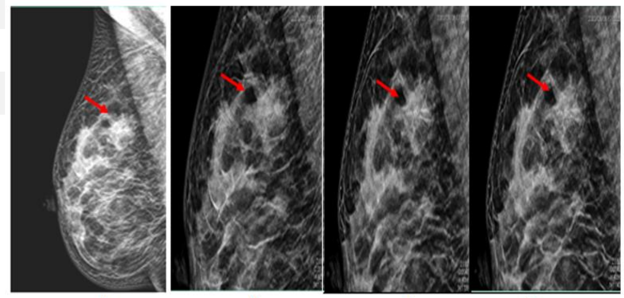
Case presentation:

Case(1) (figure 5 and 6): Thirty-eight years old female patient with negative family history of breast cancer, complaining of right breast lump.

DBT finding: Breast density B shows Right Upper Outer Quadrant UOQ irregular speculated mass lesion with fine pleomorphic calcification. No skin thickening, nipple retraction, pectoral's muscle invasion or axillary lymphadenopathy. BIRAD category 4c.

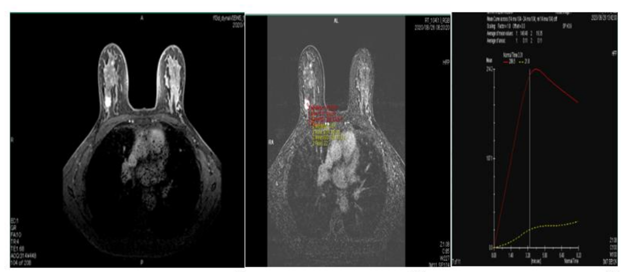
DCE-MRI finding: Moderate background parenchymal enhancement shows right UOQ rounded speculated mass lesion, which show homogenous enhancement. No skin thickening, nipple retraction, pectoral's muscle invasion, or axillary lymphadenopathy. Kinetic curve analysis: rapid initial rise with wash out delayed phase. BIRAD category 5.

DBT and DCE-MRI final diagnosis: Right breast lesion was categorized BIRAD 5 suggestive of invasive carcinoma. Histopathological result: Invasive Duct Carcinoma NOS, grade-I and Duct Carcinoma in Situ low grade.



A B C D

Figure 5. DBT right MLO (A)Magnified-focused- view (B, C and D)UOQ irregular speculated mass lesion(red arrows) with few fine pleomorphic calcifications.



A B C

Figure 6. DCE-MRI axial post-contrast (A)Right UOQ rounded speculated mass lesion show homogenous enhancement, Kinetic curve (B)and (C)Rapid initial rise with wash out delayed phase.

Case (2) (figure 7 and 8):

Forty-three years old female patient with +ve family history of breast cancer, complaining of right breast lump.

DBT finding: Breast density C show right UOQ irregular speculated mass lesion with fine pleomorphic calcification. No skin thickening, nipple retraction, pectoral's muscle invasion, or axillary lymphadenopathy, BIRAD category 4.

DCE-MRI finding: Moderate background parenchymal enhancement shows right UOQ oval speculated mass lesion, that show heterogeneous enhancement, and axillary lymphadenopathy. No skin thickening, nipple retraction or pectoral's muscle invasion. Kinetic curve analysis: rapid initial rise with wash out delayed phase. BIRAD category 5 DBT and DCE-MRI final diagnosis: Right breast lesion was categorized BIRAD 5 suggestive of invasive carcinoma. Pathological result: Classic Invasive Duct Carcinoma grade-II.

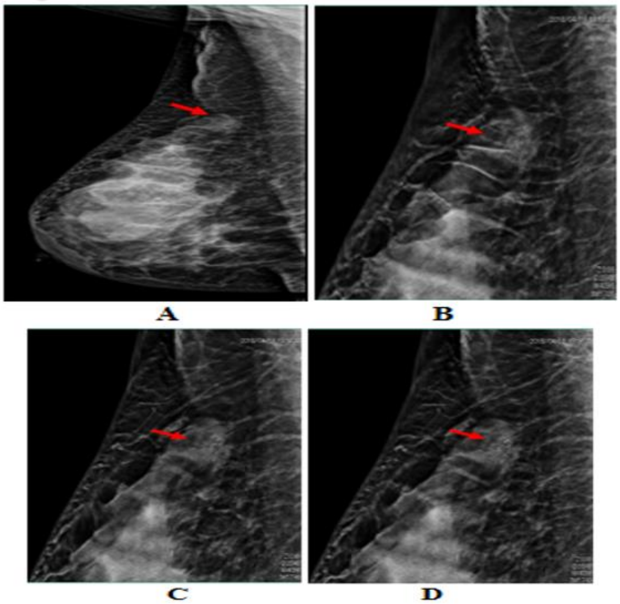


Figure 7. DBT right MLO view (A)Magnified-focused-view (B,C and D)UOQ irregular speculated mass lesion(red arrows) with fine pleomorphic calcification.

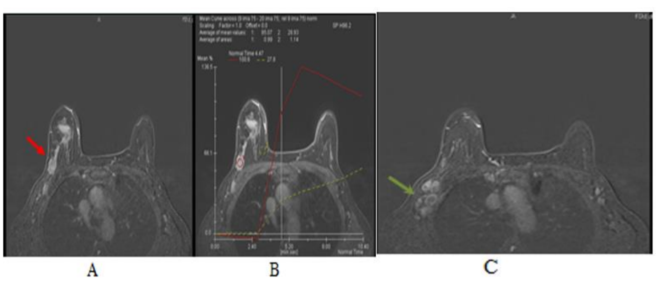


Figure 8. DCE-MRI axial post-contrast view (A)Right UOQ oval speculated mass lesion show heterogeneous enhancement(red arrow), Kinetic curve (B)Rapid initial rise with wash out delayed phase, (C)with axillary lyphadenopathy(green arrow).

4. Discussion

Reducing mortality rates, improving prognosis and therapy, and lowering treatment costs are all outcomes of cancer detection and monitoring efforts that begin early.[6]

There was a wide age range (32–66 years) among the 34 female patients with BC in this study. Their average age was 47.41 years with a standard deviation of 9.315.

Our findings are close to aligning with those of Chou et al.,[7] who found that 185 female patients had an average age of 51.3 51.3 years (range:31-70).

Our study, showed that the most common clinical presentation was breast Lump(32.35%), followed by mastalgia(8.82%). According to Meena et al.,[8] the classic presentation in patient with breast carcinoma in their study was a breast lump with associated sinus in 42.16%, isolated breast lump in 24.51%, sinus without lump in 10.78%. In our study, there was no associated sinus as a clinical presentation.

Using DCE-MRI in our study, 22/34(64.7%) breast carcinomas were detected in right breast, while 10/34(29.4%) were detected in left breast. Bilateral breast carcinomas were detected in 2/34(5.8%) patients. These sites of lesions using DCE-MRI study were corresponding to the site of lesions using Tomosynthesis and In this investigation, the two modalities did not show any statistically significant difference (P-value=1.00).

Our result disagreed with Zeeneldin et al.,[9] According to their study, Egyptian patients are more likely to get cancer in their left breast (2928 instances, or 53.64% of the total) than their right breast (2531 cases, or 46.36% of the total). Although tumors on the right side appeared to be more aggressive, cancers on the left side often have a worse prognosis in terms of survival.

Comparing between Bi-RAD DBT and DCE-MRI, our result showed that Bi-RAD 4(22/34, 64.7 %) was the most common by Tomosynthesis while BI-RAD 5(22/34, 64.7%) was the most common by DCE-MRI.

In our study, there was an upgrading of tomosynthesis Bi-RAD lesions after using DCE-MRI(25/34, 73.5 %). Three Bi-RAD 3 lesions(3/25, 12%) were upgraded correctly to Bi-RAD 4b. One Bi-RAD 3 lesion(1/25, 4 %) was upgraded to Bi-RAD 5. Fifteen Bi-RAD 4 lesions(15/25, 60%) were upgraded to Bi-RAD 5. Three Bi-RAD 4a lesions(3/25, 12%) were upgraded to Bi-RAD 4b and 3Bi-RAD 4a lesions(3/25, 12%) were upgraded to Bi-RAD 4c.

In our study, 1 DBT Bi-RAD 5 lesion (1/34, 2.9 %) was downgraded to DCE-MRI Bi-RAD 4c. Eight DBT Bi-RAD categories (8/34, 23.5 %) did not change their Bi-RAD categories after using DCE-MRI in this study.

Our study shown that Bi-RADS with DBT successfully detected Bi-RAD 3, 4, and 5 using the 2013 version of BI-RADS. But in 73.5% of the lesions that were investigated, DCE-MRI improved Bi-RAD rating, while in only one case (1/34, 2.9%), it degraded it.

We found that, when compared to DBT, which had a false negative rate of 25% and a false positive rate of 1%, DCE-MRI greatly improved Bi-RAD's ability to diagnose breast cancer ($p<0.001$).

Using histological diagnosis as a benchmark, we discovered that DBT had a diagnostic accuracy of 36.36 percent, a sensitivity of 36.36 percent, a specificity of 46.11 percent, and an NPV of 46.15 percent. In contrast, DCE-MRI demonstrated more favorable results in terms of diagnostic accuracy, sensitivity, specificity, PPV, and NPV (95.6%, 91.67%, 94.2%, 95.6%, and

91.6% respectively)

As regard histopathological diagnosis our DCE-MRI statistical results was in agreement with Rizzo et al.,[10] outcomes, they demonstrated excellent sensitivity (100% Reader 1, 98% Reader 2), decent positive predictive value (PPV) (89% Reader 1, 90% Reader 2), and accuracy (90%) for both consumers.

4. Conclusion

Significantly higher diagnostic performance of DCE-MRI using qualitative and quantitative assessment in diagnosis and Bi-RAD categorization of breast carcinoma with high sensitivity, specificity, accuracy, PPV, and NPV as compared to DBT.

DCE-MRI Bi-RAD categorization was essential for management of breast carcinoma. Dynamic MRI was more sensitive for detection of axillary adenopathy as compared to Tomosynthesis.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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