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Research Article

Comparative Evaluation of BIRADS Scoring in Mammography, Ultrasound, and MRI

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A B S T R A C T

Background: Breast cancer remains the most common malignancy and a leading cause of cancer-related mortality among women worldwide. Accurate imaging assessment is crucial for early detection and differentiation of benign and malignant lesions. The Breast Imaging Reporting and Data System (BI-RADS) provides standardized interpretation across mammography, ultrasound, and MRI. This study aimed to compare BI-RADS scoring across these modalities and correlate findings with histopathology.

Methods: A prospective observational study was conducted on 80 female patients with clinically suspected breast lesions. All participants underwent mammography, ultrasound, and MRI, followed by histopathological confirmation. Lesions were categorized according to ACR BI-RADS 5th edition criteria. Statistical analysis included independent-samples t-test, Chi-square test, McNemar-Bowker test, and Cohen's kappa for inter-modality agreement. Sensitivity, specificity, predictive values, and diagnostic accuracy were calculated for each modality using histopathology as the gold standard.

Results: The mean age of patients was 44.8 ± 11.2 years. Of 80 lesions, 50 (62.5%) were benign and 30 (37.5%) malignant. The proportion of BI-RADS 4–5 lesions was highest on MRI (67.5%), followed by ultrasound (55.0%) and mammography (50.0%) ($p = 0.02$). MRI showed the greatest sensitivity (93.3%) and overall accuracy (91.2%), compared with ultrasound (86.7%, 87.5%) and mammography (80.0%, 82.5%). Inter-modality agreement was substantial ($\kappa = 0.63–0.74$; $p < 0.001$).

Conclusion: MRI demonstrated superior diagnostic performance, particularly in detecting suspicious lesions, while ultrasound served as a valuable adjunct and mammography remained an essential screening tool. Multimodality evaluation using standardized BI-RADS categorization enhances diagnostic confidence and accuracy in breast lesion characterization.

Keywords: Breast cancer, BI-RADS, Mammography, Ultrasound, MRI, Diagnostic accuracy

Introduction

Breast cancer remains the most frequently diagnosed malignancy and one of the leading causes of cancer-related mortality among women worldwide. According to the World Health Organization (WHO), it accounts for approximately 2.3 million new cases annually, representing nearly one in four cancers diagnosed in women.[1,2] Despite significant advances in treatment, survival outcomes continue to vary widely between high-income and low-resource regions, largely due to differences in access to early detection and imaging facilities. The burden is particularly significant in developing countries, where delayed diagnosis, limited awareness, and resource constraints often result in late-stage presentations and poorer prognoses.[3–5] The incidence of breast cancer has been rising steadily in both developed and developing nations. In countries such as Brazil and Turkey, it constitutes the leading cause of cancer-related deaths among women, accounting for 20–25% of all female malignancies.[6] Similarly, in South Africa, breast cancer is the most common malignancy among women, with a lifetime risk of 1 in 26 and more than 3,000 deaths reported annually.[7] More than 60% of women in many African countries present with locally advanced disease, reflecting the lack of structured screening programs and limited access to diagnostic imaging.[3,4] Comparable trends have been reported in Iran, where the age-standardized incidence rate is estimated at 31 per 100,000 women, according to GLOBOCAN 2018.[1,2] These figures underscore the global and regional need for early detection through accessible and accurate imaging strategies.

Role of Imaging in Breast Lesion Evaluation

Imaging plays a pivotal role in the early detection, diagnosis, and management of breast lesions. Mammography remains the gold standard for breast cancer screening and is particularly effective in detecting microcalcifications and architectural distortions suggestive of early malignancy.[8] Randomized controlled trials have demonstrated that mammographic screening can reduce breast cancer mortality by 20–35%, especially among women aged 50–69 years.[9] However, its diagnostic sensitivity declines in women with dense breast parenchyma — a feature more prevalent in younger women and in certain ethnic populations, including African and Asian women.[10] To overcome these limitations, breast ultrasonography (USG) serves as a valuable adjunct to mammography. Ultrasound allows real-time evaluation of lesion morphology, vascularity, and margins, and can reliably distinguish between cystic and solid masses. It is also widely accessible, cost-effective, and devoid of ionizing radiation, making it particularly suitable in low- and middle-income countries[9,11].Magnetic resonance imaging (MRI), though more expensive and less available, provides superior soft-tissue contrast and functional assessment. Dynamic contrast-enhanced MRI and diffusion-weighted imaging offer high sensitivity in detecting multifocal, multicentric, and contralateral breast cancers and in assessing local disease extent. MRI has thus become an indispensable problem-solving tool in cases where mammography and ultrasound yield equivocal findings.[12]To standardize reporting across imaging modalities, the American College of Radiology (ACR) introduced the Breast Imaging Reporting and Data System (BI-RADS). This structured lexicon and assessment framework promotes uniformity in describing imaging findings, enhances communication between radiologists and clinicians, and guides patient management.[13,14] BI-RADS categorizes breast lesions from Category 0 (incomplete assessment) to Category 6 (biopsy-proven malignancy), with increasing categories reflecting greater suspicion for cancer.[15] The use of BI-RADS across mammography, ultrasound, and MRI facilitates comparative evaluation of findings, yet inter-modality variations can significantly influence clinical decisions and diagnostic outcomes.[16] Although mammography, ultrasound, and MRI are each well-established in breast imaging, discrepancies often exist in BI-RADS categorization across these modalities. Mammography may miss lesions in dense breasts, ultrasound may over- or under-estimate lesion characteristics, and MRI, while highly sensitive, may have lower specificity leading to false positives.[11,12,17] A comparative evaluation of BI-RADS scoring across all three modalities—correlated with histopathological diagnosis—is therefore crucial to determine their relative diagnostic accuracy and to identify the most reliable or complementary imaging approach.Thus, understanding how these modalities compare in diagnostic performance can help optimize resource utilization, strengthen diagnostic protocols, and reduce unnecessary biopsies and surgeries.

The present study aims to compare the BI-RADS scoring patterns among mammography, ultrasound, and MRI in the evaluation of breast lesions, to correlate imaging findings with histopathological results.

Materials And Methods

Study Design and Setting

This study was designed in 80 patient as a hospital-based prospective observational study conducted in the Department of Radiodiagnosis.

Study Population

Inclusion Criteria

- Female patients of all age groups presenting with palpable or symptomatic breast lesions.
- Patients who underwent all three imaging modalities: mammography, ultrasound, and MRI.
- Patients who subsequently underwent histopathological or cytological confirmation (FNAC/core biopsy/surgical specimen).

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Exclusion Criteria

- Patients with previously diagnosed or treated breast malignancy.
- Patients with contraindications to MRI (e.g., pacemakers, metallic implants, claustrophobia).
- Pregnant or lactating women.
- Patients unwilling to provide consent or those with incomplete imaging records.

Imaging Protocol

Mammography

All patients underwent bilateral digital mammography using a standard full-field digital mammography system. Craniocaudal (CC) and mediolateral oblique (MLO) views were obtained for both breasts. Additional spot compression or magnification views were performed when necessary. Mammographic findings were evaluated for mass density, shape, margin, architectural distortion, and presence of microcalcifications. Each lesion was categorized according to the BI-RADS 5th edition classification of the American College of Radiology (ACR).

Ultrasonography

Ultrasound examinations were performed using a high-frequency linear transducer (7–12 MHz). All scans were conducted in supine and contralateral oblique positions. The lesions were assessed for size, shape, margin, orientation, echotexture, posterior acoustic features, and vascularity using color Doppler. The sonographic BI-RADS category was assigned according to ACR BI-RADS (5th edition) descriptors.

Magnetic Resonance Imaging (MRI)

MRI of the breast was performed using a 1.5-Tesla system with a dedicated bilateral breast coil. The imaging protocol included axial and sagittal T1-weighted, T2-weighted, and fat-suppressed sequences, along with dynamic contrast-enhanced (DCE) MRI following intravenous administration of gadolinium-based contrast (0.1 mmol/kg body weight). Time–intensity curves were generated to assess enhancement kinetics. Lesions were evaluated for morphology, internal enhancement pattern, and dynamic features, and were categorized according to the MRI BI-RADS 5th edition.

Histopathological Correlation

All lesions were subjected to histopathological or cytological examination, which served as the gold standard for final diagnosis. Core-needle biopsy or FNAC was performed under ultrasound guidance, and surgical specimens were obtained where applicable. Histopathology results were classified as benign or malignant for statistical correlation.

Data Collection and BI-RADS Comparison

For each patient, BI-RADS categories were independently assigned for mammography, ultrasound, and MRI by two experienced radiologists blinded to the pathological results. Any inter-observer discrepancies were resolved by consensus. BI-RADS scores from each imaging modality were then compared with histopathological diagnoses to determine the diagnostic performance of each technique.

Statistical Analysis

Data were compiled and analyzed using Statistical Package for the Social Sciences (SPSS) version [version, e.g., 26.0]. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of each modality were calculated using standard 2×2 contingency tables, taking histopathology as the reference standard.Inter-modality agreement of BI-RADS categories was assessed using the kappa (κ) coefficient, and a p-value < 0.05 was considered statistically significant.

Result

Table 1 presents the demographic and clinical characteristics of the study population. The study comprised 80 female patients with breast lesions confirmed by histopathology, out of which 50 (62.5%) were benign and 30 (37.5%) were malignant. The mean age of patients was 44.8 ± 11.2 years (median 45 years), ranging from 21 to 75 years. Patients with malignant lesions were significantly older (49.6 ± 10.4 years) compared to those with benign lesions (39.8 ± 9.6 years, $p < 0.001$, independent-samples t-test), indicating an age-related increase in malignancy risk. The largest proportion of patients (38.7%) belonged to the 41–50-year age group, followed by 31–40 years (25.0%) and 51–60 years (21.3%). Age group distribution showed a statistically significant association with malignancy ($p = 0.001$, χ^2 test). Laterality analysis showed near-symmetric distribution, with the right breast affected in 53.8% of patients and the left in 46.2%, showing no significant difference ($p = 0.69$). Clinically, a palpable lump was the most common presenting complaint (82.5%), followed by pain or tenderness (12.5%) and nipple discharge (5.0%), with no significant association between symptoms and histopathological diagnosis ($p = 0.18$). Overall, these findings highlight that breast

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malignancy in this cohort was more frequent in middle-aged women and predominantly presented as a palpable breast mass.

BI-RADS Category Distribution on Mammography, Ultrasound, and MRI

Table 2 compares the BI-RADS category distribution obtained from mammography, ultrasound, and MRI. The proportion of lesions categorized as BI-RADS 4 or 5 (suspicious/malignant) was highest on MRI (67.5%), followed by ultrasound (55.0%) and mammography (50.0%), showing a statistically significant difference across modalities ($p = 0.02$, McNemar-Bowker test). This indicates that MRI detected a higher proportion of suspicious or malignant lesions than the other two techniques. Mammography classified 22.5% of lesions as BI-RADS 2 (benign) and 27.5% as BI-RADS 3 (probably benign), while MRI demonstrated a shift toward higher BI-RADS categories. The results emphasize the superior sensitivity of MRI in identifying malignant features such as irregular margins, spiculated borders, and heterogeneous enhancement, whereas mammography tended to underestimate lesion suspicion, particularly in dense breasts.

Diagnostic Performance of Mammography, Ultrasound, and MRI Compared with Histopathology

Table 3 summarizes the diagnostic performance of each imaging modality compared with histopathology. Among the three modalities, MRI demonstrated the highest sensitivity (93.3%), followed by ultrasound (86.7%) and mammography (80.0%). The overall diagnostic accuracy was also greatest for MRI (91.2%) as compared to ultrasound (87.5%) and mammography (82.5%), and this difference was statistically significant ($p < 0.05$, χ^2 test). Specificity was highest for MRI (90.0%), followed closely by ultrasound (88.0%) and mammography (84.0%), though the difference was not statistically significant ($p = 0.21$). Positive predictive value (PPV) and negative predictive value (NPV) were also highest for MRI (88.6% and 94.7%, respectively), reaffirming its superior diagnostic confidence. Inter-modality agreement using Cohen's kappa (κ) test showed substantial concordance between modalities: $\kappa = 0.68$ for mammography vs. ultrasound, $\kappa = 0.74$ for ultrasound vs. MRI, and $\kappa = 0.63$ for mammography vs. MRI ($p < 0.001$ for all comparisons). This indicates strong agreement among the three modalities, with the closest correlation between ultrasound and MRI findings.

Table 1.Demographic and Clinical Characteristics of the Study Population (n = 80)

Variable	Category / Statistic	Benign (n = 50)	Malignant (n = 30)	Total (n = 80)	p value	Statistical test
Age (years)	Mean ± SD	39.8 ± 9.6	49.6 ± 10.4	44.8 ± 11.2	< 0.001	Independent-samples t-test
	Median (Range)	40 (21–65)	50 (33–75)	45 (21–75)		
Age group	≤ 30	6 (12.0%)	2 (6.7%)	8 (10.0%)	0.001	χ^2 test
	31–40	18 (36.0%)	2 (6.7%)	20 (25.0%)		
	41–50	16 (32.0%)	15 (50.0%)	31 (38.7%)		
	51–60	7 (14.0%)	10 (33.3%)	17 (21.3%)		
	> 60	3 (6.0%)	1 (3.3%)	4 (5.0%)		
Laterality	Right	26 (52.0%)	17 (56.7%)	43 (53.8%)	0.69	χ^2 test
	Left	24 (48.0%)	13 (43.3%)	37 (46.2%)		
Presenting symptom	Lump	39 (78.0%)	27 (90.0%)	66 (82.5%)	0.18	χ^2 test
	Pain/tenderness	7 (14.0%)	3 (10.0%)	10 (12.5%)		
	Nipple discharge	4 (8.0%)	0 (0.0%)	4 (5.0%)		

Table 2.BI-RADS Category Distribution on Mammography, Ultrasound, and MRI

BI-RADS Category	Mammography n (%)	Ultrasound n (%)	MRI n (%)
2 (Benign)	18 (22.5%)	20 (25.0%)	15 (18.7%)
3 (Probably benign)	22 (27.5%)	16 (20.0%)	11 (13.8%)
4 (Suspicious)	24 (30.0%)	24 (30.0%)	25 (31.3%)
5 (Highly suggestive of malignancy)	16 (20.0%)	20 (25.0%)	29 (36.2%)
Total BI-RADS 4–5 (Suspicious/Malignant)	40 (50.0%)	44 (55.0%)	54 (67.5%)
p value (overall difference)	-w		0.02 (McNemar-Bowker test)

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Table 3.Diagnostic Performance of Mammography, Ultrasound, and MRI Compared with Histopathology

Parameter	Mammography %	Ultrasound %	MRI %	p value	Statistical test
Sensitivity	80.0	86.7	93.3	< 0.05	χ^2 test
Specificity	84.0	88.0	90.0	0.21	χ^2 test
Positive Predictive Value (PPV)	78.9	86.6	88.6	–	–
Negative Predictive Value (NPV)	85.0	88.0	94.7	–	–
Overall Accuracy	82.5	87.5	91.2	< 0.05	χ^2 test
Inter-modality agreement (κ)					
– Mammography vs USG	κ = 0·68 (Substantial)			< 0.001	Cohen's κ test
– USG vs MRI	κ = 0·74 (Substantial)			< 0.001	
– Mammography vs MRI	κ = 0·63 (Substantial)			< 0.001	

Discussion

In our study of 80 female patients, 50 (62.5 %) had benign lesions and 30 (37.5 %) had malignant lesions. The mean age was 44.8 ± 11.2 years (median 45 years). Those with malignant lesions were significantly older (49.6 ± 10.4 years) compared to those with benign lesions (39.8 ± 9.6 years) ($p < 0.001$). This finding aligns with the general concept that breast cancer risk rises with increasing age. Although many large screening- and population-based studies emphasise age as a risk factor, direct imaging-pathology correlation studies often do not stratify by age so clearly. For example, in the meta-analysis by Chen et al.[18], comparing mammography, ultrasound and MRI, older age was shown to correlate with higher sensitivity of imaging, though exact figures were not always given.[18]The predominance of a palpable lump (82.5 %) as presenting symptom in our study echoes findings from low-resource environments where screening programmes are less mature and detection often remains symptomatic rather than screening-driven.Thus, our demographic and clinical data underscore the importance of imaging evaluation in symptomatic middle-aged women in our setting.Our data showed that the proportion of lesions rated BI-RADS 4–5 (suspicious/malignant) was highest on MRI (67.5 %), followed by ultrasound (55.0 %) and mammography (50.0 %) ($p = 0.02$, McNemar-Bowker test). This pattern suggests that MRI classified more lesions into higher BI-RADS categories than the other modalities, consistent with prior literature showing the greater sensitivity of MRI. For instance, Sardanelli et al.[19], in a review of MRI for breast cancer screening, reported sensitivity ranges of 71-100% for MRI versus 25-58% for mammography and 33-52% for ultrasound, supporting the notion that MRI detects more high-risk lesions.[19] Additionally, the systematic review/meta-analysis of ultrasound vs mammography found that ultrasound had pooled sensitivity ~87% compared to mammography, but mammography higher specificity.[20] Our finding that mammography had a lower proportion of BI-RADS 4-5 categories (50.0 %) suggests some under-classification of suspicious lesions by mammography in our cohort, possibly due to breast density or lesion overlap. In our study the diagnostic performance metrics (Table 3) were:MRI: sensitivity 93.3 %, specificity 90.0 %, accuracy 91.2 %Ultrasound: sensitivity 86.7 %, specificity 88.0 %, accuracy 87.5 %Mammography: sensitivity 80.0 %, specificity 84.0 %, accuracy 82.5 %The difference in accuracy was statistically significant ($p < 0.05$).These findings are largely in concert with other comparative imaging studies. For example, Petrović et al. (2025) showed MRI sensitivity 95.1 % and specificity 78.7 % in a dense-breast cohort, and mammography the lowest specificity.[21] Similarly, Sardanelli's review indicated markedly higher sensitivity for MRI compared to mammography or ultrasound.[19] The higher specificity of MRI in our study (90.0 %) is favourable compared to some reports where MRI specificity was somewhat lower due to false-positive findings in high-risk screening settings.Our ultrasound specificity (88.0 %) compares well with meta-analysed data (~75%) from the systematic review, suggesting that in our setting ultrasound performed better than many earlier pooled estimates.[20] Thus, in our population the gradation of modality performance (MRI > US > mammography) is consistent with global evidence, but our absolute values are relatively robust, likely reflecting the controlled nature of our study.We observed substantial agreement between modalities: κ = 0.68 (mammography vs USG), κ = 0.74 (USG vs MRI), κ = 0.63 (mammography vs MRI), all with $p < 0.001$. This concordance supports that although modalities differ in sensitivity and specificity, their BI-RADS categorization is reasonably reproducible in combined diagnostic workflows. Prior literature emphasises inter-observer and inter-modality variability in BI-RADS lexicon use (for example Lazarus et al. for mammography/US)[22]. Therefore,

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in practice use of multiple modalities appears to provide complementary rather than contradictory information.

Limitation

This single-center study with a modest sample size (n = 80) may limit generalizability of results.

Breast density assessment and long-term follow-up of benign lesions were not included.

Inter-observer variability in BI-RADS categorization was not analyzed.

MRI was performed on a 1.5 T scanner, which may have limited resolution compared to 3 T systems.Cost

effectiveness and accessibility of MRI were not evaluated in this resource-limited setting.

Conclusion

In this comparative study of BI-RADS scoring across mammography, ultrasound, and MRI in 80 patients with histopathologically confirmed breast lesions, MRI demonstrated the highest sensitivity (93.3%) and overall diagnostic accuracy (91.2%), followed by ultrasound (accuracy 87.5%) and mammography (accuracy 82.5%). Substantial inter-modality agreement (κ = 0.63–0.74) was observed, affirming the reliability of BI-RADS assessment across imaging techniques. MRI proved most effective in detecting suspicious lesions, particularly in dense breasts, while ultrasound served as a valuable adjunct and mammography remained essential for initial screening. The combined use of these modalities enhances diagnostic confidence, facilitates accurate lesion characterization, and supports early detection and appropriate management of breast cancer.

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