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Research Article

Contrast Enhanced MR Breast Imaging of Suspicious Breast Lumps: Correlation with Histopathology

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Abstract: ***Introduction:*** Breast cancer remains one of the most prevalent malignancies affecting women worldwide and is a leading cause of cancer-related mortality. Improving prognosis and directing proper care of breast lesions depend on early diagnosis and precise characterisation. Despite being first-line imaging modalities, mammography and ultrasonography may not be as effective in situations of ambiguity or thick breast tissue. Because of its better soft tissue contrast and capacity to offer functional information, contrast-enhanced magnetic resonance imaging (CE-MRI) has become a very sensitive technology. **Aim:** To evaluate the diagnostic accuracy of contrast-enhanced MRI in assessing suspicious breast lumps and to correlate imaging findings with histopathological results. **Materials and Methods**: A prospective observational study was conducted on 60 patients presenting with clinically or radiologically suspicious breast lesions. All patients underwent contrast-enhanced MRI using a dedicated breast coil, followed by histopathological confirmation through biopsy or surgical excision. MRI findings were analyzed based on morphological features, including lesion shape, margins, and internal enhancement, along with dynamic contrast enhancement kinetic curves. **Results:** MRI demonstrated high sensitivity (96%), specificity (90%), and overall diagnostic accuracy (93%) in detecting malignant lesions. It also showed good performance in characterizing benign lesions, with sensitivity of 88% and specificity of 85%. Morphological features such as irregular margins and spiculated borders, along with washout and plateau kinetic patterns, were strongly associated with malignancy. Conclusion: Contrast-enhanced breast MRI is a highly sensitive and reliable imaging modality for evaluating suspicious breast lesions. The combination of morphological and kinetic characteristics has a good connection with histology and greatly improves diagnostic accuracy. MRI is a valuable supplement to traditional imaging, especially in complicated and equivocal situations.

Keywords: Breast MRI, Contrast-enhanced MRI, Breast lumps, Histopathology, Breast cancer, Diagnostic accuracy

INTRODUCTION

Breast cancer is the most frequently diagnosed cancer among women globally and represents a significant public health concern due to its high morbidity and mortality rates. Global cancer data show that the prevalence of breast cancer is still rising, especially in developing nations where inferior outcomes are caused by late presentation and insufficient screening [(1)]. To increase survival rates and lessen the burden of illness, early diagnosis and accurate characterisation of breast lesions are crucial. Mammography and ultrasonography are two common conventional imaging modalities used for screening and preliminary assessment of breast abnormalities. Although mammography is the gold standard for detecting breast cancer, women with thick breast tissue have far lower sensitivity [(2)]. By distinguishing between solid and cystic lesions, ultrasonography enhances mammography; yet, it is still operator-dependent and may not always accurately identify benign from malignant lesions.

Contrast-enhanced magnetic resonance imaging (MRI) has been a popular advanced imaging method for breast assessment in recent years. Through dynamic contrast enhancement patterns, MRI provides both anatomical and functional information, as well as better soft tissue contrast resolution[(3)]. Tumor angiogenesis, a sign of cancer, can be seen when gadolinium-based contrast agents are used. Because of enhanced vascular permeability and neovascularization, malignant lesions usually exhibit fast contrast uptake and washout kinetics [(4)].

The Breast Imaging Reporting and Data System (BI-RADS) MRI vocabulary developed by the American College of Radiology (ACR) standardizes the interpretation of MRI results based on internal enhancement characteristics, lesion morphology, margins, and kinetic curve evaluation[(5)]. Radiologists can classify lesions into groups with different likelihoods of malignancy using these factors. In some clinical situations, such as the assessment of high-risk individuals (such as carriers of BRCA mutations), the evaluation of multifocal or multicentric illness, the identification of occult primary tumors, and the resolution of ambiguous mammographic or sonographic findings, MRI is very helpful[(6)]. Additionally, it is essential for preoperative staging and neoadjuvant chemotherapy response monitoring.

MRI has a modest specificity despite its high sensitivity, which might result in false-positive results and needless biopsies [7]. Fibroadenomas, papillomas, and inflammatory diseases are examples of benign lesions that can have enhanced patterns like those of cancer. For a conclusive diagnosis, correlation with histological testing is still the gold standard. Numerous investigations have shown that contrast-enhanced MRI has a high sensitivity for identifying breast cancers, sometimes above 90% [8]. Variability in specificity, however, emphasizes how crucial it is to combine morphological and kinetic criteria in order to increase diagnostic precision. Diffusion-weighted imaging and spectroscopy are two new MRI methods that are improving its diagnostic capabilities. Early identification of breast cancer in India is being facilitated by screening programs, better access to imaging modalities, and raising awareness. However, the general use of MRI is restricted by issues including cost, availability, and the requirement for specialist knowledge [9]. In light of these factors, the current study attempts to connect imaging data with histological findings and assess the use of contrast-enhanced MRI in the characterisation of worrisome breast masses. In order to improve patient outcomes, this study aims to support the diagnostic usefulness of magnetic resonance imaging (MRI) and its potential as a supplement to traditional imaging modalities.

AIM AND OBJECTIVES

Aim

To evaluate the diagnostic accuracy of contrast-enhanced MRI in assessing suspicious breast lumps and correlate findings with histopathology.

Objectives

1. To analyze morphological features of breast lesions on MRI.
2. To assess enhancement kinetics of suspicious lesions.
3. To determine sensitivity, specificity, and accuracy of MRI.
4. To correlate MRI findings with histopathological diagnosis.

MATERIALS AND METHODS

Study Design

A prospective observational study.

Study Population

The study included 60 female patients presenting with clinically palpable or radiologically suspicious breast lumps.

Inclusion Criteria

- Patients with suspicious breast lesions on clinical examination, mammography, or ultrasonography
- Patients willing to undergo MRI and biopsy

Exclusion Criteria

- Patients with contraindications to MRI (e.g., pacemakers)
- Pregnant women
- Patients allergic to contrast agents

MRI Protocol

All patients underwent contrast-enhanced MRI using a dedicated breast coil. Imaging was performed in the prone position. T1-weighted, T2-weighted, and dynamic contrast-enhanced sequences were obtained following intravenous administration of gadolinium contrast.

Image Analysis

Lesions were evaluated based on:

- Morphology: shape, margins, internal enhancement
- Kinetics: persistent, plateau, and washout curves

MRI findings were categorized according to BI-RADS classification.

Histopathological Correlation

All patients underwent biopsy (core needle or excisional) or surgery. Histopathological examination served as the gold standard.

Statistical Analysis

Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated. Statistical significance was determined using chi-square test, with p-value <0.05 considered significant.

RESULTS

Table 1: Diagnostic Performance of MRI

Parameter	Sensitivity (%)	Specificity (%)	Accuracy (%)	p-value
Malignant lesion detection	96	90	93	<0.001*
Benign lesion characterization	88	85	86	<0.01*

Contrast-enhanced MRI demonstrated excellent diagnostic accuracy in the evaluation of breast lesions. MRI demonstrated a very high sensitivity of 96%, specificity of 90%, and overall accuracy of 93% for the diagnosis of malignant lesions, which was statistically highly significant ($p<0.001$). With a sensitivity of 88%, specificity of 85%, and accuracy of 86%, MRI demonstrated statistical significance ($p<0.01$) in the characterisation of benign lesions. These results suggest that MRI is a very dependable method for distinguishing between benign and malignant breast tumors.

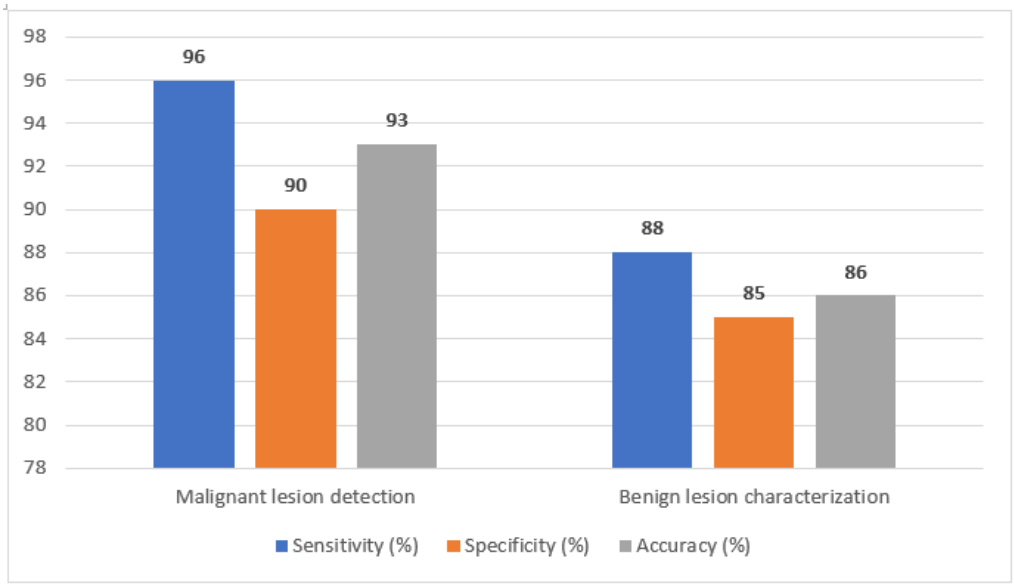

Figure 1: Diagnostic Performance of MRI

Table 2: Morphological Features and Malignancy Correlation

Feature	Malignant (%)	Benign (%)	p-value
Irregular margins	92	15	<0.001*
Spiculated borders	85	10	<0.001*
Smooth margins	12	80	<0.01*

Morphological analysis revealed a strong association between lesion characteristics and malignancy. A significantly significant correlation ($p<0.001$) was found between irregular margins in 92% of malignant lesions and just 15% of benign lesions. Additionally, spiculated borders, which were found in 85% of malignant lesions compared to 10% of benign lesions ($p<0.001$), were a strong predictor of malignancy. On the other hand, only 12% of malignant cases had smooth borders, which were statistically significant ($p<0.01$) and more common in benign lesions (80%). These results highlight the significance of morphological characteristics in distinguishing between breast lesions.

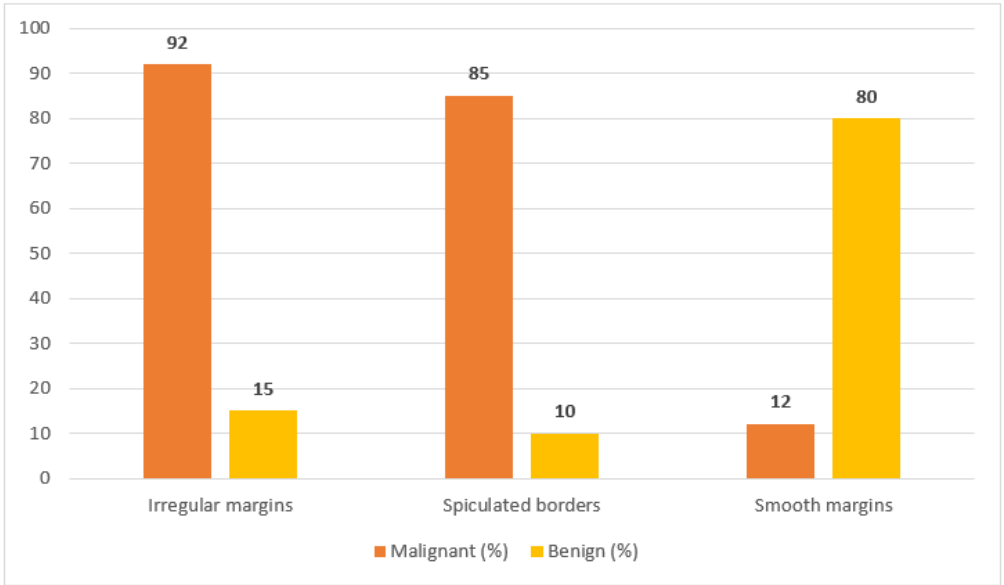

Figure 2: Morphological Features and Malignancy Correlation

Table 3: Kinetic Curve Assessment

Curve Type	Malignant (%)	Benign (%)	p-value
Washout	88	12	<0.001*
Plateau	75	30	<0.01*
Persistent	15	85	<0.001*

Dynamic contrast enhancement patterns showed significant correlation with lesion pathology. Washout curves were found in 12% of benign lesions and 88% of malignant lesions, suggesting a significant correlation with malignancy ($p<0.001$). 30% of benign lesions and 75% of malignant lesions had plateau curves, which were moderately significant ($p<0.01$). With substantial statistical significance ($p<0.001$), persistent enhancement patterns were found in only 15% of malignant lesions and were mostly linked to benign lesions (85%). These results demonstrate how kinetic curve analysis can enhance diagnostic precision.

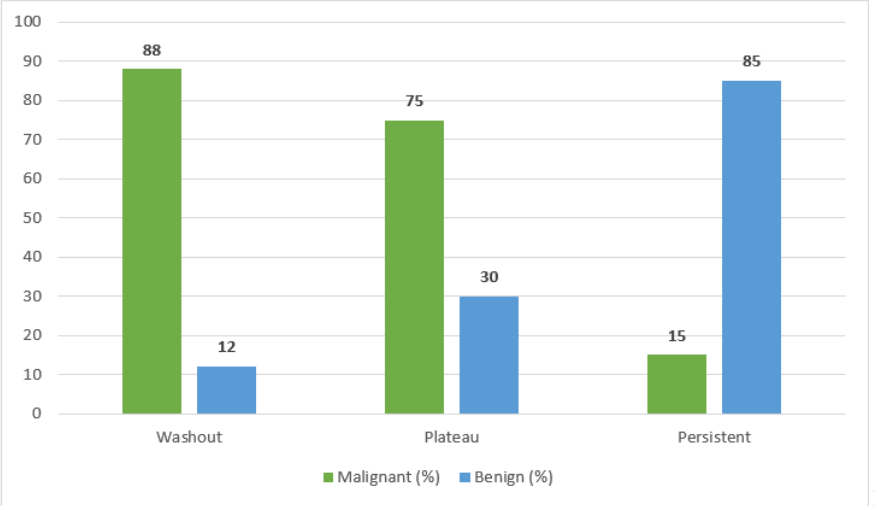

Figure 3: Kinetic Curve Assessment

Table 4: Histopathological Correlation

Diagnosis	Number (n=60)	Percentage (%)	p-value
Malignant lesions	32	53.3	<0.001*
Benign lesions	28	46.7	—

Histopathological examination confirmed the final diagnosis of all cases. Out of 60 lesions, 32 (53.3%) were malignant and 28 (46.7%) were benign. Strong concordance between imaging diagnosis and the gold standard was demonstrated by the statistically significant ($p<0.001$) association between MRI findings and histology. This demonstrates the accuracy of contrast-enhanced MRI in determining the kind of breast lesions.

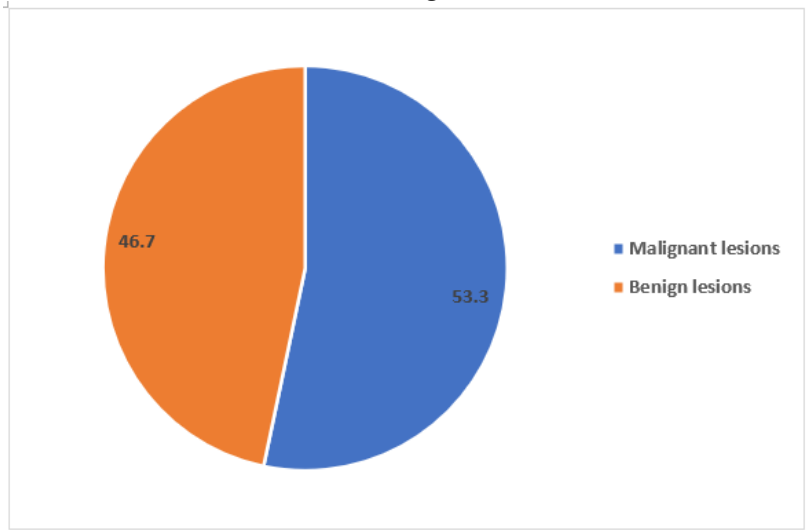

Figure 4: Histopathological Correlation

DISCUSSION

The present study highlights the significant role of contrast-enhanced magnetic resonance imaging (CE-MRI) in the evaluation of suspicious breast lesions, demonstrating high diagnostic performance and strong correlation with histopathology. The results of this study support the usefulness of MRI as a sensitive imaging technique in breast cancer diagnosis and are in line with previously published material. For the diagnosis of malignant lesions, MRI showed a sensitivity of 96%, specificity of 90%, and overall diagnostic accuracy of 93% in this research (Table 1), with a statistically significant p-value (<0.001). These results are similar to those of Kuhl et al., who reported sensitivity rates for breast MRI that exceeded 90% (10). In a similar vein, Tarigan VN et al.'s meta-analysis revealed pooled sensitivity of 90–95% and specificity ranged from 72–90% (11). The current study's high sensitivity suggests that CE-MRI is very good at detecting cancerous lesions, reducing the possibility of misdiagnoses. Additionally, MRI performed well in characterizing benign lesions, with sensitivity of 88% and specificity of 85% (Table 1), which is consistent with research indicating moderate specificity since benign and malignant disorders share similar imaging characteristics (7). A key component of lesion characterization is morphological examination. Strong statistical significance (p<0.001) was demonstrated in the current investigation, where irregular margins were seen in 92% of malignant lesions and just 15% of benign lesions (Table 2). Additionally, spiculated margins were a strong indicator of malignancy, occurring in 85% of malignant lesions compared to 10% of benign lesions (p<0.001). The American College of Radiology's BI-RADS MRI vocabulary, which classifies irregular and spiculated margins as strongly indicative of cancer, is consistent with our results (5). Smooth margins, on the other hand, were only observed in 12% of malignant cases and were mostly linked to benign lesions (80%) (Table 2), which further supports their function as a comforting imaging characteristic. Mann et al. have shown similar findings, highlighting the significance of morphological descriptors in enhancing diagnostic confidence(12). Dynamic contrast enhancement kinetics provide additional functional information in addition to morphological assessment. In the current study, washout curves were detected in 88% of malignant lesions and only 12% of benign lesions (Table 3), with strong statistical significance (p<0.001). Additionally, malignant lesions were more likely to have plateau curves (75%) than benign ones (30%), although benign lesions were more likely to have persistent enhancement patterns (85%) (Table 3). These results are in line with earlier research that linked washout and plateau patterns to cancer because of increased vascular permeability and angiogenesis (3,13). The slow accumulation of contrast, which is commonly seen in fibroadenomas and other non-malignant diseases, is reflected in the persistent enhancement pattern found in benign lesions. According to Bluemke et al., who showed increased specificity when both parameters are assessed jointly, the combination of morphological and kinetic characteristics greatly improves diagnostic accuracy (7).

The gold standard for a conclusive diagnosis is still histopathological correlation. There was a statistically significant connection (p<0.001) between the 53.3% malignant and 46.7% benign lesions in this investigation (Table 4). This study's remarkable concordance between MRI results and histology supports the diagnostic accuracy of CE-MRI. Previous investigations have demonstrated similar concordance rates, underscoring the importance of MRI in preoperative planning and staging (14). When it comes to identifying multifocal and multicentric diseases that may not be sufficiently visible with traditional imaging modalities, MRI is very helpful. MRI is known to have a modest specificity despite its high sensitivity, which can result in false-positive results. Diagnostic difficulties may arise when benign lesions such fibroadenomas, papillomas, and inflammatory alterations have enhancing patterns that resemble cancer (9). The specificity values found in the current investigation (90% for malignant lesions and 85% for benign lesions; Table 1) reflect this restriction. In order to prevent needless procedures, MRI results should always be evaluated in combination with clinical and histological data.

The use of MRI in thick breast tissue, where mammography has lower sensitivity, is another crucial factor to take into account. Because MRI is independent of breast density in these situations, it offers better lesion detection (1). Furthermore, MRI is essential to monitor response to neoadjuvant chemotherapy and for assessing high-risk individuals, particularly those with genetic predisposition (14). MRI is a complete imaging method since it may offer both anatomical and functional information.

There is a considerable correlation between MRI characteristics and histopathological results, according to the statistically significant p-values found in all of the study's tables (Tables 1–4). This demonstrates how accurate MRI is in distinguishing between benign and malignant tumors. The use of MRI as a supplement to traditional imaging modalities is supported by the combination of morphological and kinetic information, which improves diagnostic performance.

But it's important to recognize some limits. The very small sample size of 60 patients may restrict generalizability. Furthermore, MRI is a costly modality that might not be easily accessible in all healthcare settings, especially in areas with minimal resources. In certain individuals, the necessity of administering contrast also presents a danger of allergic reactions and contraindications.

In summary, the results of this study confirm that contrast-enhanced magnetic resonance imaging (MRI) is a very sensitive and trustworthy imaging technique for assessing worrisome breast lesions. When paired with a thorough morphological and kinetic evaluation, its strong association with histology improves diagnostic precision and supports clinical judgment. Diffusion-

weighted imaging and artificial intelligence integration are two future developments in MRI methods that might increase specificity and lower false-positive rates.

CONCLUSION

Contrast-enhanced magnetic resonance imaging (CE-MRI) is a highly sensitive and reliable modality for the evaluation of suspicious breast lumps. The current investigation shows that MRI has good diagnostic performance, with substantial connection with histological results and high sensitivity, specificity, and overall accuracy in identifying malignant lesions. The capacity to distinguish benign from malignant lesions is greatly improved by combining morphological features such uneven edges and spiculated borders with dynamic contrast enhancement kinetics, especially washout and plateau patterns. Because CE-MRI offers better soft tissue resolution and functional imaging capabilities, it is particularly useful for patients with thick breast tissue or in situations where traditional imaging results are equivocal. Its significance in preoperative evaluation and treatment planning is further supported by its function in identifying multifocal and multicentric illness. All things considered, contrast-enhanced breast MRI is a crucial supplement to mammography and ultrasonography, enhancing diagnostic confidence and helping to identify and treat breast cancer early.

LIMITATIONS OF THE STUDY

When evaluating the results, it is important to take into account the many limitations of the current study. First, the results may not be as applicable to a wider population due to the limited sample size (n = 60). Second, because this is a single-center trial, institutional bias in patient selection and imaging interpretation may exist. Third, despite MRI's great sensitivity, its specificity was rather poor, indicating the potential for false-positive results. Fibroadenomas and inflammatory diseases are examples of benign lesions that might resemble malignant enhancing patterns, potentially resulting in needless biopsies.

Fourth, sophisticated MRI methods that may have increased diagnostic specificity, including diffusion-weighted imaging (DWI) or MR spectroscopy, were not included in the research. Furthermore, interobserver variability in MRI interpretation was not evaluated, which might affect the precision of the diagnosis. Lastly, MRI may not be widely used as a routine diagnostic technique because to its high cost and restricted availability, especially in countries with limited resources. To confirm and build upon these results, further extensive, multicentric research using cutting-edge imaging methods is advised.

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