Comparing the Diagnostic Value of Sonomammography and MRI with Diffusion Techniques in Detection and Characterization of Lesions in Mammographically Dense Breast

Hassan Magdy Abd Elrazek*[1], Eman Abd elaziz Elnaghy[1], Omar Farouk[2], Sieza Samir Abdallah[1]

Departments of [1]Diagnostic Radiology and [2]Surgical Oncology, Faculty of Medicine, Mansoura University, Egypt

*Corresponding author: Hassan Magdy Abd Elrazek, **Mobile:** (+20) 01063074147, **E-Mail:** drhassanmagdy92@gmail.com

ABSTRACT

Background: Sonography has been used as adjunct to mammography to increase the accuracy during screening. Breast MRI is the most sensitive tool in imaging of breast cancer. Diffusion weighted imaging (DWI) does not depend on intra-venous contrast injection and is currently investigated to be added to screening of females with dense beast. Diffusion tensor imaging is a rising technique that can be of value in breast imaging.

Objective: The aim of the current study was to evaluate the diagnostic accuracy of MRI and MRI with diffusion techniques and compare it with sonomammography which is the routine exam for dense breasts.

Patient and methods: A diagnostic study was carried out and included 88 patients (age range 40-67 years) referred to Radiology Department of Mansoura University Hospital. All patients were subjected to proper history taking, sonomammography, conventional, contrast enhanced, diffusion weighted MRI and DTI. This study was using a 7-11 MHz hand held ultrasound, full field digital mammography and 1.5 T MRI scanner.

Results: The sensitivity of sonomammography was found to be 71%, with a specificity of 90%, a Positive Predicative Value (PPV) of 89%, a Negative Predictive Value (NPV) of 93%, and an overall accuracy of 91%. However, the sensitivity and specificity of sonomammography were significantly lower than those of MRI with DWI and MRI with DTI, as indicated by the lower values of these parameters (P<0.001) for sonomammography compared to MRI with DWI and DTI. Specifically, MRI with DWI had a sensitivity of 82% and a specificity of 85%, with a PPV of 91.4% and a NPV of 89.5%, resulting in an overall accuracy of 90.7%. Similarly, MRI with DTI had a sensitivity of 82% and a specificity of 90%, with a PPV of 94.3% and an NPV of 94.7%, resulting in an overall accuracy of 94.4%. **Conclusion:** MRI with diffusion techniques is a more reliable imaging modality in mammographically dense breasts, with higher sensitivity and specificity.

Keywords: Dense Breast, Sonomammography, Diffusion weighted imaging, Fractional Anisotropy.

INTRODUCTION

Cancer is second cause of deaths between the age zero and sixty nine years as reported by the global cancer estimates (GLOBOCAN-2018) in Egypt [1]. According to the results of the national population-based cancer registry program, breast cancer ranked as the leading cause of death in females [2]. As a result, breast cancer screening has become essential for early identification and management to lessen the burden of the illness since the odds of survival are quite high when breast cancer is discovered and treated early [3]. The primary breast imaging modality for the early identification and diagnosis of breast cancer has always been advised to be sonomammography [4].The thicker breast tissue shown on mammography is one of the biggest barriers to screening. In the most recent edition of the Breast Imaging Reporting and Data System (BI-RADS) from the American College of Radiology, there are four labels for breast density, ranging from "A" to "D," where A indicates that the tissue is almost entirely fatty and D indicates that the breasts are extremely dense. Breast density in mammography has been shown to be a powerful independent predictor of breast cancer and a direct cause of mammography's decreased sensitivity. 3 According to reports, women with high breast densities are 4 to 6 times more likely to get breast cancer than those with low breast densities [5].

To solve the problem of mammographically dense breast, ultrasound has been used as adjunct in

screening [6]. It has the advantage of absence of radiation hazards. However, it shows high operator-dependence and a lower specificity compared to mammography [7]. Breast MRI is the most accurate imaging method for finding breast cancer and is superior to other methods for finding malignancy in dense breast tissue [8]. However, it has low specificity. Another disadvantage of conventional MRI is the lengthy exam duration of about 40 minutes [9].

DWI is a quick (between 2 and 3 minutes) unenhanced MRI method that has demonstrated potential for the identification and characterization of breast cancer [8].Diffusion Tensor Imaging (DTI) is a fresh MRI breast scanning method that has recently been developed. This DWI-based technique tracks water molecule diffusion in the tissue and reveals information on the strength of the cell membrane [10].

Based on their biological characteristics, DTI with several quantitative parameters was able to identify benign lesions from breast malignancies [11].

The aim of the current study was to evaluate the diagnostic accuracy of MRI and MRI with diffusion techniques and compare it with sonomammography which is the routine exam for dense breasts.

PATIENT AND METHODS

A prospective diagnostic study was carried out in the period between August 2020 and September 2022 in the Diagnostic Radiology Department, Mansoura University Hospital. A total of 88 female patients were included in the study and were referred from the

outpatient clinics of General Surgery and Surgical Oncology Departments.

Inclusion criteria:
- Female patients with breast density matching with (ACR- C,D) mammography whether they are symptomatic or asymptomatic.
- No history of breast surgical intervention.

Exclusion criteria:
- Male patients.
- Patients with breast density matching with (ACR-A,B) on mammography.
- Patients with C, D breast density but underwent surgical intervention.
- Patients who had general contra-indications to MRI:
   - Claustrophobic patients.
   - Patients with impaired renal function.
   - Patients with contrast media allergy.
   - Patients with metallic implants (aneurysm clips, cochlear implants and cardiac pacemakers).

Methodology:

Full Field Digital Mammography: Positioning and technique; according to breast size and density, a mammogram should include two standard views for each breast: a craniocaudal view and a mediolateral oblique view with a KV range of 22–37 and an MA/sec range of 400–600.

Every patient was asked to stand while having her breast flattened out on the film cassette to prevent motion and improve vision. A craniocaudal film was made with the beam pointed 90° in that direction. 45° of obliqueness was used for the middle view.

Interpretation; each mammographic image was scanned for breast density, masses, asymmetry, architectural distortion and calcifications. Masses were described according to site, size and shape. Calcifications were described according to morphology and distribution. Associated features, as skin thickening or nipple retraction, were also reported.

Sonography: Positioning and technique; the ipsilateral arm was raised over the patient's head while the patient was lying on their back. Breast was imaged as a clock-face using a hand-held linear ultrasound probe operating at 7–11 MHz, on a sagittal plane, starting at 12 o'clock, with the probe's toe at the nipple. By moving the probe around the nipple, we scanned.

Interpretation; on ultrasonography, we reported breast composition according to the amount of fibroglandular tissue, suspicious mass morphology and suspicious parenchymal distortion. Associated features as skin edema, duct changes and vascularity changes were also reported.

After description of the findings, we classified the findings according the fifth ACR Sonomammography BI-RADS classification.

Breast Magnetic Resonance Imaging (MRI) examination: MRI positioning; The patient was properly positioned with the sternum covering the center bar and was centered over the symmetrical bilateral breast coils. After removing the inframammary folds from the lateral perspective, each breast's position was checked from the top down, the medial folds were removed, and the other breast underwent the same procedures.

MRI Techniques: A) Conventional MRI. B) Diffusion Weighted Imaging. C) Diffusion Tensor Imaging. D) Contrast Enhanced MRI.

MR protocol: A breast coil and a 1.5 T magnet were used to do MR imaging. The MR test was performed between the seventh and fourteenth days of the menstrual cycle.

The protocol was:
- Axial T2-FSE (4 mm slice thickness, TR=3730ms, TE=120ms, FOV=300-350 mm).
- Axial T1-FSE (3-mm slice thickness, TR=487ms, TE=8ms, FOV=300–350 mm).
- Axial STIR (3083 ms TR, 65 ms TE, 175 ms TI, 300–350 mm FOV, 3 mm slice thickness).
- For the DWI research, use axial echo planar imaging with the following parameters: TR = 10036 ms, TE = 80 ms, NOE = 2, matrix = 256x256, FOV = 421, ST = 3 mm, slice gap = 0 mm.
- Axial two-dimensional spin-echo echoplanar imaging sequence for a DTI study with the following parameters: b value = 0 and 800 s/mm2, diffusion gradient directions = 12, TR = 4000 ms, TE = 101 ms, slice-thickness = 2.5 mm with slice gap = 0 mm, NOE = 4, FOV = 380285 mm2, matrix = 256256, acquisition time = 4 min.
- GRE-T1W1 with the following specifications: TR 4–8 ms, TE 2 ms, flip angle 20–25 degrees, slice thickness 2 mm without an inter-slice gap, field of vision (FOV) 300–360 mm, and a matrix of 307 x 512.

Dynamic study: With fat suppression, all dynamic experiments were conducted in the axial plane. The FLASH 3D GRE-T1W1 sequence was employed, and its parameters were as follows: TR 4-8 ms, TE 2 ms, flip angle 20–25 degrees, slice thickness 2 mm with no inter-slice gap, field of view (FOV) 300–360 mm, and a matrix of 307 x 512.

A 20-second pause is taken between the pre contrast and post contrast studies in the dynamic study, which comprises of one pre contrast and five post contrast series. Following the pre-contrast study, an antecubital vein-infiltrating 18-20 gauge intravenous cannula is used to administer a bolus of gadolinium contrast at a dosage of 0.1mmol/kg using an automated injector at a rate of 3-5ml/sec. A bolus injection of saline (20 ml at 3-5 ml/sec) is given after that.

In order to reduce motion artefacts throughout breast tissue, particularly those caused by cardiac and respiratory movements, the phase-encoding direction is orientated. This entails orienting phase-encoding to be from right to left for trans-axial imaging.The most enhancing area of the lesion was selected for the ROI. Depending on the size and form of the lesion, different ROI sizes will be selected. Each ROI's time to signal

intensity curve was obtained. The vertical axis of the curve indicates signal intensity, which was automatically calibrated by the machine in accordance with the SI (enhancement) of the lesion. The horizontal axis of the curve represents the series number or time.

Dynamic study interpretation:

The dynamic post contrast series were employed for the study of DCE-MRI. The ROI was placed in the hot region for maximal improvement, and dynamic curve patterns were evaluated (whether type I, II or III patterns). The literature states that benign lesions have a sustained curve (type I), whereas malignant lesions have a quick wash-out curve (type III), and plateaued lesions (type II) are indicative of malignancy.The dynamic curve was automatically used to determine dynamic enhancement kinetics, such as maximum enhancement, relative enhancement, time to peak, wash in rate, and wash out rate.

Using delayed contrast-enhanced T1-weighted images, BPE was evaluated subjectively and globally. It was rated based on the degree of augmentation and the proportion of the area it covered to the overall amount of fibroglandular tissue. We had four categories that were appropriate for the new BI-RADS lexicon: minimum enhancement, mild enhancement, moderate enhancement, and notable enhancement.

Diffusion Weighted Imaging (DWI) Sequence:

For DWI, it was done before contrast was administered in order to exclude any potential impact the contrast agent's presence would have on water diffusion inside the tumor tissue as well as any T2 shortening it might cause. To boost sensitivity to cellular packing, echo-planar imaging, or "EPI" DW imaging, was carried out in the transverse plane with diffusion gradients utilizing b values of 0, 500, and 1000 sec/mm2. The additional criteria were as follows: Time of Repetition (TR) = 10036 ms, Time to Echo (TE) = 80 ms, Number of Excitations (NEX) = 2, Matrix of 256x256 with Field of vision (FOV) = 421 and ST = 3 mm, and Slice gap 0 mm. Both breasts' MRI-found lesions underwent evaluation.

DWI Data Interpretation: In order to determine whether a signal is low signal corresponding to low ADC values with true diffusion restriction or increased signal with high ADC values that are more associated with low cellular lesions, we first examined the diffusion map and looked for corresponding increased signal on DWI. Then, we looked for the corresponding ADC map. By placing a ROI across the lesion, the mean ADC of each identified lesion is calculated. After a summary of the results, we categorized them using the fifth ACR MR BI-RADS classification.

Diffusion Tensor Image (DTI): DTI was carried out using an axial two-dimensional spin-echo echoplanar imaging sequence with the following parameters: b value = 0 and 800 s/mm2, diffusion gradient directions = 12, TR = 4000 ms, TE = 101 ms, slice-thickness = 2.5 mm with no inter-slice gap, NOE = 4, FOV = 380285 mm2, matrix = 256256, and acquisition time = 4 min.

DTI was carried out before to the contrast-enhanced investigation as well.

DTI Imaging Interpretation: Using an MRI workstation for post-processing, all DTI data were analyzed. For image analysis, the slice with the largest lesion width is chosen. Automatically DTI parametric colored maps were produced for mean diffusivity (MD) and fractional anisotropy (FA).

In DCE-MRI images, which were employed as a reference to characterize the lesion and enable precise ROI placement, FA and MD parametric maps were superimposed. In both benign and malignant breast lesions, a free-hand ROI was created to only encompass the greatest solid portion of the lesion in a single slice, leaving out the necrotic, hemorrhagic, and cystic regions. Two ROI were obtained from each lesion, and the mean value was computed. On dense breast parenchyma was where the ROI was drawn in the control instances. The fractional anisotropy (FA) was determined automatically.

The Radiology Department of Mansoura University Hospital's 1.5 T MRI scanner was used to process all patients for this investigation.

Histopathological Analysis: Tru-cut biopsy was only performed on patients who had suspected lesions on imaging (BI-RADS 4a,b,c and BI-RADS 5), and the results were then compared to both sonomammography and MRI with diffusion and DTI.

Ethical consent:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Mansoura University. Written informed consent was obtained from all participants. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical Analysis: The collected data were introduced and statistically analyzed by utilizing the Statistical Package for Social Sciences (SPSS Inc., Chicago) version 18 for windows. Qualitative data were defined as numbers and percentages. Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as mean and standard deviation (SD), and non-parametric data were described as median and range. P value ≤0.05 was considered to be statistically significant. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were estimated for sonomammography, MRI with DWI and MRI with DTI.

RESULTS

In our study, 19 of benign cases were diagnosed through typical radiological findings. One case was diagnosed through histopathology. All malignant lesions were suspected by imaging findings and confirmed by histopathology (**Table 1**).

**Table (1): Final diagnosis of studied cases.**

Diagnosis	Number	%
Normal	34	38.6%
Malignant Lesion	34	38.6%
Benign Lesion	20	22.8%
Total	88	100%

On comparing the validity of different modalities, MRI with DTI has the highest diagnostic accuracy, with the highest sensitivity, specificity, and positive predictive value, and the lowest false negative rate. Sonomammography has a lower sensitivity but a high specificity, while MRI with DWI has an intermediate performance. The table also shows that all three techniques have a statistically significant ability to distinguish between benign and malignant breast lesions, as indicated by the low p-values (**Table 2**).

Table (2): Comparing the validity of sonomammography, MRI with DWI and MRI with DTI in diagnosis of breast lesions in dense breasts.

Variable	P-value	Sensitivity%	Specificity%	PPV%	NPV%	Accuracy%
Sono-mammo-graphy	<0.001 *	71%	90%	89%	93%	91%
MRI with DWI	<0.001 **	82%	85%	91.4%	89.5	90.7%
MRI with DTI	<0.001 **	82%	90%	94.3%	94.7%	94.4%

CASES PRESENTATION
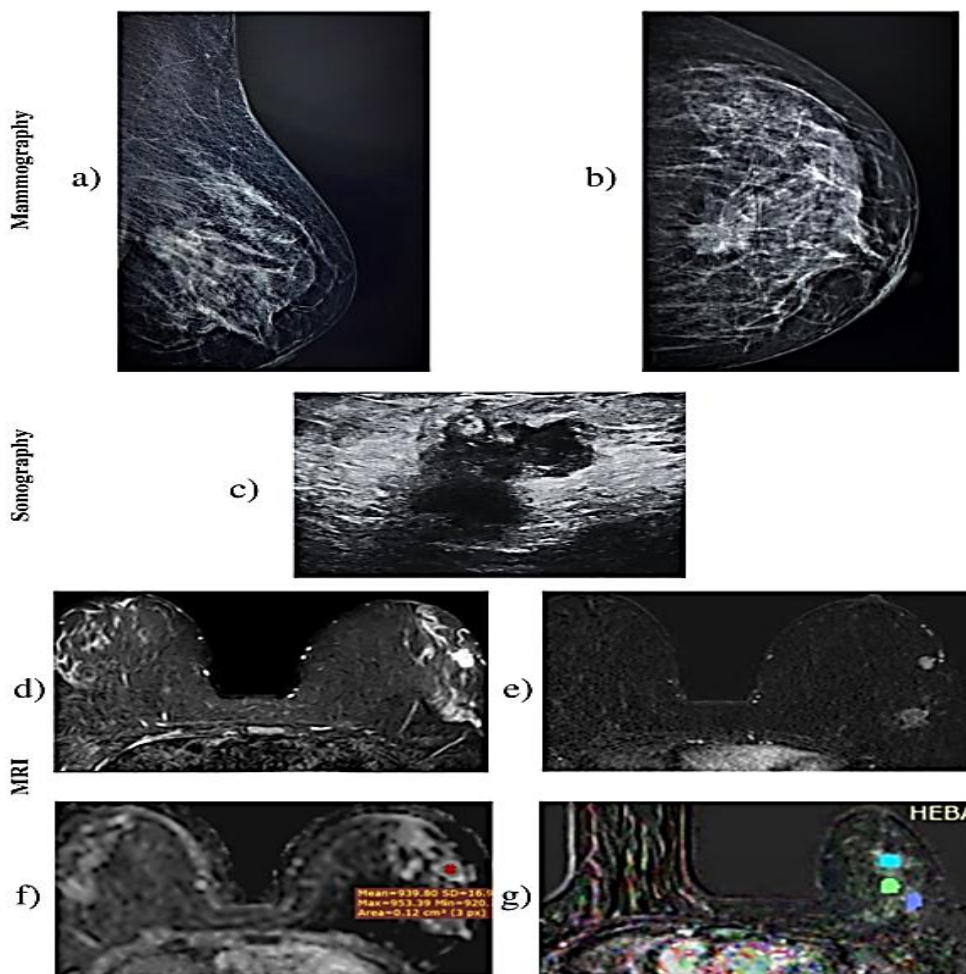
Case (1): A female patient aged 45 year-old presented with lump sensation in the left breast.

Sonomammographic findings:
A) MLO and B) CC views of the right breast: ACR C breast density showing non circumscribed mass with irregular shape and speculated margins, seen in the lower outer quadrant of the left breast. No detected calcifications.

C) US showing non circumscribed hypoechoic mass with irregular shape and speculated margins, seen at 5 o'clock

position zone B with surrounding desmoplastic reaction and posterior shadowing.
Sonomammography copes with BIRADS 5 category.

MRI findings:
D) **STIR**: showing high signal intensity irregular shaped mass with speculated margin.
E) **Post Contrast Subtraction Image**: showing heterogeneously enhanced irregular mass.
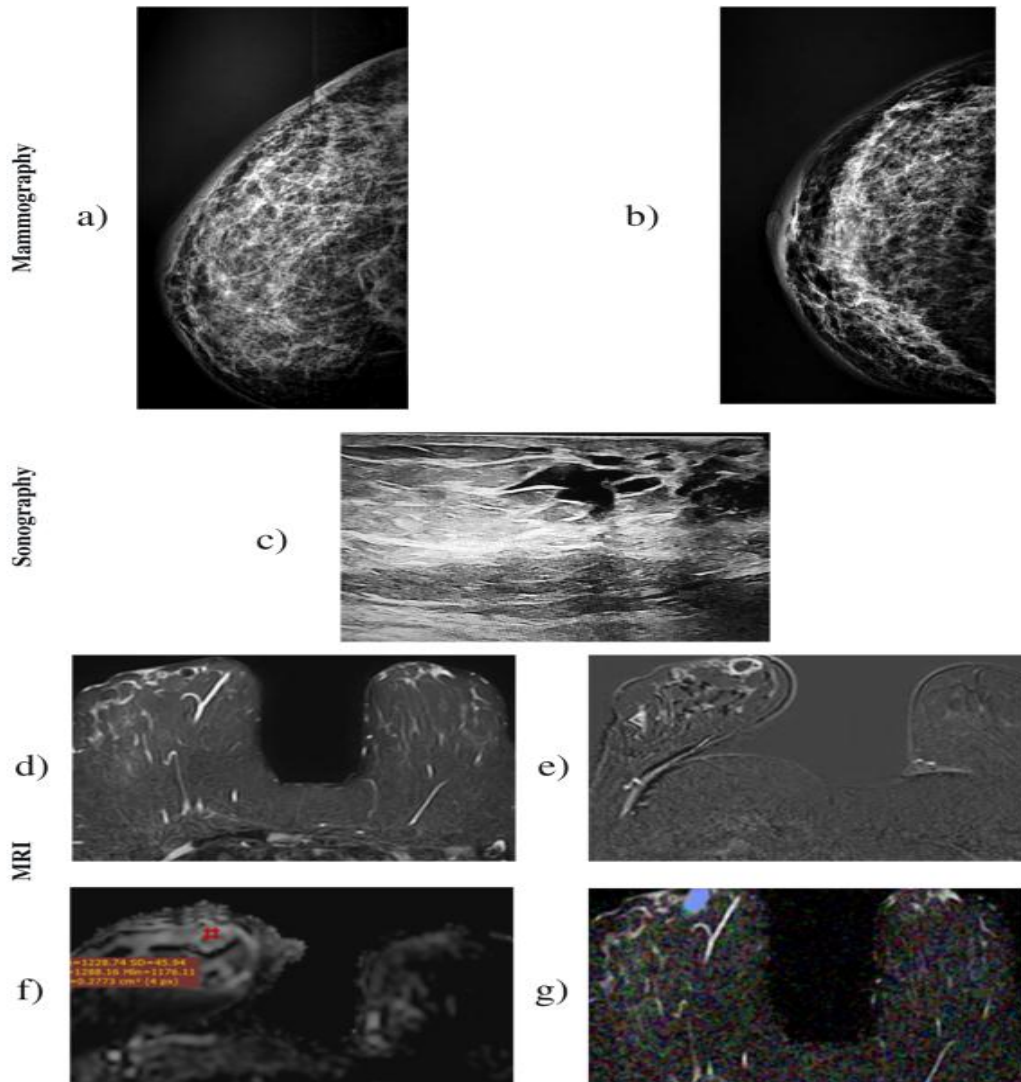
F) **ADC map**: the mass displays low SI (restricted diffusion) with ADC value = 0.939 x10-3mm2/sec
G) **DTI**: 3 ROIs were placed on the suspected areas. Mean FA= 0.361
MRI copes with BIRADS 5 **BIRADS final category**: 5
Final Radiological Diagnosis: Highly suspicious left lower outer quadrant mass BIRADS 5 category.
Histopathological diagnosis: Grade II invasive ductal carcinoma.

Case (2): A female patient aged 40 year-old complaining from hotness and pain in the right breast and reddish nipple discharge.

Sonomammographic findings:
A) MLO and B) CC views of the right breast: ACR C breast density, diffuse skin thickening of the right breast. No suspicious masses or calcifications.
C) **US**: Multiple dilated retroareolar ducts associated with small cystic lesion are noted with coarse echoes inside; they are associated with increased echogenicity of adjacent fat planes suggestive of complicated ductectasia.
Sonomammography copes with BIRADS 3.

MRI findings:
D) **STIR**: Dilated retro-areolar ducts associated with small cystic lesion with edema of the overlying skin.
E) **Post Contrast Subtraction Image**: cystic lesion showing marginal enhancement.
F) **ADC map**: The mass displays low SI (restricted) with ADC value = 1.228 x10-3mm2/sec
G) **DTI**: The ROI was placed on the suspected lesion. FA= 0.433.
MRI BIRADS copes with BIRADS 2
BIRADS final category: 2 Final diagnosis: right breast infected ductectasia with small abscess formation.

DISCUSSION

Breast density reduces the sensitivity of mammography for screening as thick breast tissue hides internal lesions, making it a risk factor for the development of breast cancer on its own [12].

Breast MRI has gained clinical acceptance for a variety of clinical indications, including supplemental screening for women at high risk of developing breast cancer and pre-operative evaluation of extent of newly diagnosed breast cancer. Breast MRI is a highly sensitive imaging tool for the detection of breast cancer [13]. In order to identify and characterize breast cancer, DWI is currently frequently employed. For detecting the Brownian motion of water molecules in tissues, MRI uses a non-invasive approach. Using apparent diffusion coefficient (ADC) values, it gauges how those molecules' Brownian motion is constrained [14].

In addition to the diffusion rate as determined by regular DWI, DTI extends standard DWI to define the directional variability of the diffusion process [13].

This study investigated the diagnostic accuracy of MRI and MRI with diffusion techniques and compared it with sonomammography which is the routine exam for dense breasts.

All patients had MRI and sonomammography examinations. T1, STIR, T2, Diffusion Weighted Imaging, and Diffusion Tensor Imaging were used in the 1.5 T MRI. Following the injection of the contrast medium, the post-contrast study, which included one pre-contrast and five post-contrast series, took place. It took each of them roughly 1.16 minutes, with a 20-second pause in between.

The apparent necrotic or cystic components were avoided by using standard MR images, and then the ADC and FA values were automatically computed on the MRI workstation after manual placement of various ROIs inside the mass. 1000, 500, and 0 mm2/sec were employed.

This is in line with the findings of studies by **Razek et al.** [15] and **Wang et al.** [16]; both studies made use of the same technology and application approach, while **Wang et al.** [16] employed b value 0 and 600 mm2/s for the DTI sequence.

There were 88 individuals with thick breasts in this research. This is consistent with **Yamakanamardi and Hiremath** [17], who said that there were 90 patients in all of the instances. The patients were between the ages of 40 and 65. Between the ages of 40 and 50, where there were the most instances (85.3% of all cases), This is consistent with the research by **Yamakanamardi and Hiremath** [17], which found that the majority of patients with malignant breast lesions were between the ages of 41 and 50.

According to **Woodhams et al.** [18], the ideal b value for diffusion-weighted breast imaging is still debatable, and it may be different for visual interpretation from that needed for ADC value analysis. High b value was chosen in this investigation since **Kul et al.** [19] shown that the ADC generated with the use of high b values is more useful for differentiating malignant from benign tumors.

In this study, there were 34 malignant breast masses, 20 cases with benign breast lesions and 34 normal cases. Invasive ductal carcinoma (29 instances) and ductal carcinoma in situ were the malignant cases (5 cases).

Invasive ductal carcinoma, which made up 82.9% of all malignant masses, and fibroadenoma, which made up 36.84% of benign masses were the two most frequent types of tumors.

This is consistent with the findings of **Sangma et al.** [20] research's, which determined that invasive ductal carcinoma was the most prevalent malignant lesion (60%) and fibroadenoma was the most frequent benign lesion (50%) in breast lesions. Moreover, **Ahin and Aribal** [21] observed that invasive ductal carcinoma (71.4%) was the most prevalent malignancy in their research, whereas fibroadenoma (43.7%) was the most prevalent benign lesion.

In our investigation, 41% of the total numbers of malignant breast lesions were worrisome breast calcifications. This is consistent with **Yamakanamardi and Hiremath** [17], who found that 60% of the malignant tumors overall were suspicious breast calcifications. The commonality in age group may be the root of this agreement. Whereas most of the patients in **Yamakanamardi and Hiremath's** [17] study were between the ages of 41 and 60, in our study 85.3% of the patients were under the age of 40.

Sonoamammography in this investigation exhibited a sensitivity of 71% and a specificity of 90%.

These results are in line with those of **Ohuchi et al.** [22] who found a sensitivity and specificity of 83.1% and 86.3% for mammography and ultrasonography, respectively. ADC is particularly helpful in identifying and separating benign from malignant breast tumors [14].

Malignant masses in this research had considerably lower mean ADC values than benign masses. With a sensitivity of 82.5% and a specificity of 85%, the cutoff ADC value is 1.3075. These findings were in agreement with many other investigations, such as those by **Partridge et al.** [23] who found 1.14 x 10-3 mm2/s and 1.49 x 10-3 mm2/s, respectively, for malignant and benign tumors. **Jiang et al.** [10] found that the mean ADC values of malignant masses were significantly lower than those of benign masses (1.47 x 0.35 x10-3 mm2/s), **Teruel et al.** [24] reported a mean of (1.03 0.15 x10-3 mm2/s) and (1.70 x 0.23 x10-3 mm2/s), and **Onaygil et al.** [25] reported (1.03 ± 0.19 x10-3 mm²/s).

In this study, the best ADC cut off value was 1.07×10-3 mm²/s for differentiation between benign and malignant masses with low values for malignant masses, 87% Sensitivity, 73% Specificity, 88% PPV, 76% NPV and 78% Accuracy.

These findings were contrasted with those from **Onaygil et al.** [25], who showed that the ADC cut off value to distinguish between benign and malignant lesions was 1.2310-3 mm2/s with 92.3% Sensitivity, 91.3% Specificity, 90.0% PPV, 93.3% NPV, and 78% Accuracy. **Teruel et al.** [24] discovered that the ADC cut off value was 1.110-3 mm2/s with a 94.1% Sensitivity and 94.7% Specificity to distinguish between benign and malignant tumors.

In this study, Invasive breast cancer had higher mean FA than in-situ carcinoma but with no statistical significance.

The findings of **Wang et al.** [16] and **Jiang et al.** [15] that invasive carcinoma tends to have bigger FA than ductal carcinoma in situ were corroborated by this finding.

In benign breast lesions, the average ADC value was 1.6x10-3mm2/sec. This is consistent with the meta-analysis research by **Surov et al.** [26] which found that the benign lesions had a mean value of 1.5103mm2/s.

With benign breast lesions, the mean FA value was between 0.2 and 0.18. This is consistent with **Wang et al.** [16] meta-analysis's research, which stated that the mean value of the benign lesions was 0.2.

In this study 7 cases of fibroadenomas, all showed oval shape with smooth regular borders. On post contrast study, five of them showed non-enhancing internal septations and the other 2 showed homogenous mass enhancement.

On DWI all fibroadenomas showed free diffusion Mean ADC = 1.4573 x10-3 mm²/s, STD ± 0.29731 on DTI, all fibroadenomas showed Mean FA 0.3694 STD ± 0.24836). These findings corroborated those of **Marino et al.** [27] who found that the mean ADC of fibroadenomas was (1.5 X 103 mm2/s), which is significantly higher than the threshold for malignancy. **Baltzer et al.** [28] previously explained this finding by pointing out that fibroadenomas have specific histopathological characteristics, including a fibroid stroma and glandular structures. Due to the enhanced myxoid extracellular matrix and lack of directed tubular structures, high ADC and low FA values may be predicted in this situation.

In malignant breast lesions, the average ADC value was 1.06x10-3mm2/sec. This is consistent with the meta-analysis research by **Surov et al.** [26] that found the malignant lesions' mean ADC value to be 1.03 103 mm2/s.

In this study 5 cases of DCIS. All DCIS cases showed restricted diffusion, mean ADC value of (1.0082 x10-3 mm²/s, STD ± 0.3019) and mean FA value of (0.2865, STD ± 0.06681).

This agreed with **Wang et al.** [16] as DCIS lesions in their study they found that the mean ADC for DCIS lesions was 1.28 x10^{-3} mm²/s (which was near to the results in this study).

In this study 29 invasive ductal carcinomas. All were irregular in shape with irregular or speculated margins. They showed heterogeneous mass enhancement pattern on post contrast study. All showed type III washout curve and then confirmed by pathology. On DWI and DTI, they showed restricted diffusion, low ADC values and high FA values (Mean ADC = 1.0627 x10-3 mm²/s, STD ± 0.2991, Mean FA = 0.4250, STD ± 0.12859).

These findings are consistent with those of **Osman and Shebrya** [29] and **Fiki et al.** [30], who found that medullary and mucinous carcinomas may exhibit limited diffusion due to their poor cellularity and elevated water contents. In terms of DTI, these findings corroborated those of **Baltzer et al.** [28] who discovered that the FA of malignant lesions is greater than that of benign lesions.

According to our findings, sonomammography performed considerably worse than MRI with DWI and MRI with DTI in terms of sensitivity, specificity, PPV, NPV, and overall accuracy in dense breasts.

The sensitivity of sonomammography was found to be 71%, with a specificity of 90%, a PPV of 89%, an NPV of 93%, and an overall accuracy of 91%. However, the sensitivity and specificity of sonomammography were significantly lower than those of MRI with DWI and MRI with DTI, as indicated by the lower values of these parameters and higher p value (<0.001) for sonomammography compared to MRI with DWI and DTI. Specifically, MRI with DWI had a sensitivity of 82% and a specificity of 85%, with a PPV of 91.4% and an NPV of 89.5%, resulting in an overall accuracy of 90.7%. Similarly, MRI with DTI had a sensitivity of 82% and a specificity of 90%, with a PPV of 94.3% and an NPV of 94.7%, resulting in an overall accuracy of 94.4%.

The findings of this study demonstrate that the validity of breast imaging modalities varies depending on breast density. In particular, MRI with DWI and DTI have been found to have better sensitivity and specificity in dense breast tissue compared to sonomammography. These results are consistent with the European Society of Breast Imaging (EUSOBI) recommendations in [12], which emphasize the need for further imaging techniques to identify breast cancer in patients with thick breasts that is mammographically undetectable.

CONCLUSION

Dense breast tissue can pose a diagnostic challenge in mammography, as it can reduce the detection of breast lesions. However, supplementing mammography with expert sonography can improve the specificity of the study. MRI with diffusion techniques is a more reliable imaging modality in mammographically dense breasts, with higher sensitivity and specificity. Furthermore, diffusion tensor imaging is a promising modality that may provide even higher specificity and sensitivity in breast imaging. Future studies should focus on expanding the

use of diffusion tensor imaging in larger populations to further validate its effectiveness in breast imaging.

Supporting and sponsoring financially: Nil.
Competing interests: Nil.

REFERENCES

1. **Bray F, Ferlay J, Soerjomataram I** *et al.* **(2018):** Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. A Cancer Journal for Clinicians, 68(6):394-424.

2. **Ibrahim A, Khaled H, Mikhail N** *et al.* **(2014):** Cancer incidence in Egypt: results of the national population-based cancer registry program. Journal of Cancer Epidemiology, 14:437971. doi: 10.1155/2014/437971

3. **Ginsburg O, Yip C, Brooks A** *et al.* **(2020):** Breast cancer early detection: A phased approach to implementation. Cancer, 126:2379-93.

4. **Abdullah R, Abdelmonem L, Nasry N** *et al.* **(2020):** Contrast Enhanced Mammography: The added value in the assessment of Suspicious Breast Lesions. An International Journal of Medicine, 113(1):68. doi: 10.1093/qjmed/hcaa068.001a

5. **Duffy S, Morrish O, Allgood P** *et al.* **(2018):** Mammographic density and breast cancer risk in breast screening assessment cases and women with a family history of breast cancer. European Journal of Cancer, 88:48-56.

6. **Boyd N, Martin L, Yaffe M** *et al.* **(2011):** Mammographic density and breast cancer risk: current understanding and future prospects. Breast Cancer Research, 13:1-2.

7. **Scheel J, Lee J, Sprague B** *et al.* **(2015):** Screening ultrasound as an adjunct to mammography in women with mammographically dense breasts. American Journal of Obstetrics and Gynecology, 212 (1):9-17.

8. **Millet I, Pages E, Hoa D** *et al.* **(2012):** Pearls and pitfalls in breast MRI. The British Journal of Radiology, 85(1011):197-207.

9. **Bray T, Singh S, Latifoltojar A** *et al.* **(2017):** Diagnostic utility of whole body Dixon MRI in multiple myeloma: a multi-reader study. PLoS One, 12(7):e0180562. doi: 10.1371/journal.pone.0180562

10. **Jiang R, Ma Z, Dong H** *et al.* **(2016):** Diffusion tensor imaging of breast lesions: evaluation of apparent diffusion coefficient and fractional anisotropy and tissue cellularity. The British Journal of Radiology, 89(1064):20160076. doi: 10.1259/bjr.20160076

11. **Wang K, Li Z, Wu Z** *et al.* **(2019):** Diagnostic performance of diffusion tensor imaging for characterizing breast tumors: a comprehensive meta-analysis. Frontiers in Oncology, 9:1229. doi: 10.3389/fonc.2019.01229

12. **Mann R, Athanasiou A, Baltzer P** *et al.* **(2022):** Breast cancer screening in women with extremely dense breasts recommendations of the European Society of Breast Imaging (EUSOBI). European Radiology, 32(6):4036-45.

13. **Partridge S, Nissan N, Rahbar H** *et al.* **(2017):** Diffusion-weighted breast MRI: Clinical applications and emerging techniques. Journal of Magnetic Resonance Imaging, 45(2):337-55.

14. **Chhetri A, Li X, Rispoli J (2020):** Current and emerging magnetic resonance-based techniques for breast cancer. Frontiers in Medicine, 7:175. doi: 10.3389/fmed.2020.00175

15. **Razek A, Zaky M, Bayoumi D** *et al.* **(2019):** Diffusion tensor imaging parameters in differentiation recurrent breast cancer from post-operative changes in patients with breast-conserving surgery. European Journal of Radiology, 111:76-80.

16. **Wang Y, Zhang X, Cao K** *et al.* **(2015):** Diffusion-tensor imaging as an adjunct to dynamic contrast-enhanced MRI for improved accuracy of differential diagnosis between breast ductal carcinoma in situ and invasive breast carcinoma. Chinese Journal of Cancer Research, 27(2):209-17.

17. **Yamakanamardi S, Hiremath B (2021):** Accuracy of mammography and sonomammography and its correlation with histopathology in the detection of breast cancer. International Surgery Journal, 8(2):624-30.

18. **Woodhams R, Ramadan S, Stanwell P** *et al.* **(2011):** Diffusion-weighted imaging of the breast: principles and clinical applications. Radiographics, 31(4):1059-84.

19. **Kul S, Cansu A, Alhan E** *et al.* **(2011):** Contribution of diffusion-weighted imaging to dynamic contrast-enhanced MRI in the characterization of breast tumors. American Journal of Roentgenology, 196(1):210-7.

20. **Sangma M, Panda K, Dasiah S (2013):** A clinico-pathological study on benign breast diseases. Journal of Clinical and Diagnostic Research, 7(3):503-6.

21. **Sahin C, Aribal E (2013):** The role of apparent diffusion coefficient values in the differential diagnosis of breast lesions in diffusion-weighted MRI. Diagnostic and Interventional Radiology, 19(6):457-62.

22. **Ohuchi N, Suzuki A, Sobue T** *et al.* **(2016):** Sensitivity and specificity of mammography and adjunctive ultrasonography to screen for breast cancer in the Japan Strategic Anti-cancer Randomized Trial (J-START): a randomised controlled trial. The Lancet, 387(10016):341-8.

23. **Partridge S, DeMartini W, Kurland B** *et al.* **(2010):** Differential diagnosis of mammographically and clinically occult breast lesions on diffusion-weighted MRI. Journal of Magnetic Resonance Imaging, 31(3):562-70.

24. **Teruel J, Goa P, Sjøbakk T** *et al.* **(2016):** Diffusion weighted imaging for the differentiation of breast tumors: from apparent diffusion coefficient to high order diffusion tensor imaging. Journal of Magnetic Resonance Imaging, 43(5):1111-21.

25. **Onaygil C, Kaya H, Ugurlu M** *et al.* **(2017):** Diagnostic performance of diffusion tensor imaging parameters in breast cancer and correlation with the prognostic factors. Journal of Magnetic Resonance Imaging, 45(3):660-72.

26. **Surov A, Meyer H, Wienke A (2019):** Can apparent diffusion coefficient (ADC) distinguish breast cancer from benign breast findings? A meta-analysis based on 13 847 lesions. BMC Cancer, 19(1):1-4.

27. **Marino M, Helbich T, Baltzer P** *et al.* **(2018):** Multiparametric MRI of the breast: A review. Journal of Magnetic Resonance Imaging, 47(2):301-15.

28. **Baltzer P, Schäfer A, Dietzel M** *et al.* **(2011):** Diffusion tensor magnetic resonance imaging of the breast: a pilot study. European Radiology, 21:1-10.

29. **Osman A, Shebrya N (2016):** Value of diffusion weighted imaging (DWI) and apparent diffusion coefficient factor (ADC) calculation in differentiation of solid breast lesions. The Egyptian Journal of Radiology and Nuclear Medicine, 47(1):363-71.

30. **El Fiki I, Abdel-Rahman H, Morsy M (2015):** Assessment of breast mass: Utility of diffusion-weighted MR and MR spectroscopy imaging. The Egyptian Journal of Radiology and Nuclear Medicine, 46(4):1327-35.