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ORIGINAL RESEARCH

Role of MRI in non mass enhancing lesions in breast

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ABSTRACT

Breast cancer is the most prevalent cancer among women worldwide, with an incidence rate of approximately 12%. Accurate diagnosis of breast lesions requires a combination of clinical evaluation, radiological imaging, and pathological analysis. Among imaging modalities, breast MRI is recognized for its high sensitivity in detecting breast abnormalities, particularly in high-risk populations. Diffusion-weighted imaging (DWI), which measures water molecule diffusion through apparent diffusion coefficient (ADC) values, has emerged as a valuable tool for differentiating benign and malignant lesions.

This hospital-based, prospective, cross-sectional study was conducted at Mahatma Gandhi Medical College and Hospital, Jaipur, India, to assess the radiological characteristics of non-mass enhancing (NME) breast lesions using MRI and to determine their correlation with histopathological findings. A total of 69 patients were included in the study, with MRI findings categorized using BI-RADS descriptors. Biopsy samples were obtained for definitive diagnosis.

Findings revealed that MRI exhibited high sensitivity (97.22%) and specificity (90.91%) in detecting malignant lesions. The mean ADC value of benign lesions (1.44±0.27) was significantly higher than that of malignant lesions (1.00±0.31) ($p<0.05$). NME lesions with linear, regional, or segmental distribution and heterogeneous or clumped internal enhancement were significantly associated with malignancy ($p<0.05$). These findings underscore the potential of MRI in improving diagnostic accuracy and reducing unnecessary biopsies.

In conclusion, integrating morphological features, enhancement patterns, and ADC values enhances the accuracy of breast lesion characterization. MRI, particularly DWI, proves to be a valuable non-invasive tool for assessing NME lesions, aiding in early and precise breast cancer diagnosis. Further multicentric studies with larger sample sizes are recommended to validate these findings.

INTRODUCTION

Globally with an incidence rate of around 12%, breast cancer is the most prevalent form of cancer among women. A thorough and accurate history is essential when dealing with a new breast tumor.[1] Typically, the technique adheres to the triple-assessment pathway involving clinical evaluation, radiographic imaging, and pathology analysis.[2] Mammography, ultrasound, and MRI are the predominant radiological techniques used for imaging breast tissue.

Breast MRI is widely regarded as the most sensitive method for screening the breast and is increasingly being used for screening high-risk populations, determining the extent of disease before surgery, and assessing the effectiveness of therapy.[3] Diffusion-weighted imaging (DWI) has become a valuable tool for assessing the breast, it offers valuable information about tissue micro-structural characteristics by quantifying the diffusion of water molecules, which is represented as the apparent diffusion coefficient (ADC).[4]

Based on this property, DWI can provide contrast images that are distinct from the traditional T1- and T2-weighted images. The signal strength in diffusion-weighted imaging is inversely related to the extent of water molecule diffusion. This implies that structures with high cellularity and limited diffusion will have a stronger signal.[5]

Lesions identified by MRI can be classified based on their morphology into three categories: mass, nonmass, or focus. Nonmass enhancement (NME) is characterized as an area of increased signal intensity without a corresponding mass that occupies space and is separate from the surrounding background tissue. The association between NME and a broad range of benign and malignant lesions has been established.[6,7] Differentiating between benign, high risk, and malignant NME lesions on MRI might be challenging

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because of their similar characteristic imaging characteristics. Integration of morphological characteristics such as distribution and internal enhancing pattern with kinetics might enhance the accuracy of clinical management recommendations and reduce the occurrence of negative biopsies.[8]

The morphological evaluation of NME should encompass the analysis of its distribution and internal enhancing patterns (IEP). In contrast to the homogeneous, heterogeneous, clustered ring, or clumped classification of IEPs, the distribution of the lesion may be linear, focal, segmental, regional, numerous regions, or diffuse.Frequency of segmental or clumped linear and ductal enhancement was shown to be higher in ductal carcinoma in situ (DCIS) compared to benign lesions among lesions exhibiting non-mass-like enhancement.[9]

Prior investigations have documented significant inconsistency in the depiction of morphological and contrast enhancement features of breast NME lesions on MRI, as well as a lack of consistency in characterizing these abnormalities. some researchers have proposed that BI-RADS descriptors lack utility in evaluating the malignancy risk of MRI-detected NME.[10,11]

Moreover, there is currently no established standardised approach for interpreting and classifying NME lesions. Therefore, this study was conducted with the objective of to assess the importance of radiological findings in individuals with breast lesions to successfully diagnose and characterize properties of non mass enhancing lesions of breast mass.

MATERIALS AND METHODS

This hospital based, prospective, cross-sectional study was conducted under the department of Radio-diagnosis, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India after approval from the institutional ethical committee. All patients of breast lesions presenting to the department of Radiodiagnosis for the investigation purpose during the study period of 18 months from … to …., who gave written informed consentafter explaining purpose of the study were included in the study. Patients with lesions of size less than 1 cm on diffusion weighted images, and / or who could not lie prone for the examination due to fungating mass lesions or painful etiology, or patients with contraindications for MRI or DWI were excluded from the study.

Methodology

All enrolled patients were explained about the procedure, and inquired about the symptoms and their basic demographic profile using a pre designed semi structured questionnaire. Their MRI findings were collected and recorded as per BI-RADS. Sample for biopsywas taken either by Tru cut needle or surgical biopsy for histopathological investigation, and association of MRI and histopathological findings were made.

Siemens MRI 3 Tesla

The system is a specialized high-field scanner specifically designed for neurological imaging. The maximum dimensions of the patient aperture are 60 cm x 60 cm (width x height), and the height of the couch can be adjusted between 46 cm and 80.4 cm. The gradient system has a maximum amplitude of 40 millitesla per meter (mT/m) and a slew rate of 400 millitesla per meter per millisecond (mT/m/ms).The host computer system consists of two Pentium IV machines operating on Windows NT 4.0. Each computer has a CPU speed of 2.2 GHz and 1 GB of main memory. The hard disk has a capacity of 18GB for software and 36GB for picture storage, allowing for the storing of 95,000,256^2 images. The Pentium IV processor has a clock speed of 2.2 GHz, resulting in a reconstruction time of 0.0056 seconds for a 2562 image. The fundamental RF hardware comprises a Quadrature Head Coil. Available neurological imaging techniques include T1- and T2-weighted diffusion, multi-directional diffusion, perfusion, and spectroscopy. This system also offers software for parametric image mapping of T1 and T2 readings.

Statistical Analysis

Data thus collected was entered in Microsoft Excel Sheet by investigator himself on same day to minimize data entry bias. Continuous/Quantitative data was summarised in form of mean and standard deviation. The significance of difference between two means was analysed using student's t test. Discrete/Qualitative data was summarised in form of proportion. The significance of difference in proportion was analysed using chi-square test. The level of significance was kept at 95% for all statistical analysis.

RESULT

Total 69 patients were included in the study with the mean age of 45.78±12.12 years. (Table-1) describes basic characteristics of breast lesions. Two thirds of cases have heterogenous fibro glandular tissue, followed by scattered fibro glandular tissue in 17(24.6%), and least two (2.9%) cases had almost entire fat. Moderate level of BPE was seen in 27(39.1%) cases, followed by minimal in 24(34.8%) cases, and two (2.9%) cases had marked level of BPE. Around three fourth of cases (75.4%, 52/69) have asymmetrical BPE, and rest cases have symmetrical BPE. More than half of cases(37/69) have irregular shape, and least six (8.7%) cases have round shape. Maximum 31(44.9%) of cases have well circumscribed margin, and 18(26.1%) cases have spiculated type of non-circumscribed margins. 32(46.4%) cases have heterogenous internal enhancement, and homogenous in 10 (14.5%) cases.

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In our study, type III and type II kinetic curve each was seen in 23(33.3%) cases, type I in 20(19.0%) cases and no solid lesion in three (4.3%) cases.

(Table-2) Maximum 43(62.3%) cases have no non-mass enhancements; linear distribution of non-mass enhancements was seen in 12(17.4%) cases. Heterogenous internal enhancement patterns was seen in 13(18.8%) cases, 10(14.5%) cases with clumped internal enhancement, and clustered ring was seen in none of the cases.

(Table-3) In MRI, maximum 29(42.0%) cases have benign etiology, moderate suspicion of malignancy and biopsy proven malignant etiology each in 11(15.9%) cases, and no lesion in one (1.4%) case.

(Table-4) For detecting Malignant lesion, MRI have 97.22% of sensitivity, 90.91% specificity, 92.11% PPV, and 96.77% NPV considering biopsy as gold standard test. The mean ADC value of benign lesion was significantly higher than ADC value of malignant lesion (1.44±0.27 vs 1.00±0.31; $p<0.05$).

(Table-5) All cases with regional distribution have malignant lesion, 91.7% of cases with linear distribution, 83.3% of cases with segmental distribution have malignant lesion, and one third of cases with focal distribution have malignant lesion. Among cases with heterogenous internal enhancement 84.6% of them have malignant lesion, 80% of cases with clumped internal enhancement patterns, and one third of cases with homogenous enhancement have malignant lesion. This association of distribution and internal enhancement of non-mass was statistically significant ($p<0.05$)

Table 1- Characteristics of breast lesions

Variable		Number (n=69)	Percentage
Amount of fibro glandular tissue			
a (Almost entirely fat)		2	2.9
b (Scattered fibro glandular tissue)		17	24.6
c (Heterogenous fibro glandular tissue)		46	66.7
d (Extreme fibro glandular tissue)		4	5.8
Background parenchymal enhancement (BPE)			
Level	Minimal	24	34.8
	Mild	16	23.2
	Moderate	27	39.1
	Marked	2	2.9
Symmetric or Asymmetric	Symmetrical	17	24.6
	Asymmetrical	52	75.4
Masses			
Shape	Oval	13	18.8
	Round	6	8.7
	Irregular	37	53.6
	No mass	13	18.8
Margins	Well Circumscribed	31	44.9
	Not circumscribed		
	Irregular	7	10.1
	Spiculated	18	26.1
	No mass	13	18.8
Internal enhancement characteristics	Homogenous	10	14.5
	Heterogenous	32	46.4
	Rim enhancement	7	10.1
	Dark internal septation	5	7.2
	No mass	15	21.7

Table 2- Non-mass enhancements

Non-mass enhancement (NME)		Number	Percentage
Distribution	Focal	3	4.3
	Linear	12	17.4
	Multiple regions	2	2.9
	Regional	2	2.9
	Segmental	6	8.7
	Diffuse	1	1.4
	No	43	62.3
Internal enhancement patterns	Clumped	10	14.5
	Heterogenous	13	18.8

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	Homogenous	3	4.3
	Clustered ring	0	-
	No	43	62.3
Total		69	100.0

Table 3- Diagnosis according to MRI findings

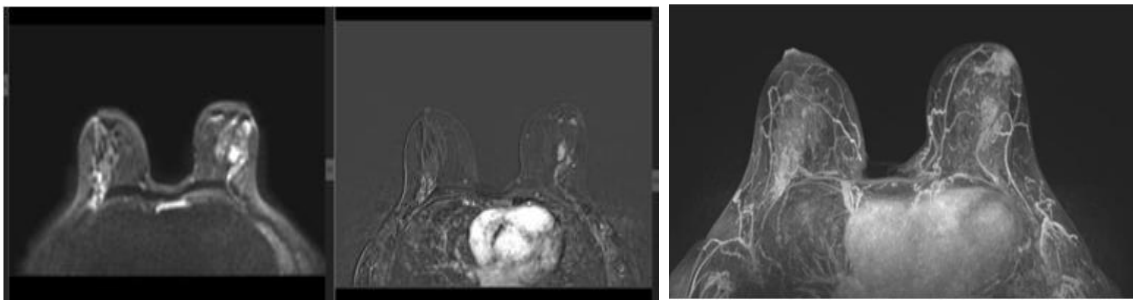
Diagnosis	Number	Percentage
Accessory Breast	1	1.4
Benign etiology	29	42.0
Low suspicion of malignancy	4	5.8
Moderate suspicion of malignancy	11	15.9
High suspicion of malignancy	4	5.8
Malignant etiology	8	11.6
Biopsy proven malignant etiology	11	15.9
No lesion	1	1.4
Total	69	100.0

Table 4 – Diagnostic accuracy of MRI considering histopathology as gold standard test

MRI Finding	Histopathology		Total
	Benign (n=33)	Malignant (n=36)	
Benign	30	1	31
Malignant	3	35	38
Total	33	36	69

Table 5– Association of Non-mass enhancement (NME) with malignancy

Non-mass enhancement (NME)		Benign (n=33)	Malignant (n=36)	Total	p value
Distribution	Focal	2(66.7)	1(33.3)	3(100)	**0.009**
	Linear	1(8.3)	11(91.7)	12(100)	
	Multiple regions	1(50)	1(50)	2(100)	
	Regional	-	2(100)	2(100)	
	Segmental	1(16.7)	5(83.3)	6(100)	
	Diffuse	1(100)	-	1(100)	
	No	27(62.8)	16(37.2)	43(100)	
Internal enhancement patterns	Clumped	2(20)	8(80)	10(100)	**0.020**
	Heterogenous	2(15.4)	11(84.6)	13(100)	
	Homogenous	2(66.7)	1(33.3)	3(100)	
	Clustered ring	-	-	-	
	No	27(62.8)	16(37.2)	43(100)	



MRI imaging in a 35-year-old woman. (A) Diffusion weighted imaging show diffusion restriction ,the ADC value of this malignant lesion equals to 0.8×10−3 mm2/s(B)subtraction images in post contrast enhanced breast MRI showed focal distribution and heterogeneous enhancement;. Final biopsy showed IDC. MRI, magnetic resonance imaging; DWI, diffusion-weighted images; ADC, apparent diffusion coefficient.

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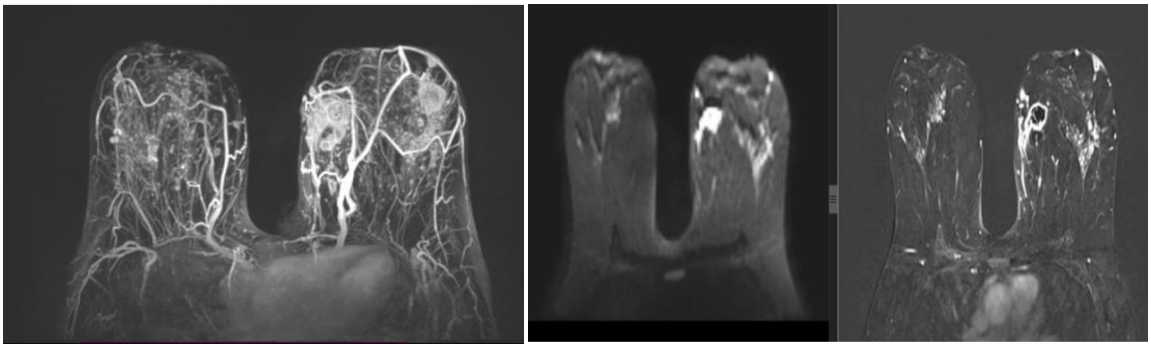

MRI imaging in 42 year old women.(A) Diffusion weighted imaging show diffusion restriction in left breast, the ADC value of this benign lesion equals to 1.4x 10-3 mm2/s (B) subtraction images in post contrast sequence showed segmental distribution and heterogenous enhancement; final biopsy showed sclerosingadenosis.

DISCUSSION

In current study the mean age was 45.78±12.12 years. In a study undertaken by **Niraj Kumar Srivastava et al**[12], researchers stated that the average age of breast cancer patients was 39 ± 3.028 years, with a range of 31 to 50 years. This data suggests that the highest occurrence of breast abnormalities is observed in women between the ages of 31 and 40, as well as between the ages of 41 and 50.

Amount of fibroglandular tissue

In current study, 66.7% of cases have heterogenous fibro glandular tissue, followed by scattered fibro glandular tissue in 24.6% cases, and 2.9% cases had almost entire fat. Heterogeneity refers to the presence of different amounts of glandular and fibrous tissue in the breast. Scattered distribution refers to a more even combination of glandular and fibrous components. The majority of fat is directly related to low breast density, which is linked to a decreased risk of cancer. Women with a significant amount of fibroglandular tissue appear to have an elevated chance of developing breast cancer.

Background Parenchymal Enhancement

In present study, moderate level of BPE was seen in 39.1% cases, followed by minimal in 34.8% cases, mild in 23.2% cases and 2.9% cases had marked level of BPE. 75.4% cases have asymmetrical BPE, and rest 24.6% cases have symmetrical BPE. BPE is considered an indicator of the level of blood circulation in the thick tissue and may serve as an indication of breast function.**Pike MC et al**[13] examined the correlation between breast cancer andBPE on MRI. In their findings, 51% of breast cancer cases exhibit moderate to notable BPE, while the remaining 41% of cases show minimal to mild BPE. The risk of breast cancer rises consistently as BPE grows. Women who have uneven breast density are more likely to get breast cancer.

Characteristics of mass

The present study reveals that 53.6%exhibit an irregular shape, followed by oval shape in 18.8% of cases. Round shape was observed in 8.7% of cases, and 18.8% of cases did not have a mass. 44.9% of cases have well-defined margins, whereas 26.1% of cases display spiculated margins that are not clearly defined. 46.4% exhibit heterogenous internal enhancement, whereas 14.5% cases have homogeneous enhancement.

A mass refers to a lesion that occupies space and has a size of 5mm or greater, while lesser than 5mm is referred as foci. A mass consists of a three-dimensional abnormal growth. When dealing with a mass, the main diagnostic possibilities are either aggressive breast cancer or a solid benign tumor such a fibroadenoma.[14] The irregular form indicates a potential presence of cancer. The most common invasive cancers manifest on MRI as enhancing masses, with spiculated, irregular, or lobulated margins. The internal enhancement is heterogenous and may demonstrate rim enhancement, a feature highly predictive of malignancy.

Varshitha GR et al[15], mentioned in their findings that 15 out of 54 lesions exhibited an irregular shape, while 20 lesions had an oval shape and 19 round shapes. 33 had well-defined boundaries, while the remaining 21 lesions had boundaries that were not clearly defined (16 were irregular and five were spiculated). 44.4% had heterogenous lesions, followed by 25.9% who had enhancement with dark interior septations, and 20.4% had homogeneous enhancement. This study reported almost similar distribution of participants.

In our study, MRI has sensitivity, specificity, positive predictive value, and negative predictive value was 97.2%, 90.9%, 92.1%, and 96.8% respectively. It shows excellent diagnostic efficacy of MRI in differentiating benign and malignant breast lesion. MRI is a non-invasive, and less time-consuming procedure compared to histopathology results, and have comparable diagnostic accuracy thus can be used as an alternative method. ***N. Aristokli et al***[16]reported sensitivity of 94.6%, and 74.2% of specificity, which is comparable to our study. And also indicated excellent efficacy of MRI in differentiating malignancy of breast lesion.

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Non-mass enhancement

In our study, linear distribution was seen in 17.4% cases, one case with diffuse distribution, and 62.3% cases have no non-mass enhancements. Heterogenous internal enhancement pattern was seen in 18.8% cases, 14.5% cases with clumped internal enhancement, and clustered ring was seen in none of the cases.

Non-mass enhancement of an area that isn't a mass or a blood vessel. The pattern of enhancement is different from the normal breast tissue around it. There is no space-occupying effect. Less than 20% of cases of estrogen receptor negative invasive ductal cancer show increase that is not like a mass, but none of the cases of estrogen positive cancer do.[17,18]

If the NME is spread out in different segments or regions, it should raise concerns for cancer, just like this pattern with calcifications. Also, either linear or ductal increase is a bad sign for DCIS. In our study, diffusion was present in 78.3% cases. A study reported that 34 cases out of 66 cases with breast lesion have diffusion restriction. 70.6% cases with presence of DWI restriction have malignant lesion.

ADC values of Benign and Malignant lesion

The mean ADC value of benign lesion is 1.44±0.27, and of malignant lesion was 1.00±0.31. ADC value of benign lesion was significantly higher than malignant lesion. Most reports indicated that malignant lesions have lower ADC values than benign findings but there was a broad spectrum of ADC threshold values to discriminate benign and malignant breast lesions.***Alexey Surov et al[19]*** *(2019)* found that the average apparent diffusion coefficient (ADC) value for malignant lesions was 1.03×10^{-3} mm2/s, while the average value for benign lesions was 1.5×10^{-3} mm2/s. These results are concurrent to our findings.

Association of Non-mass enhancement (NME) with malignancy

All cases with regional distribution, 91.7% of cases with linear distribution, 83.3% of cases with segmental distribution have malignant lesion, and one third of cases with focal distribution have malignant lesion. One third of cases with homogenous internal enhancement patterns, 80% of cases with clumped, 84.6% of cases with heterogenous internal enhancement have malignant lesion. This association of distribution and internal enhancement of non-mass was statistically significant ($p<0.05$). Our study supports the fact that that linear, regional and segmental distribution of NME is suggestive of malignancy of breast lesions. And heterogenous internal enhancement patterns is also seen predominantly in malignant breast lesions.

Mohemad S et al[20]reported in their study that none of the breast lesions exhibiting homogenous enhancement had malignant lesions. In contrast, 63.3% of patients with heterogenous enhancement, 33.3% of cases with clustered ring pattern, and half of the cases with clumped pattern were found to have malignant lesions. This study supports our finding that heterogenous internal enhancement patterns is strongly suggestive of malignancy, and homogenous patterns supports benign finding of breast lesions. Non-mass enhancement (NME) frequently displays benign kinetic patterns of enhancement, even when caused by malignant tumors. The sole distinguishing factors between benign and malignant NME are the distribution and internal enhancing pattern. The most significant indicators of malignancy for NME are: segmental, asymmetric distribution, and a clustered ring or clumped enhancement pattern.[21]

Limitations and recommendations

This study was conducted at a single center, it causes lack of generalizability of our findings. And in this study, we had a relative smaller sample size. Augmenting the sample size would enhance the statistical potency of the findings. Therefore, it is recommended to conduct multicentric investigations with larger patient groups.

CONCLUSION

Routine MRI technique can qualitatively evaluate NME lesions by analyzing their distribution and enhancement pattern, leading to improved characterization of benign and malignant lesions. The presence of an irregularly shaped mass, an uneven and spiculated border, and heterogeneous enhancement significantly indicate the likelihood of a malignant breast tumor. The presence of linear, regional, and segmental distribution of NME indicates the likelihood of breast lesions being malignant. In brief, the integration of morphological characteristics such as distribution and internal enhancement pattern with kinetics and difusion might enhance the certainty of clinical management decisions

The correlation between different aspects of breast lesions and MRI findings underscores the importance of employing modern imaging techniques to enhance diagnostic precision and patient management. DWI of the breast offers further data for the characterization of localized breast lesions in a rapid and effortless manner. By integrating ADC measurements and dynamic investigations with the analysis of enhancement patterns, the overall precision of MRI can be enhanced, leading to a decrease in unnecessary invasive operations.

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