ORIGINAL RESEARCH PAPER

Radio-Diagnosis

MRI AND ULTRASONOGRAPHY IN THE EVALUATION OF BREAST LESIONS: A DIAGNOSTIC CORRELATION STUDY

KEY WORDS: Breast lesions, Ultrasonography, Magnetic Resonance Imaging, Breast cancer diagnosis, Multimodal imaging

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ABSTRACT

Background: Breast cancer remains the most prevalent malignancy among women globally, with its incidence steadily increasing in developing nations such as India. Early and precise diagnosis is critical to improving treatment outcomes; however, the availability of advanced imaging modalities is often limited in low-resource settings. This study was designed to assess and compare the diagnostic performance of ultrasonography (USG) and magnetic resonance imaging (MRI) in differentiating benign from malignant breast lesions, and to explore the potential diagnostic enhancement achieved by combining both imaging techniques. **Material & Methods:** A prospective study was carried out involving 100 female participants aged 35 years and above who presented with palpable breast lumps or suspicious imaging findings. All subjects underwent both USG and MRI evaluations. Imaging results were subsequently correlated with histopathological findings to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of each imaging modality. **Results:** Among the 100 patients studied, the highest incidence of breast cancer was observed in the 56–65-year age group. Malignant lesions were more frequently located in the left breast, particularly in the upper outer quadrant. MRI outperformed USG in sensitivity (100% vs. 78.05%) and NPV (100% vs. 47.06%), while both modalities demonstrated similar specificity (88.89%). MRI reliably detected aggressive tumor characteristics such as spiculated margins, skin infiltration, and Type III kinetic enhancement curves. Notably, combining MRI and USG increased the overall diagnostic accuracy to 89%, underscoring the complementary role of both techniques. **Conclusion:** MRI demonstrated superior capability in detecting malignant breast lesions, whereas USG remained valuable due to its affordability and widespread availability. The findings emphasize the clinical benefit of integrating MRI with USG to enhance diagnostic precision in breast cancer evaluation, particularly in settings with limited access to advanced imaging.

INTRODUCTION

Breast cancer (BC) has emerged as the most commonly diagnosed cancer among women globally, overtaking lung cancer in 2020 with approximately 2.3 million new cases, representing 11.7% of all cancer diagnoses worldwide [1]. Epidemiological projections suggest that the global incidence may approach 2 million cases annually by 2030 [2]. In India, breast cancer incidence has risen significantly, with nearly a 50% increase reported between 1965 and 1985 [3]. Although breast cancer rates are generally higher in developed nations, this difference is often linked to underreporting, limited awareness, and lack of accessible diagnostic tools in developing and underdeveloped countries [4].

In India, breast cancer is the leading malignancy among women, with an age-adjusted incidence of 25.8 per 100,000 and a mortality rate of 12.7 per 100,000. Globally, in 2012, female breast cancer accounted for 25% of all cancer cases and 15% of cancer-related deaths in women [5]. Importantly, timely and accurate diagnosis can significantly improve outcomes, with 20–30% of early-stage breast cancer patients achieving long-term survival and reduced recurrence rates [6,7]. According to the Indian Council of Medical Research, one in every 22 Indian women may develop breast cancer during her lifetime. Despite the availability of genetic screening tools such as BRCA1 and BRCA2 mutation testing, their relevance remains limited within the Indian population, making early detection strategies such as self-examination and awareness critically important [8].

Breast cancer is a complex disease influenced by both genetic and environmental factors. While mutations in high-risk genes such as BRCA1/2 account for 5–10% of cases, other contributing risk factors include family history, prior malignancies, hormonal influences (e.g., early menarche, late menopause), and lifestyle-related factors like low breastfeeding rates [8,9]. Unfortunately, the majority of Indian patients present at advanced stages (Stage II–IV), thereby limiting curative treatment options.

The primary goal of breast imaging is to detect and evaluate suspicious lesions at an early stage, guiding appropriate clinical management while minimizing unnecessary interventions. Various imaging modalities, including ultrasonography (USG), mammography, computed tomography (CT), Doppler imaging, and magnetic resonance imaging (MRI), are employed, each with specific advantages and limitations [10,11].

USG is a cost-effective and widely accessible tool, especially in low-resource settings, capable of distinguishing cystic from solid masses [12–14]. MRI, though highly sensitive (85–100%), suffers from reduced specificity and limited availability in resource-limited regions [15–19]. In this context, the present study aims to evaluate, compare, and correlate the diagnostic utility of USG and MRI in characterizing breast lesions.

MATERIAL AND METHODS

Following approval from the Institutional Ethics Committee, this prospective observational study was conducted in the Department of Radiodiagnosis at Sri Aurobindo Institute of Medical Sciences & PG Institute, Indore. The study recruited 100 female patients aged 35 years and older who presented with clinically palpable breast lumps or were referred to the department for further imaging evaluation using ultrasonography (USG) and magnetic resonance imaging (MRI). Written informed consent was obtained from all participants after explaining the nature and objectives of the study.

Inclusion Criteria

- Women aged 35 years and above presenting with

symptoms suggestive of breast carcinoma.
- Women over 35 years with risk factors associated with breast cancer.

Exclusion Criteria

- Patients with contraindications to MRI (e.g., metallic implants, pacemakers).
- Cases involving non-palpable breast lesions, post-operative changes, or adjacent hematomas.
- Individuals with fungating or ulcerative breast lesions.
- Patients in a moribund state or with already confirmed diagnoses of malignancy.
- Those unwilling to participate in the study.

Study Procedure

A detailed clinical history was obtained, including information on age at menarche, reproductive history, menopausal status, and family history of breast malignancy. This was followed by a thorough clinical breast examination. All participants underwent initial ultrasonography, followed by MRI evaluation. Lesions were categorized according to the Breast Imaging Reporting and Data System (BI-RADS) classification.

Ultrasonography with Color Doppler

USG was performed using a GE logiq E9 machine with multi-frequency linear, curvilinear, and transvaginal probes. B-mode USG assessed lesion laterality, quadrant involvement, size, shape, margin characteristics, echotexture, posterior acoustic features, architectural distortion, ductal extension, vascularity, and height-to-width ratios. BI-RADS criteria guided lesion categorization.

Magnetic Resonance Imaging

MRI was conducted using a 3 Tesla system (SIEMENS Magnetom Vida 3T) with patients positioned prone using a dedicated breast coil. T1-weighted and T2-weighted sequences were obtained, with contrast-enhanced imaging performed when necessary. Parameters such as lesion morphology, margin definition, internal architecture, enhancement kinetics, and axillary involvement were analyzed. Lesions were classified as benign, probably benign, probably malignant, or malignant.

Histopathological Confirmation

Fine needle aspiration cytology (FNAC) or core biopsy was used for cytological or histological verification. Radiologists independently reviewed all imaging studies, and imaging findings were compared with histopathology to determine diagnostic accuracy.

Statistical Analysis

Data were processed using Microsoft Excel and IBM SPSS version 22.0. Descriptive statistics were used for continuous variables, while categorical data were analyzed with Chi-square and two-way ANOVA. Sensitivity, specificity, PPV, NPV, and overall accuracy were calculated for both MRI and USG, using histopathology as the gold standard. A p-value < 0.05 was considered statistically significant.

RESULTS

Among the 100 female patients evaluated, the most affected age group was 56–65 years (40%), followed by 45–55 years (27%), those aged 66 and above (21%), and 35–44 years (12%). The mean patient age was approximately 55.6 years, with ages ranging between 35 and 75 years. Histo-pathological analysis confirmed malignancy in 82% of cases, while 18% were benign. The majority of participants were Hindu (80%), with smaller proportions identifying as Muslim (14%) and Christian (6%). Assessment of risk factors revealed that 10% had a history of hormone therapy, 12% had previously diagnosed benign breast disease, and 4% reported a family history of breast cancer. Early menarche and late menopause were observed in 20% of patients, though over half (54%) had no identifiable risk factors. Tumor laterality showed a predominance on the left side (57%), compared to the right (43%). Notably, the upper outer quadrant was the most frequent site of lesion occurrence across all age groups, consistent with established epidemiological patterns. [Table 1]

Table 1. Clinicodemographic Distribution of Study Participants

Parameters	Number (%)
Age Group (Years)	
35-45	12 (12%)
46-55	28 (28%)
56-65	40 (40%)
66 and above	20 (20%)
Ethnic Distribution	
Hindu	80 (80%)
Muslim	14 (14%)
Christian	06 (6%)
Pathology	
Malignant	82 (82%)
Benign	18 (18%)
Associated features	
HRT	10 (10%)
Benign breast disease	12 (12%)
Family h/o breast cancer	04 (4%)
Early menarche	14 (14%)
Last menopause	06 (6%)
No risk factors	54 (54%)
Sidewise distribution of cases (Malignant) N=82	
Left	47 (57.3%)
Right	35 (42.7%)

In this study, the outer upper quadrant was the most frequently involved site of malignant tumors in both age groups, accounting for 64.3% (18/28) of cases in patients aged <55 years and 48.1% (26/54) in those >55 years. Among older patients, there was a broader distribution of tumors, with significant involvement of the inner lower quadrant (10 cases, 18.5%) and retroareolar region (10 cases, 18.5%). In contrast, these locations were far less involved in younger individuals, each with only 2 cases (7.1%). Notably, no tumors were observed in the outer lower quadrant among patients under 55. [Table 2]

Table 2. Gross Location of Malignant Tumour

Quadrant	<55 years	> 55 years
Outer upper	18	26
Inner upper	6	6
Outer lower	0	2
Inner lower	2	10
Retroareolar	2	10
Total	28	54

In this study of 100 patients, 104 breast lesions were detected, with four cases showing multiple lesions. Benign lesions were mostly wider than tall (L/AP ratio >1.4), round to oval in shape, and had smooth or lobulated margins. In contrast, malignant lesions often appeared taller than wide (L/AP ratio <1.4), with irregular shape and margins, although 24 malignant lesions mimicked benign shapes. Spiculated margins and internal vascularity were highly suggestive of malignancy—vascularity was noted in 60 lesions, all malignant. Heterogeneous echotexture was common in malignancies, whereas benign lesions were predominantly hypoechoic. Posterior acoustic shadowing was a characteristic malignant feature, though not universally present. Some malignant lesions showed enhancement or no acoustic effect. Among benign lesions, a few exhibited enhancement (6%) or attenuations (2%). Additional malignant indicators included skin involvement (8%), calcifications (12%), and axillary lymphadenopathy (10%)—the latter confirmed by loss of the central fatty hilum in lymph nodes. These sonographic features collectively aid in differentiating benign from malignant breast lesions. [Table 3]

Table 3. USG with Colour Doppler Findings of Breast Lesions

USG features		No of lesions	Benign	Malignant
Size, shape, margin& vascularity assessment of mass lesion				
Size	L/AP >1.4	50	20	30
	L/AP <1.4	54	2	52
Shape	Round	24	10	14
	Oval	20	10	10
	Irregular	60	2	58
Margins	Smooth	10	10	0
	Lobulated	34	10	24
	Spiculated	60	2	58
Vascularity	Vascular	60	0	60 (RI>0.8)
	Avascular	44	22	22
Echotexture and posterior transmission				
Echogenicity	Hypoechoic	34	20	14
	Hyperechoic	2	2	0
	Heteroechoic	68	0	68
Posterior sound transmission	Attenuation	60	2	58
	Enhancement	8	6	2
	No change	36	14	22
Other associated findings				
Skin Thickening/ Invasion of pectoralis	8	0	8	
Calcification	18	6	12	
Axillary lymphadenopathy (with loss of central fatty hilum	10	0	10	

MRI findings showed that spiculated margins were the most reliable indicator of malignancy, present in the majority of malignant lesions. However, 20% of malignant lesions also showed lobulated margins, a feature more commonly associated with benign pathology. Skin or pectoralis muscle involvement was observed in 30 lesions (30%), and importantly, all were malignant, highlighting its association with aggressive disease. Dynamic contrast enhancement curves further aided in differentiation: Type I curves (persistent enhancement) were seen in 18 benign lesions (18%), with no malignant cases, Type II curves (plateau pattern) were observed in 10 lesions, of which 8 (8%) were malignant and 2 (2%) benign, Type III curves (washout pattern), strongly linked to malignancy, were present in 76 lesions (76%), including 74 malignant and only 2 benign cases. [Table 4]

Table 4. MRI Findings of Breast Lesions

MRI features		No of lesions	Benign	Malignant
Assessment of margins, skin involvement and pectoralis invasion				
Margins	Smooth	8	8	0
	Lobulated	34	14	20
	Spiculated	62	0	32
Time intensity curve on contrast enhanced MRI				
	Type I	18	18	0
	Type II	10	2	8
	Type III	76	2	74

In this study, the diagnostic performance of ultrasonography (USG) and magnetic resonance imaging (MRI) was evaluated using BIRADS classification, where lesions graded I to III were considered negative and those graded IV and V were considered positive for malignancy. Out of 100 cases, both USG and MRI showed agreement with histopathological diagnosis in 74% of cases. USG demonstrated a sensitivity of 78.05%, specificity of 88.89%, PPV of 96.97%, NPV of 47.06%, and overall accuracy of 80%. In comparison, MRI showed superior results with 100% sensitivity and NPV, 88.89% specificity, 96.62% PPV, and 98% diagnostic accuracy. When both imaging modalities were combined, the sensitivity, specificity, PPV, NPV, and overall accuracy improved to 89.02%, 88.89%, 96.79%, 73.53%, and 89%, respectively. These findings highlight MRI's significantly higher sensitivity and NPV, making it more reliable in detecting malignant lesions and excluding false negatives. While both modalities had similar specificity, MRI offered slightly better PPV, confirming its superior overall diagnostic potential compared to USG alone. [Table 5]

Table 5. Accuracy of Cancer Detection Cases by USG and MRI

Modality	True positive	False positive	True Negative	False Negative
Ultrasonography	64	2	16	18
MRI	82	2	16	0

Table 6. Concordance of All Three Modalities with the Final Histopathological Diagnosis

	No of cases
Cases positive for malignancy by USG & MRI	60
Cases negative for malignancy by USG & MRI	14
Total	74

Table 7. Performance Characteristics of Each Screening Modality (USG and MRI)

Modality	Sensitivity	Specificity	Positive Predictive Value (PPV)	Negative Predictive Value (NPV)	Accuracy
Ultrasonography	78.05%	88.89%	96.97%	47.06%	80%
MRI	100%	88.89%	97.62%	100%	98%
Combined	89.02%	88.89%	96.79%	73.53%	89%

DISCUSSION

This prospective study was conducted on 100 female patients referred to the radiology department of a tertiary care center, aiming to evaluate and compare the diagnostic performance of ultrasonography (USG) and magnetic resonance imaging (MRI) in the assessment of breast lesions. The study focused on characterizing palpable breast masses through both imaging modalities and correlating the findings with histopathological diagnoses. A secondary objective was to evaluate the risk-benefit profile of each modality to inform optimal diagnostic decision-making.

The participants in the study ranged in age from 35 to 77 years, with a mean age of 55.64 years. The most commonly affected age group was 56 to 65 years, consistent with previous reports by Wiener JI et al. [10] and Nair et al. [8], whose studies on the diagnostic performance of MRI in suspected early-stage breast cancer reported mean patient ages of 56.6 and 56.24 years, respectively.

Out of the 100 patients, 82% were diagnosed with malignant lesions and 18% with benign ones. Malignancies were more frequently observed in the left breast (47 cases, 57.3%) than the right (35 cases, 42.7%), with the upper outer quadrant being the most commonly involved location across all age groups. These findings correlate with studies by Nair et al. [8] and Fisher et al., which also reported a slight left-sided predominance (58.54% and 51.4%, respectively).

The distribution of tumor location across breast quadrants remained consistent in patients below and above 55 years of age. This observation is in line with findings from Nair et al. [8] and Tellum et al. [21], who also reported the upper outer quadrant as the most common site of malignancy.

Ultrasonography was found to be the most reliable modality for accurate measurement of mass lesions, echoing the conclusions drawn by Fornage et al. [22] and Nair et al. [8]. Their studies demonstrated that real-time USG offers more precise preoperative tumor size estimation than physical examination or mammography. Combining clinical examination with mammography or USG was shown to enhance the overall accuracy of non-invasive tumor size evaluation.

In this study, most malignant lesions were taller-than-wide, reinforcing similar findings reported by Fornage et al. [22] and Nair et al. [8]. In contrast, benign lesions generally appeared round or oval with smooth or lobulated margins and posterior acoustic enhancement. Malignant lesions were typically irregular in shape, with spiculated or indistinct margins, heterogeneous echotexture, and posterior acoustic shadowing. These imaging characteristics align with those described in previous studies by Nair et al. [8], Vlaisavljevic V et al. [23], and Chao TC et al. [24].

MRI analysis revealed that most malignant lesions exhibited either spiculated (62 cases) or lobulated (20 cases) margins. Among the malignant cases, 74 demonstrated a type III signal intensity (SI) curve on dynamic contrast-enhanced MRI, while 8 displayed a type II curve. Conversely, benign lesions commonly showed smooth or lobulated margins and a type I SI curve. These observations correspond with findings by Kinkel K et al. [25]. Furthermore, internal vascularity was noted in 60 of the 82 malignant lesions, while all benign lesions were avascular—supporting results from Nair et al. [8] and similar studies.

There was discordance in imaging findings in 26 cases between the two modalities. Of these, 22 lesions were histopathologically confirmed as malignant. MRI accurately identified all 22 malignant cases, whereas 10 were misclassified as low-risk by USG. Additionally, 18 lesions were categorized as low-risk by USG alone. The remaining 4 cases were benign; however, 2 of these were incorrectly labeled as high-risk by both USG and MRI due to features such as a spiculated, taller-than-wide configuration on ultrasound and lobulated heterogeneous enhancement on MRI. These discrepancies align with findings from Nair et al. [8], although their study also included mammography as an additional diagnostic tool.

The diagnostic performance metrics for USG in this study were as follows: sensitivity of 78.05%, specificity of 88.89%, positive predictive value (PPV) of 96.97%, negative predictive value (NPV) of 47.06%, and an overall accuracy of 80%. In contrast, MRI demonstrated superior performance, with a sensitivity of 100%, specificity of 88.89%, PPV of 96.62%, NPV of 100%, and an accuracy of 98%. When both modalities were combined, the resulting sensitivity was 89.02%, specificity 88.89%, PPV 96.79%, NPV 73.53%, and diagnostic accuracy 89%.

MRI's significantly higher sensitivity and NPV, when compared with USG, are consistent with findings from studies by Malur S et al. [27], Nair et al. [8], and Berg WA et al. [28]. Although specificity remained equal for both modalities, MRI's PPV was marginally higher, in line with observations reported by Nair et al. [8].

However, this study had certain limitations, including a relatively small sample size (n=100), potential inter-observer variability in image interpretation, and the single-center design, which may limit the external applicability of the findings. Furthermore, limited follow-up and exclusive reliance on BIRADS classification may have impacted diagnostic accuracy.

CONCLUSION

This study underscores the superior diagnostic sensitivity and accuracy of magnetic resonance imaging (MRI) over ultrasonography (USG) in the evaluation of palpable breast lesions. Although both modalities exhibited comparable specificity, MRI demonstrated markedly higher sensitivity and negative predictive value, making it particularly effective in detecting malignant lesions potentially missed by USG. The combined application of USG and MRI further improved overall diagnostic accuracy, suggesting that a multimodal imaging approach may provide the most reliable diagnostic framework, especially in high-risk patients or in cases where USG findings are equivocal. These findings support the adjunctive role of MRI alongside ultrasonography in the comprehensive assessment of breast lesions. Nonetheless, larger-scale, multi-center studies are warranted to validate these observations and to inform standardized imaging protocols for breast cancer diagnosis.

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