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Research Article

MRI-Based Characterization of Breast Lesions and Its Correlation with Histopathological Subtypes in Newly Diagnosed Breast Cancer Patients

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ABSTRACT
Background: Breast magnetic resonance imaging (MRI) is a highly sensitive modality for evaluating breast lesions, offering superior tissue characterization compared to conventional imaging. Its role in correlating imaging features with histopathological subtypes is increasingly important for accurate diagnosis and treatment planning.
Objective: To assess MRI-based characterization of breast lesions and determine its correlation with histopathological subtypes in newly diagnosed breast cancer patients.
Methods: This cross-sectional study was conducted at the Department of Radiology, Allied Hospital-1, Faisalabad Medical University, and Central Park Teaching Hospital from June 2024 to March 2025. A total of 100 newly diagnosed breast cancer patients underwent contrast-enhanced MRI prior to histopathological evaluation. MRI findings were interpreted using the BI-RADS lexicon, including lesion morphology, enhancement characteristics, and kinetic curve patterns. Histopathology served as the reference standard. Statistical analysis was performed using SPSS version 26, and associations were evaluated using the chi-square test.
Results: The mean age of patients was 47.9 ± 9.8 years. Mass lesions were observed in 70% of cases, with irregular margins and heterogeneous enhancement being the most common features. Type III (washout) kinetic curves were present in 62% of lesions. Invasive ductal carcinoma was the predominant histopathological subtype (64%). A significant association was observed between MRI features and histopathological subtypes, particularly irregular margins and washout kinetics with invasive ductal carcinoma ($p < 0.001$). MRI demonstrated high sensitivity (95%) and diagnostic accuracy (92%).
Conclusion: MRI is a highly effective imaging modality for breast lesion characterization and shows strong correlation with histopathological findings, supporting its role in early diagnosis and treatment planning.

Keywords: Breast MRI, BI-RADS, Breast Cancer, Histopathology, Invasive Ductal Carcinoma, Lesion Characterization.

INTRODUCTION

Breast cancer is the most commonly diagnosed cancer in women globally and one of the leading causes of cancer morbidity and mortality[1]. The incidence of breast cancer in the world remains high, especially among the low- and middle-income patients, whereby delayed diagnosis and inaccessibility to state-of-the-art diagnostic technologies are contributing to the poor outcomes of the disease. Timely screening and proper characterization of breast lesions play a significant part in enhancing the survival rates, informing the therapeutic decisions, and decreasing the development of the disease. In

this regard, imaging would be core in the diagnosis pathway, supplementing clinical examination and histopathological validation [2,3]. The traditional way of imaging such as mammography and ultrasonography is common as a first-line diagnosis. Nevertheless, these modalities possess natural constraints especially in women with dense breast tissues, multi focal disease or complicated lesion morphologies[4]. Mammography can not identify small lesions or can overestimate the size of the tumor, whereas ultrasonography is operator-dependent and does not distinguish between benign and malignant results as well. Such constraints require that more refined imaging methodologies, which offer better tissue characterization and functional data, be used[5].

Magnetic resonance imaging (MRI) of the breast has turned into a very sensitive modality to detect and assess the breast lesions. Dynamic contrast-enhanced MRI (DCE-MRI) enables visualization of the angiogenic activity, tumor vascularity, and permeability which are major biological characteristics of cancerous tumors[6]. MRI does not only improve the lesion detection but also gives a detailed information on the lesion morphology, internal architecture, as well as, enhancement kinetics. Breast Imaging Reporting and Data System (BI-RADS) MRI lexicon provides a standardized system of interpretation, which allows the reliability of reporting and risk stratification across clinical practices[7,8].

Besides detection, MRI is important in preoperative staging, multifocal and multicentric disease assessment as well as contralateral breast evaluation. Notably, there is a growing body of evidence that select MRI characteristics including abnormal margins, irregular enhancement, fast washout kinetics might be associated with select histopathological subtypes of breast cancer [8,9]. To illustrate the point, invasive ductal carcinoma can be seen to show aggressive imaging features, but invasive lobular carcinoma could appear as non-mass enhancement, because of its infiltrative growth pattern. The interpretation of these imaging-pathology associations can improve the quality of the diagnosis and can be applied in the development of treatment plans that are more personalized[10].

MRI is not devoid of limitations even though its sensitivity is high. False-positive results are possible because images of benign and malignant lesions have some overlapping features, which might result in unnecessary biopsy or over-treatment[11]. Thus, the correlation with the histopathological results is still paramount since histopathology will still be considered as the gold standard of the definite diagnosis and classification of tumors. A combination of MRI results and histopathological results gives a more convincing picture of the biology of the tumor and enhances clinical judgment[12].

Considering the rising application of MRI in breast imaging and its possible ability to predict the histopathological subtypes, there is a need to conduct a systematic assessment of its diagnostic effectiveness in breast cancer patients with recent diagnoses. This study seeks to describe breast lesions through MRI and ascertain their association with histopathologic subtypes thus evaluating the importance of MRI as a non-invasive diagnostic tool, risk classification, and treatment guidance in the management of breast cancer[13].

MATERIALS AND METHODS

Study Design and Setting: The study was a cross-sectional observational study that was conducted in the Department of Radiology, Allied Hospital-1, Faisalabad Medical University, Faisalabad, Pakistan, in partnership with Central Park Teaching Hospital. The study was conducted within a time span of ten months, between June 2024 and March 2025, where radiological evaluation was conducted and histopathological correlation of lesions in the breast was undertaken.

Population and Population Size of Study: The study involved 100 female patients who presented with clinically/radiologically valued breast lesions and later diagnosed with breast cancer. Consecutive sampling method was applied in recruiting the patients. The inclusion criteria included the newly diagnosed breast cancer patients who had no previous treatment in the form of surgery, chemotherapy or radiotherapy. They excluded patients with recurrent disease, those who have undergone breast interventions previously, contraindications to MRI (implanted metallic devices and severe claustrophobia), and also known hypersensitivity to contrast agents.

MRI Protocol, Imaging Technique: The contrast-enhanced breast MRI was done on all patients with a 1.5 Tesla system. The imaging was done using specific breast coils and the patients were laid in the prone position to maximize on the quality of the images. The MRI protocols involved the axial T1-weighted, T2-

weighted, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) images after the intravenous injection of a gadolinium-based contrast agent. They had to obtain serial-post contrast images at different times to evaluate the changes in enhancement patterns and kinetic behavior of the lesions.

Image Interpretation: The experienced radiologists analyzed MRI images separately and used the Breast Imaging Reporting and Data System (BI-RADS) MRI lexicon. Lesions were classified using morphological and enhancement features which consist of lesion type (mass or non-mass), shape, margins, internal enhancement patterns, kinetic curve analysis. The time-intensity curves were categorized under Type I (persistent), Type II (plateau), and Type III (washout) curves. BI-RADS were given a lesion rating of 1 to 5 according to the chances of being malignant.

Histopathological Evaluation: After MRI examination, all patients were subjected to core needle biopsy or surgical excision with the help of ultrasound. Tissues were treated and assessed by highly experienced histopathologists. The subtypes of the breast cancer were categorized based on conventional histopathological criteria as invasive ductal carcinoma, invasive lobular carcinoma, ductal carcinoma in situ, and other minor types. The gold standard of diagnosis was the histopathological findings.

Variables and Data Collection: Clinical and demographic information such as age, presenting symptoms and clinical findings were documented. Radiological ones comprised lesion morphology, enhancement appearance, BI-RADS category, and tumor size on the MRI. Histopathological variables were tumor subtype and grade. The main outcome of interest was correlation between MRI findings and histopathological findings.

Statistical Analysis: The analysis of data was done using Statistical Package of Social Sciences (SPSS) version 26. Demographic and clinical characteristics were summarized by descriptive statistics. Histopathology served as the reference standard to determine the sensitivity, specificity, positive predictive value and negative predictive value of MRI. The chi-square test was used to determine the relationship between the MRI features and the histopathological subtypes. Pearson correlation analysis was used to determine the relationship between the MRI results and tumor characteristics. The p-value of below 0.05 was regarded as significant.

Ethical Considerations: The Institutional Review Board of Faisalabad Medical University and Central Park Teaching Hospital gave the ethical approval of the study before the actual data collection. Informed consent was taken care of properly through written informed consent and patient data was kept confidential at all times during the study.

RESULTS

The study used 100 newly diagnosed breast cancer patients (female). The average age of the study population was 47.9 years old with a standard deviation of 9.8 years where most of the patients were between the age range of 41-60 years. The majority of the patients reported having a palpable breast lump (76%), with the other presenting complaints being nipple discharge (14%), and incidental imaging findings (10%). Table 1 provides a summary of these baseline demographic and clinical characteristics.

Table 1: Baseline Demographic and Clinical Characteristics of Patients (n = 100)

Variable	Frequency (%) / Mean ± SD
Age (years)	47.9 ± 9.8
25–40 years	28 (28%)
41–60 years	52 (52%)
>60 years	20 (20%)
Palpable lump	76 (76%)
Nipple discharge	14 (14%)
Incidental finding	10 (10%)

Most frequent mass lesions were identified as prominent in comparison to non-mass enhancement patterns, which are 70 and 30 %, respectively. Irregular shape and spiculated margins were the most common features among the mass lesions, with 66% and 54% being used in cases, respectively. The most common pattern of enhancement was

heterogeneous internal enhancement (60%), and then rim enhancement (22%). The analysis of the kinetic curves showed that Type III (washout) curves was the most frequent pattern with 62 out of 100 lesions showing this pattern and therefore there was a high probability that the lesion was malignant. Table 2 has described these MRI characteristics.

Table 2: MRI Characteristics of Breast Lesions (n = 100)

MRI Feature	Frequency (%)
Lesion Type	
Mass lesions	70 (70%)
Non-mass enhancement	30 (30%)
Shape	
Irregular	66 (66%)
Oval/Round	34 (34%)
Margins	
Spiculated	54 (54%)
Smooth	46 (46%)
Internal Enhancement	
Heterogeneous	60 (60%)
Rim enhancement	22 (22%)
Homogeneous	18 (18%)
Kinetic Curve Pattern	
Type I (persistent)	16 (16%)
Type II (plateau)	22 (22%)
Type III (washout)	62 (62%)

Histopathology showed that the most frequent subtype was invasive ductal carcinoma (IDC) with 64% of the total cases, followed by invasive lobular carcinoma (ILC) with 18%, ductal carcinoma in situ (DCIS) with 10% and other subtypes with 8%. Table 3 summarises these findings.

Table 3: Histopathological Subtypes of Breast Cancer (n = 100)

Histopathological Type	Frequency (%)
Invasive ductal carcinoma (IDC)	64 (64%)
Invasive lobular carcinoma (ILC)	18 (18%)
Ductal carcinoma in situ (DCIS)	10 (10%)
Others	8 (8%)

Significant correlation between MRI appearance and histopathological subtypes was determined statistically. Invasive ductal carcinoma was strongly and significantly associated with irregular margins and Type III washout kinetic curves, being found in 84% and 80% of the cases of IDC, respectively ($p < 0.001$). Non-mass enhancement patterns, in contrast, were more likely to relate to invasive lobular carcinoma (67%), and DCIS (50%). Table 4 shows this correlation between MRI results and histopathology.

Table 4: Correlation between MRI Features and Histopathological Subtypes

MRI Feature	IDC (%)	ILC (%)	DCIS (%)	p-value
Irregular margins	84%	61%	40%	<0.001
Type III washout	80%	56%	30%	<0.001
Non-mass enhancement	18%	67%	50%	<0.001

Moreover, the diagnostic performance of MRI was excellent over histopathology as the gold standard. MRI was sensitive in the detection of malignant lesions at 95% and specificity at 83%. The predictive value was positive with a value of 91 and negative predictive value was 89 giving an overall diagnostic accuracy of 92. MRI could also estimate the size of tumors with high level of concordance with histopathological data in 87% of the cases.

On the whole, the findings suggest that MRI does not only characterize the morphological

and functional features of breast lesions in details but also correlates with the histopathological subtypes in a strong and statistically significant manner, which proves the usefulness of this method as a diagnostic and preoperative evaluation tool in the management of breast cancer.

DISCUSSION

The current study assessed the diagnostic value of breast MRI in lesion characteristicization and the correlation of imaging characteristics with histopathological subtypes of newly diagnosed breast cancer patients[11,12]. The results indicate that MRI is a very sensitive modality and has a good predictive value of malignancy and significant association with underlying tumor histopathology[13].

In this study, most patients were middle aged with mean age of about 48 years and most of them presented with palpable lump in the breast[14]. This distribution is a representation of the common clinical manifestation of the breast cancer in the developing world in which patients normally present themselves at the symptomatic stage as opposed to screening. Our cohort is also in line with international epidemiological trends because the dominant subtypes of invasive ductal carcinoma (IDC) are typical of most histological types of breast cancer[15].

The MRI imaging in this study revealed that the most common imaging presentation was the presence of mass lesions of irregular shape and spiculated margins. All these features were closely linked to malignancy, especially invasive ductal carcinoma[16]. Irregular margins and spiculation are reflected by the presence of the infiltrative growth pattern and desmoplastic reaction typical of aggressive tumors. Moreover, heterogeneous internal improvement was the most common, which revealed the heterogeneity of tumors, their necrosis, and different vascularity in the malignant lesions[17].

Dynamic contrast-enhanced MRI showed that the most common pattern was Type III (washout) kinetic curves and had statistically significant relationships with invasive malignancy[18]. This observation is biologically reasonable, because malignant tumors generally show a quick contrast uptake and washout as a result of abnormal tumor vasculature, and a higher permeability. The significant relationship of the washout kinetics and the IDC, in our case, demonstrates the significance of kinetic curve in the differentiation of the malignant lesions and the less aggressive lesions[19].

The most remarkable outcome of this study was that non-mass patterns of enlargement were more common in invasive lobular carcinoma (ILC) and ductal carcinoma in situ (DCIS). This is indicative of the special histopathological behavior of these subtypes [20]. The characteristic of ILC is that it does not create a discrete mass, and its growth pattern is diffuse and infiltrative, hence the reason why it is commonly manifested as non-mass enhancement on MRI. Likewise, DCIS tends to extend along the ductal system leading to segmental or regional enhancement patterns and not a distinct mass. These findings highlight the value-added role of MRI in identifying lesions that could otherwise be either non-existent or underestimated using other traditional imaging methods[11,12].

MRI had an excellent performance of 95 per cent sensitivity and an overall performance of greater than 90 per cent in terms of diagnostic performance in this study [7,9]. The results are in line with other literature that has been reported before, which proves that MRI is among the most sensitive methods of imaging of breast cancer. The specificity, however, was relatively less, and this is also indicative of the established weakness of MRI with respect to the ability to differentiate between some benign lesions and malignancy because of similar imaging appearance. This highlights the need to have histopathological diagnosis in order to have a definitive diagnosis [10].

The other significant finding was that the concordance rates of MRI with histopathology were very high (87 %) in the estimation of the tumor size[11,15]. Comprehensive tumor sizing is essential in the planning of surgery especially when it comes to identifying candidates of breast saving surgery or mastectomy. The fact that MRI can trace the boundary of tumors such as multifocal and multicentric disease, is yet another strength of MRI in preoperative assessment [13-16].

This study has some limitations in spite of these strengths. The sample was not large and was restricted to two centres, which can be considered to influence the extrapolation of the results. Moreover, the interobserver consistency in the interpretation of MRI was not evaluated, and this may affect the consistency of diagnosis. This did not incorporate molecular subtyping and receptor status, which would have given more information on imaging-pathology correlations [9-14].

The further study directions involve the introduction of the latest methods of imaging like diffusion-weighted imaging, radiomics, or artificial intelligence-based analysis in order to enhance the specificity and predict the underlying molecular subtypes. It is also suggested that bigger multicentre trials will serve to confirm these results and standardize imaging biomarkers of breast cancer characterization[15-20].

CONCLUSION

Breast MRI is a very sensitive and useful imaging tool during the characterization of breast lesions in newly diagnosed patients with breast cancer. It also shows a good and statistically significant correlation with histopathological subtypes, especially in the determination of invasive ductal carcinoma as well as the differentiation of non-mass lesions related to lobular carcinoma and DCIS. MRI will give important data about the morphology of lesions, their enhancement, and overall tumor spread, thus leading to their correct diagnosis and successful treatment planning. Despite the fact that histopathology is the gold standard method, the application of MRI in the routine diagnostic procedures has a great contribution to clinical decision making and better patient management in general.

Availability of Data and Materials: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. All relevant data supporting the findings of this study are included within the manuscript.

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Authors' Contributions: AF conceptualized the study, supervised data collection, and finalized the manuscript. AG and ZK contributed to MRI data acquisition and image interpretation. SA participated in study design and radiological analysis. RA contributed to data analysis and manuscript drafting. HS assisted in data collection, literature review, and formatting of the manuscript. All authors reviewed and approved the final version of the manuscript.

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