ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 11 | November - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ROLE OF DIFFUSION WEIGHTED MRI IN THE IMAGING OF BENIGN AND MALIGNANT BREAST LESIONS : A HOSPITAL BASED, CROSS-SECTIONAL STUDY IN A TERTIARY CARE HOSPITAL IN CENTRAL INDIA

Radiology

Dr. Vidhina Khade* Junior Resident, *Corresponding Author
Dr. Mayur Patel Junior Resident,
Dr. Niveditha R. Nairy Junior Resident,
Dr. Aarti Anand Prof. and Head of the Department,

ABSTRACT

Breast cancer remains a leading cause of morbidity and mortality among women worldwide, underscoring the need for accurate and non-invasive diagnostic tools. While mammography and ultrasound are first-line modalities, magnetic resonance imaging (MRI) has assumed a pivotal role, particularly with the addition of diffusion-weighted imaging (DWI). This hospital-based cross-sectional study evaluated the diagnostic utility of DWI and apparent diffusion coefficient (ADC) values in differentiating benign and malignant breast lesions. A total of 53 patients undergoing breast MRI were reviewed over 24 months, of whom 45 were included based on strict criteria. All underwent conventional MRI and DWI at b-values of 0, 500, and 1000 s/mm², with findings correlated against histopathology. Of the 45 lesions, 21 were malignant and 24 benign. Malignant lesions consistently showed diffusion restriction and lower ADC values, with significant differences from benign lesions at both b-values. ROC analysis demonstrated superior diagnostic performance at b=1000 (AUC 0.948). Cohen's Kappa showed substantial agreement at b=500 (κ=0.73) and near-perfect agreement at b=1000 (κ=0.91). Discordant cases highlighted the value of higher b-values in reducing false positives. These results support the inclusion of DWI and ADC mapping, particularly at b=1000, in breast MRI protocols to enhance specificity, reduce unnecessary biopsies, and guide clinical decision-making.

KEYWORDS

Breast MRI, Diffusion-weighted Imaging, Apparent Diffusion Coefficient, Breast Cancer Diagnosis, Lesion Characterization

INTRODUCTION

Breast cancer is the most frequently diagnosed cancer among women and remains a leading cause of cancer-related mortality worldwide [1]. In India, its incidence has been steadily increasing, with urban registries reporting it as the most common malignancy among women [2]. Early and accurate diagnosis is therefore vital for improving outcomes, yet delayed presentation and diagnostic challenges continue to compromise survival [3].

Mammography and ultrasonography remain the standard frontline imaging modalities. While widely available, both techniques have limitations, particularly in women with dense breasts and in differentiating benign from malignant lesions [4,5]. Magnetic resonance imaging (MRI) has emerged as a powerful adjunct, with high sensitivity in the detection and staging of breast cancer [6]. However, the need for contrast administration, high cost, and limited specificity have constrained its universal application [7].

Diffusion-weighted imaging (DWI), a functional MRI sequence, provides information on the mobility of water molecules within tissues. Malignant lesions typically exhibit restricted diffusion due to increased cellular density and reduced extracellular space, resulting in lower apparent diffusion coefficient (ADC) values compared to benign lesions [8,9]. Multiple studies have confirmed the utility of DWI and ADC mapping in enhancing diagnostic accuracy, improving lesion characterization, and potentially reducing unnecessary biopsies [10,11].

In this context, the present study was undertaken to evaluate the diagnostic performance of DWI and ADC values in differentiating benign and malignant breast lesions in patients undergoing breast MRI at a tertiary care center. By focusing on reproducible imaging biomarkers, the study aims to contribute locally relevant evidence toward improving breast cancer diagnosis.

MATERIALS AND METHODS

This hospital-based, cross-sectional observational study was conducted in the Department of Radiodiagnosis at a tertiary care government hospital in Central India over a period of 24 months (June 2023–May 2025). Patients presenting with breast lumps to surgical, medical, or gynecological outpatient departments and referred for breast MRI were considered for inclusion. A purposive sampling technique was employed. Ethical clearance was obtained from the Institutional Ethics Committee, and informed written consent was taken from all participants prior to enrolment.

Inclusion Criteria Were: (i) patients ≥18 years of age with breast lesions detected on clinical examination, mammography, or ultrasonography; (ii) those undergoing breast MRI with diffusion-weighted imaging as part of their diagnostic work-up; and (iii) histopathologically confirmed benign or malignant diagnosis obtained via biopsy or surgery. Lesions were required to be ≥5 mm, clearly visualized on DWI/ADC maps, and enhancing on contrast MRI to allow region-of-interest (ROI) placement.

Exclusion Criteria included contraindications to MRI, refusal or inability to undergo biopsy, incomplete or poor-quality imaging, lesions not visible on MRI, and pregnant or lactating women.

MRI was performed on a Siemens 3T Magnetom Vida scanner using a dedicated 18-channel breast coil, with patients positioned prone. Protocol included T1- and T2-weighted sequences, STIR, dynamic contrast-enhanced imaging, and diffusion-weighted sequences with b-values of 0, 500, and 1000 s/mm². ADC maps were generated using mono-exponential model fitting. Two circular ROIs (50 ±10 mm²) were manually placed within the solid enhancing portion of each lesion, avoiding necrotic or hemorrhagic areas. Mean ADC values were recorded.

All scans were reviewed on SyngoVia software (HP Z8 G4 workstation) by the principal investigator, blinded to histopathology. Lesions were assessed for morphology, signal intensity, diffusion characteristics, kinetic curve types, and background parenchymal enhancement. Observations were documented in a structured case record form. Final imaging impressions were correlated with histopathology, and lesions were categorized as true or false positives/negatives.

Statistical analysis was performed using SPSS version 18.0 (IBM, Armonk, NY) and OpenEpi version 3.01. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated. ROC curves were generated to evaluate diagnostic thresholds, and Cohen's Kappa statistics were used to assess agreement between qualitative DWI interpretation and quantitative ADC values.

RESULTS

Out of 53 patients evaluated, 45 met the inclusion criteria for final analysis, while eight were excluded due to refusal of biopsy, loss to follow-up, or inadequate image quality. The study population included 44 females (97.8%) and one male-to-female transgender patient

(2.2%), with ages ranging from 18 to 70 years (mean age 47.6 years). The majority of lesions occurred in women between 40 and 59 years, and malignant tumors were more frequent in postmenopausal patients.

Histopathology revealed 21 malignant and 24 benign lesions. Infiltrating ductal carcinoma was the predominant malignancy, whereas fibroadenomas and benign ductal changes accounted for most benign diagnoses. Malignant lesions were more often associated with dense breast parenchyma, while benign lesions occurred in relatively fatty breasts.

On diffusion-weighted imaging, 62.2% of lesions showed restricted diffusion at b=500 and 48.9% at b=1000. Malignant lesions consistently demonstrated restricted diffusion with lower ADC values than benign lesions. At b=500, mean ADC values were $1.111 \pm 0.088 \times 10^{-3}$ mm²/s for malignant and $1.407 \pm 0.142 \times 10^{-3}$ mm²/s for benign lesions ($p<0.00001$). At b=1000, the mean ADC further separated the two groups ($1.016 \pm 0.142 \times 10^{-3}$ mm²/s vs. $1.378 \pm 0.144 \times 10^{-3}$ mm²/s, $p<0.00001$).

Receiver operating characteristic (ROC) analysis confirmed the discriminative ability of ADC values, with an AUC of 0.943 at b=500 and 0.929 at b=1000. An ADC threshold of 1.24×10^{-3} mm²/s yielded the best trade-off between sensitivity and specificity. Agreement between qualitative DWI assessment and quantitative ADC values was substantial at b=500 ($\kappa=0.73$) and almost perfect at b=1000 ($\kappa=0.91$).

Discordant findings included fat necrosis and intraductal papilloma, which produced false-positive restriction, and one case of ductal carcinoma in situ, which was missed on qualitative DWI. These outliers illustrate the limitations of DWI alone and highlight the importance of using higher b-values and quantitative ADC analysis to reduce artifacts and improve diagnostic accuracy.

SUMMARY AND CONCLUSION

This prospective study analyzed 45 breast lesions in 45 patients over two years, correlating MRI findings with histopathology. The study cohort was predominantly female (97.8%), with a single transgender patient included. Most patients were in the 40–59 year age group, and malignant lesions were more frequent in postmenopausal women and those with dense breasts, echoing earlier observations linking breast density and age with cancer risk [12].

Histopathology confirmed 21 malignant and 24 benign lesions. Infiltrating ductal carcinoma was the most common malignancy, while fibroadenomas and benign ductal changes predominated among benign cases. Morphologically, irregular margins, heterogeneity, and type III kinetic curves strongly correlated with malignancy, consistent with prior reports [13,14].

Diffusion-weighted imaging (DWI) revealed restricted diffusion in most malignant lesions, while benign lesions generally lacked restriction. Quantitatively, malignant lesions showed significantly lower ADC values compared with benign ones at both b=500 and b=1000 s/mm². At b=500, the mean ADC was $1.111 \pm 0.088 \times 10^{-3}$ mm²/s for malignant and $1.407 \pm 0.142 \times 10^{-3}$ mm²/s for benign lesions; at b=1000, mean ADCs were $1.016 \pm 0.142 \times 10^{-3}$ mm²/s and $1.378 \pm 0.144 \times 10^{-3}$ mm²/s, respectively ($p<0.00001$). These results align with Guo et al. [29], Woodhams et al. [27], Pereira et al. [31], and others, who similarly demonstrated lower ADC values in malignancy [15–17].

ROC analysis confirmed excellent diagnostic performance, with AUCs of 0.943 at b=500 and 0.929 at b=1000. An ADC cutoff of 1.24×10^{-3} mm²/s provided the optimal sensitivity-specificity balance, comparable to cutoffs identified by Guo et al. and Woodhams et al. [29,27]. Agreement between qualitative DWI and quantitative ADC was substantial at b=500 ($\kappa=0.73$) and almost perfect at b=1000 ($\kappa=0.91$), supporting the use of higher b-values for reliable classification [18].

Discordant cases were clinically instructive: fat necrosis and papilloma mimicked malignancy with false-positive restriction, while DCIS and papillary carcinoma with necrosis produced false negatives. These patterns mirror limitations documented in earlier studies [19,20].

In conclusion, DWI with ADC mapping, particularly at b=1000, significantly improves lesion characterization in breast MRI. By enhancing specificity and reducing false positives, it can limit unnecessary biopsies and provide a rapid, contrast-free adjunct to multiparametric imaging. Larger multicentric studies, ideally incorporating receptor profiling, are warranted to standardize ADC thresholds and consolidate the role of DWI in routine clinical practice.

Case 1

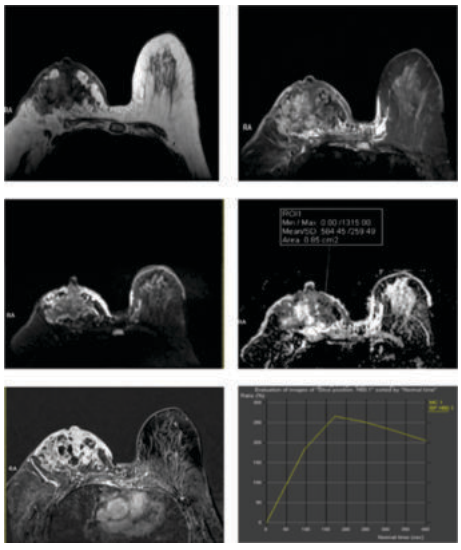

Figure 1: An ill-defined, lobulated T2 hypointense, STIR hyperintense lesion is seen in involving most of the right breast parenchyma, involving the nipple-areola complex, reaching up to the cutaneous surface causing reactive thickening of the skin. The lesion shows diffusion restriction with corresponding ADC hypointensity (mean ADC – 0.58 x 10 -3 mm2/s), with heterogeneous post-contrast enhancement. No chest wall/ pectoralis muscle invasion.

The lesion shows Type III kinetic curve on dynamic contrast enhanced MRI. (washout).

Histopathology revealed Invasive ductal carcinoma.

Case 2

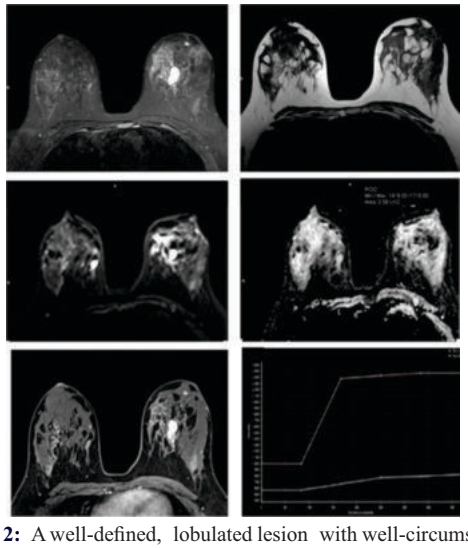

Figure 2: A well-defined, lobulated lesion with well-circumscribed margins is noted in the inner quadrant of the left breast. The lesion appears hyperintense on STIR sequence, shows restricted diffusion with corresponding hypointensity on ADC maps at b-value of 1000. The mean ADC value is above the cutoff-1.4×10^{-3} mm²/s.

The lesion shows Type I kinetic curve on dynamic contrast enhanced MRI. (persistent)

On histopathology, the lesion was revealed to be a Fibroadenoma.

REFERENCES

1. Guray M, Sahin AA. Benign breast diseases: classification, diagnosis, and management. Oncologist. 2006;11(5):435–49.
2. Aggarwal P, Sutarkar SK, Jatav J, Rajpoot PS, Yadav S, Sharma P. Histopathological spectrum of benign and borderline breast lesions: a cross-sectional study from Vindhya region, Madhya Pradesh, India. J Clin Diagn Res. 2024;18(5):EC22–EC26.
3. Berg WA, Campassi C, Langenberg P, Sexton MJ. Breast imaging reporting and data system: inter- and intraobserver variability in feature analysis and final assessment. Radiology. 2000;215(3):759–65.
4. Tavassoli FA, Devilee P, editors. World Health Organization Classification of Tumours: Pathology and Genetics of Tumours of the Breast and Female Genital Organs. Lyon: IARC Press; 2003.
5. Hartmann LC, Sellers TA, Frost MH, Lingle WL, Degnim AC, Ghosh K, et al. Benign breast disease and the risk of breast cancer. N Engl J Med. 2005;353(3):229–37.
6. Lakhani SR, Ellis IO, Schnitt SJ, Tan PH, van de Vijver MJ, editors. WHO Classification of Tumours of the Breast. 4th ed. Lyon: IARC Press; 2012.
7. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209–49.
8. Malvia S, Bagadi SA, Dubey US, Saxena S. Epidemiology of breast cancer in Indian women. Asia Pac J Clin Oncol. 2017;13(4):289–95.
9. Sandhu D, Sandhu S, Karwasra R, Marwah S. Profile of breast cancer patients at a tertiary care hospital in north India. Indian Journal of Cancer. 2010;47(1):16.
10. Sishir Poudel, Sushan Pokharel, Sarada Khadka. Benign Breast Disease among Patients Visiting the Breast and Endocrine Clinic of a Tertiary Care Centre. Journal of Nepal Medical Association [Internet]. 2024 Feb 24 [cited 2024 May 23];62(270):92–4.
11. Raina V, Bhutani M, Bedi R, Sharma A, Deo SV, Shukla NK, et al. Clinical features and prognostic factors of early breast cancer at a major cancer center in North India. Indian J Cancer. 2005;42(4):151–5.
12. Yabuuchi H, et al. Enhanced mass on contrast-enhanced breast MR imaging: lesion characterization using combination of DCE and DWI. J Magn Reson Imaging. 2008;28(5):1157–65.
13. Rubesova E, Grell AS, De Maertelaer V, Metens T, Chao SL, Lemort M. Quantitative diffusion imaging in breast cancer: a clinical application. Radiology. 2006;238(2):404–11.
14. Pereira FPA, et al. Assessment of breast lesions with DW-MRI and ADC values. AJR Am J Roentgenol. 2009;193(4):W314–20.
15. Guo Y, Cai YQ, Cai ZL, Gao YG, An NY, Ma L, et al. Differentiation of clinically benign and malignant breast lesions using DWI. J Magn Reson Imaging. 2002;16(2):172–8.
16. Woodhams R, et al. ADC mapping of benign and malignant breast tumors. Magn Reson Med Sci. 2005;4(1):35–42.
17. Bennani-Baiti B, Baltzer PAT. Diagnostic performance of breast DWI: a systematic review and meta-analysis. Eur Radiol. 2016;26(2):559–81.
18. Baltzer PAT, et al. Application of DWI in the breast using EPI. Eur Radiol. 2010;20(6):1547–55.
19. Kul S, Eyuboglu I, Cansu A, Alhan E. Diagnostic efficacy of DWI in the characterization of different types of breast lesions. J Magn Reson Imaging. 2011;196(1):210–7.
20. Hatakenaka M, Soeda H, Yabuuchi H, et al. Apparent diffusion coefficients of breast tumors: clinical application. Magn Reson Med Sci. 2008;7(1):23–29.