

DIAGNOSTIC ACCURACY OF DYNAMIC CONTRAST-ENHANCED MRI FOR BREAST LESIONS USING HISTOPATHOLOGY AS THE GOLD STANDARD

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ABSTRACT

OBJECTIVES

This study aimed to determine the diagnostic accuracy of dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) for differentiating benign and malignant breast lesions, using histopathology as the reference standard.

METHODOLOGY

This cross-sectional diagnostic-accuracy study was conducted at DHQ Hospital, Gujranwala, Pakistan, from November 2023 to April 2024. Ninety-six patients with clinically suspected breast lesions were enrolled by non-probability consecutive sampling. DCE-MRI was performed before histopathological examination by biopsy or surgical excision. Sensitivity, specificity, predictive values, overall accuracy, and the association between MRI and histopathological diagnosis were analyzed using SPSS version 26.

RESULTS

The mean age of participants was 45.52 ± 12.73 years, and histopathology confirmed malignancy in 54/96 (56.3%) lesions. DCE-MRI showed a sensitivity of 90.7%, specificity of 83.3%, positive predictive value of 87.5%, negative predictive value of 87.5%, and overall accuracy of 87.5%. MRI diagnosis was strongly associated with histopathology ($\chi^2 = 53.33$, $p < 0.001$; Cramer's $V = 0.745$).

CONCLUSION

DCE-MRI demonstrated high diagnostic accuracy for differentiating benign and malignant breast lesions and may serve as a valuable adjunct in the evaluation of suspicious lesions.

KEYWORDS: Breast Neoplasms; Diagnostic Accuracy; Dynamic Contrast-Enhanced Magnetic Resonance Imaging; Histopathology; Magnetic Resonance Imaging

INTRODUCTION

Breast cancer is one of the most commonly diagnosed malignancies in women and remains a major cause of cancer-related morbidity and mortality worldwide.¹ Early detection and accurate characterization of breast lesions are important for guiding management and improving outcomes.² Mammography and ultrasonography are central to initial breast assessment but may have limitations in lesion characterization, particularly in dense breast tissue.³ Magnetic resonance imaging (MRI) provides excellent soft-tissue contrast together with anatomical and functional information.^{4,5} Dynamic contrast-enhanced MRI (DCE-MRI) evaluates lesion vascularity and enhancement kinetics after contrast administration, thereby supporting differentiation of benign and malignant lesions.⁶ Its high sensitivity has led to increasing use as an adjunct when conventional imaging is inconclusive or when further lesion characterization is required.^{7,8} Morphological characteristics and enhancement patterns on breast MRI can contribute to diagnostic discrimination.^{9,10,11} Features such as irregular margins, heterogeneous or rim enhancement, and rapid contrast

uptake may raise suspicion for malignancy. Standardized reporting through the Breast Imaging Reporting and Data System (BI-RADS) has further improved consistency in breast MRI interpretation. Histopathological examination remains the reference standard for definitive diagnosis. Accordingly, evaluating DCE-MRI against histopathology is essential for determining its clinical utility. The present study aimed to determine the diagnostic accuracy of DCE-MRI for differentiating benign and malignant breast lesions using histopathology as the gold standard.

METHODOLOGY

This cross-sectional diagnostic-accuracy study was conducted in the Department of Radiology in collaboration with the Departments of Surgery and Pathology at DHQ Hospital, Gujranwala, Pakistan, from November 2023 to April 2024. Approval and research permission were obtained from the Research Evaluation Unit (REU), College of Physicians and Surgeons Pakistan (CPSP), under Reference No. CPSP/REU/RAD-2019-093-2889 dated 5 November 2021. Written informed consent was obtained from all

participants, and patient confidentiality was maintained throughout the study. A total of 96 patients with breast lesions were enrolled using non-probability consecutive sampling. Eligible participants were patients of either sex with clinically suspected breast lesions referred for DCE-MRI and subsequently undergoing histopathological examination by biopsy or surgical excision. Patients with contraindications to MRI, including metallic implants, pacemakers, or severe claustrophobia, were excluded. Patients with prior breast surgery, chemotherapy, or radiotherapy, as well as those with incomplete imaging or histopathological records, were also excluded. Data were recorded on a structured proforma, including age, marital status, family history of breast cancer, presenting symptoms, side and location of the lesion, and lesion size. All participants underwent DCE-MRI before histopathological assessment. MRI variables included lesion margins, enhancement pattern, BI-RADS category, and overall MRI diagnosis (benign or malignant). Histopathology was considered the reference standard. MRI examinations were interpreted by qualified radiologists according to standardized BI-RADS criteria. Histopathological assessment was performed by qualified pathologists who were reported to be unaware of the MRI diagnosis, thereby reducing observer bias. Data were analyzed using IBM SPSS Statistics version 26. Quantitative variables are presented as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. The association between MRI diagnosis and histopathology was assessed using the chi-square test, and Cramer's V was calculated as an effect-size measure. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 96 patients with breast lesions were included. The mean age was 45.52 ± 12.73 years (range 22–65 years); 38.5% were older than 50 years. Most participants were married (75.0%), and 18.8% had a family history of breast cancer. A palpable breast lump was the most common presenting symptom (41.7%). Right-sided lesions accounted for 59.4%, and lesions measuring 2–5 cm were the largest size category (37.5%).

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 96)

Variable	Category	n (%age)
Age (years)	Mean $\pm$ SD	45.52 $\pm$ 12.73
	Range	22 – 65
Age group	≤ 30 years	17 (17.7)
	31–40 years	15 (15.6)
	41–50 years	27 (28.1)
	> 50 years	37 (38.5)
Marital status	Married	72 (75.0)
	Unmarried	24 (25.0)
Family history of breast cancer	Yes	18 (18.8)
	No	78 (81.3)
Presenting symptom	Breast lump	40 (41.7)
	Breast pain	29 (30.2)
	Nipple discharge	27 (28.1)
Breast side	Right	57 (59.4)
	Left	39 (40.6)
Lesion location	Lower inner quadrant	26 (27.1)
	Lower outer quadrant	21 (21.9)
	Upper inner quadrant	26 (27.1)
	Upper outer quadrant	23 (24.0)
Lesion size	< 2 cm	31 (32.3)
	2–5 cm	36 (37.5)
	> 5 cm	29 (30.2)

Irregular margins were the most frequent MRI margin pattern (38.5%), followed by smooth (36.5%) and spiculated margins (25.0%). Rim enhancement was observed in 37.5% of lesions and heterogeneous enhancement in 34.4%. BI-RADS categories 3, 4, and 5 accounted for 34.4%, 33.3%, and 32.3% of lesions, respectively. MRI classified 56/96 (58.3%) lesions as malignant.

Table 2: Dynamic Contrast-Enhanced MRI Findings (n = 96)

Variable	Category	n (%age)
MRI margin	Smooth	35 (36.5)
	Irregular	37 (38.5)
	Spiculated	24 (25.0)
Enhancement pattern	Homogeneous	27 (28.1)
	Heterogeneous	33 (34.4)
	Rim enhancement	36 (37.5)
BI-RADS category	03	33 (34.4)
	04	32 (33.3)
	05	31 (32.3)
MRI diagnosis	Benign	40 (41.7)
	Malignant	56 (58.3)

Histopathology classified 54/96 (56.3%) lesions as malignant and 42/96 (43.8%) as benign.

Table 3: Histopathological Diagnosis of Breast Lesions (n = 96)

Histopathological Diagnosis	n (%age)
Benign	42 (43.8)
Malignant	54 (56.3)
Total	96 (100)

MRI diagnosis was strongly associated with histopathological diagnosis ($\chi^2 = 53.33$, $p < 0.001$; Cramer's V = 0.745). DCE-MRI correctly identified 49 of 54 malignant lesions and 35 of 42 benign lesions.

Table 4: Comparison of DCE-MRI Diagnosis with Histopathology (n = 96)

MRI Result	Histopathology Benign n (%)	Histopathology Malignant n (%)	Total	χ^2	p-value	Cramer's V
Benign	35 (36.5)	5 (5.2)	40	53.3	<0.001	0.745
Malignant	7 (7.3)	49 (51.0)	56			
Total	42 (43.8)	54 (56.3)	96			

Using histopathology as the reference standard, DCE-MRI achieved a sensitivity of 90.7%, specificity of 83.3%, PPV of 87.5%, NPV of 87.5%, and overall diagnostic accuracy of 87.5%.

Table 5: Diagnostic Accuracy of Dynamic Contrast-Enhanced MRI

Parameter	value
Sensitivity	90.7%
Specificity	83.3%
Positive Predictive Value (PPV)	87.5%
Negative Predictive Value (NPV)	87.5%
Overall Diagnostic Accuracy	87.5%

DISCUSSION

The present study evaluated the diagnostic accuracy of dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) in differentiating benign and malignant breast lesions using histopathology as the gold standard. The findings demonstrated that dynamic MRI has high diagnostic performance, with sensitivity of 90.7%, specificity of 83.3%, and overall diagnostic accuracy of 87.5%. These results indicate that dynamic MRI is a reliable imaging modality for evaluating breast lesions and support its increasing role in breast imaging practice. In the current research, the average age of the participants was 45.52 ± 12.73 years, with most of the patients aged over 50 years. The incidence of breast cancer is age-dependent, and the same demographic patterns were evident in other imaging studies conducted on the assessment of breast lesions. Advanced imaging modalities are thus necessary to detect the problem early so as to enhance patient outcomes. The clinical presentation observed during this research was that a palpable lump in the breast was the most prevalent symptom of patients with lesions in the breast. This fact confirms the earlier studies that

show breast lumps as the commonest primary clinical presentation of breast malignancy, which may necessitate further diagnostic radiology and histopathological studies. In the present study, dynamic MRI revealed that anomalous margins and rim enlargement occurred commonly with suspicious lesions. These are the imaging features that have been extensively reported to be normal MRI features of malignant breast lesions. It has been shown that morphological features like irregularity of the margin and contrast enhancement patterns have a significant role to play in the differentiation between malignant and benign lesions on MRI. Time-intensity curves and enhancement patterns made available by imaging based on DCE-MRI have proven to give useful diagnostic information distinguishing between malignant and benign breast lesions.¹² In the current research, histopathology analysis established that 56.3 percent of lesions were malignant. This observation shows that precise imaging modalities are significant in the detection of suspicious lesions that need biopsy or surgical intervention. Histopathology has been the gold standard to validate the diagnosis of breast cancer, although imaging methods (e.g. MRI) aid in making clinical decisions and minimizing unnecessary invasive procedures. The diagnostic performance of the current study is similar to that published in several recent systematic reviews and meta-analyses. A meta-analysis assessing the diagnostic validity of DCE-MRI showed a pooled sensitivity of about 80% and specificity of about 84% in the detection of malignant breast lesions, and this implies good diagnostic capability.¹³ Likewise, the results of a recent study assessing the categorization of benign and malignant breast lesions stated that MRI exhibits a sensitivity rate of approximately 90-92% and a specificity value of about 72-75% in the diagnostic power of MRI in breast imaging.¹⁴ The results are similar to the current study, where sensitivity was over 90%. Another systematic review of studies comparing contrast-enhanced mammography versus breast MRI showed that a pooled MRI sensitivity of around 97% was found with equal levels of specificity, again indicating the high diagnostic potential of MRI in breast cancer.¹⁵ There is also evidence of advanced MRI techniques to enhance the accuracy of diagnosis. The diffusion-weighted imaging (DWI) and multiparametric MRI methods have also yielded encouraging outcomes in the distinction of benign and malignant lesions of the breast. A more recent meta-analysis had sensitivity pooled at 92% and specificity at 88% in cases of diffusion-weighted MRI in the evaluation of breast lesions.¹⁶ The recent advances in ultrafast dynamic MRI have also enhanced characterization of lesions. Researchers have proven that ultrafast dynamic contrast-enhanced MRI is able to effectively distinguish

between benign and malignant breast lesions with less scanning time.¹⁷ Moreover, recent studies have demonstrated that dynamic contrast-enhanced MRI plus diffusion-weighted imaging is the most diagnostic of all MRI procedures, with better specificity and fewer false-positive results.^{18,19,20} The statistically significant association observed in this study between MRI findings and histopathological diagnosis ($\chi^2 = 53.33$, $p < 0.001$) further confirms the strong relationship between MRI imaging characteristics and final pathological outcomes. The calculated Cramer's V value of 0.745 indicates a strong effect size and highlights the reliability of MRI as a diagnostic tool for breast lesion evaluation. The negative predictive value and the positive predictive value in this study were both 87.5%, and this means that MRI is effective in detecting malignant lesions as well as in ruling out benign lesions. This diagnostic ability is especially required in the clinical environment where early and precise diagnosis of breast cancer has a major impact on treatment. Overall, the results of the current study are in line with the increasing literature that has shown that dynamic contrast-enhanced MRI is among the most sensitive imaging techniques in the detection of breast cancer and differentiation of malignant versus benign tumors. MRI can give morphological and functional data of the breast tissue, and this can enhance characterization of lesions and aid in making clinical decisions.

LIMITATIONS

This was a single-center study with a modest sample size, which may limit generalizability. Diagnostic performance may also vary across scanners, imaging protocols, reader experience, and patient populations. Larger multicenter studies using standardized DCE-MRI protocols are recommended.

CONCLUSIONS

Dynamic contrast-enhanced MRI demonstrated high sensitivity, good specificity, and strong overall diagnostic accuracy for differentiating benign and malignant breast lesions when compared with histopathology. DCE-MRI may therefore serve as a valuable adjunct in the evaluation of suspicious breast lesions, particularly when conventional imaging is inconclusive.

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Areeba Rashid - Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision; Supervision; Final Approval

The authors accept responsibility for all aspects of the work and will ensure that any concerns regarding the accuracy or integrity of any part are properly investigated and resolved.



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