Diagnostic Accuracy of Diffusion Weighted Imaging in Differentiating Benign and Malignant Breast Lesions: A Cross-Sectional Study

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Abstract

Objective: To evaluate the role of diffusion-weighted MRI and to identify proper cut-off ADC value to differentiate benign from malignant breast lesions by correlating them with cytology/ histopathology examination. Apparent Diffusion Coefficient (ADC) is the objective measure of diffusion and is usually lower in malignant breast lesions.

Methods: This was prospective cross-sectional research done in the Department of Radiodiagnosis involving 56 patients (with 82 breast lumps involving bilateral breasts). The breast lesions were identified by mammography, palpation, or B Mode ultrasonography. All these patients underwent MRI breast (Diffusion-weighted imaging). ADC mapping was done and ADC values were computed with the b values of 0, 800 & 1000. For every case that had an MRI, a histopathological or cytological confirmation was performed with the patient's consent. The results of HPE/ cytology were correlated with MRI findings (Table/ Fig 1).

Results: The mean ADC value among Malignant breast lesions has been 0.89 (±0.13) $x10^{-3}$ mm^2/s which is lower by 0.41 and statistically significant ($P<0.05$) compared to the ADC value of benign lesions which was 1.3 (±0.13) $x10^{-3}$ mm^2/s. The AUC for the value of ADC in predicting malignancy was 0.965 (0.928 - 1). In this investigation, the ADC value cut-off of 1.05 x 10^{-3} mm^2/s has been utilized to predict malignant and benign lesions. This value had a specificity of 93.0%, sensitivity of 92.30%, NPV (negative predictive value) of 93.22%, PPV (positive predictive value) of 92.28%, and accuracy of 92.67%.

Conclusion: ADC value can be used as an efficient tool in the characterization of breast lesions with 1.05 $x10^{-3}$ mm^2/s as the best cut-off value for differentiating malignant tumors.

Keywords: Breast carcinoma, ADC, Diffusion Weighted Imaging, DWI, Benign breast lesion.

IRB: Approved by the Ethical Review Committee, SRM Medical College Hospital and Research Centre. Ref# 2397/IEC/2021. Dated: 29th January 2021.

Citaton: Khan S, Aiyappa S, Ramesh R, Natarajan S, Dachepalli RS, Nishant. Diagnostic Accuracy of Diffusion Weighted Imaging in Differentiating Benign and Malignant Breast Lesions: A Cross-Sectional Study. Annals of ASH & KMDC, 2024:29(4): 406-411

Introduction

In developed as well as developing countries, breast cancer is the most frequent cancer among women, and it also ranks second in terms of the causes of mortality for these patients[1]. With a prevalence incidence of 25.8/ 100,000 and an age-adjusted mortality rate of 12.7/ 100,000 breast cancer is the most common malignancy among Indian women[2,3]. Delhi was found to have the breast cancer's highest age-adjusted incidence rate, with 41 incidences per 100,000 women. The districts with the lowest incidence rates were Thiruvananthapuram District (33.7), Chennai (37.9), Bangalore (34.4)[4-7].

While DCE-MRI is the most sensitive approach for screening women at higher risk, it has limitations such as the requirement for intravenous contrast, longer processing times, and a higher rate of false-positive results. MRI which has now become a useful imaging modality for the diagnosis & staging of breast cancer. Using DWI in conjunction with

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Date of Submission: 30th September 2023
Date of Revision: 1st October 2024
Date of Acceptance: 7th November 2024

standard techniques may lower the number of biopsies and false-positive outcomes from breast MRIs[8].

It has been discovered that malignant breast lesions have far lower ADC values as compared to benign tumors. However, there isn't always a conventional ADC threshold value to distinguish between malignant & benign tumors.

Thus, this study's purpose is to use DWI to distinguish between benign & malignant breast masses and to find out the appropriate cut-off ADC value for the diagnosis of malignant breast tumors by comparing it with cytology and histological evaluation.

Methodology

In the Department of Radiology at SRM Medical College Hospital and Research Centre, Kattankulathur, Chengalpattu, Tamil Nadu, India, a cross-sectional study including eighty-two patients was enrolled and carried out between January 2021 and June 2022. Sample size has been computed by utilizing the formula as N = Z21 -á/2 * Sn * (1 - Sn) /p * d2 Z1- á/ 2 - two-tailed probability for 95% CI =1.96 Sn (%) - sensitivity of apparent diffusion coefficient ADC) using DWI cut- off value of 1. 31 = 0.96d (%) - precision or allowable error for the sensitivity of apparent diffusion coefficient (ADC) using DWI cut-off value of 1.31 = 0. 073. p (%) - frequency of the malignant breast lesions = 0.473 N = 1.96^2* 0.962 * (1 - 0. 962) / 0. 473 * 7.3^2 N = 55. 71. As a result, 56 patients served as the study's minimum total sample size. We were able to gather information for 82 breast lesions in this investigation throughout the study period. All focal breast lesions detected either by palpation, ultrasound, or mammography who gave consent for the imaging modalities included in the study and were ready to undergo FNAC/ biopsy. In the case of both benign and malignant-looking lesions in a patient, both lesions were included. Both male and female breast lesion suspicious of malignancy was included. Patients with Purely cystic lesions, less than 5 mm in size and Patients not giving consent for HPE/ FNAC examination are excluded. Informed consent was gained from the patients following an explanation of the technique. Using a Siemens Essenza 1.5 Tesla MRI machine, the patients with lumps in their breasts underwent MRI testing. An exclusive phased-array breast coil was employed. To get DWI, a single-shot echo-planar imaging (EPI) sequence in the axial plane was employed, with b values of 0, 800, and 1000. ADC maps and corresponding ADC values have been attained. (Figure -1) Histological confirmation has been done by tru-cut biopsy/ FNAC of the lumps. In some patients, the imaging results were correlated with surgical histopathology specimens if the patient underwent surgery.

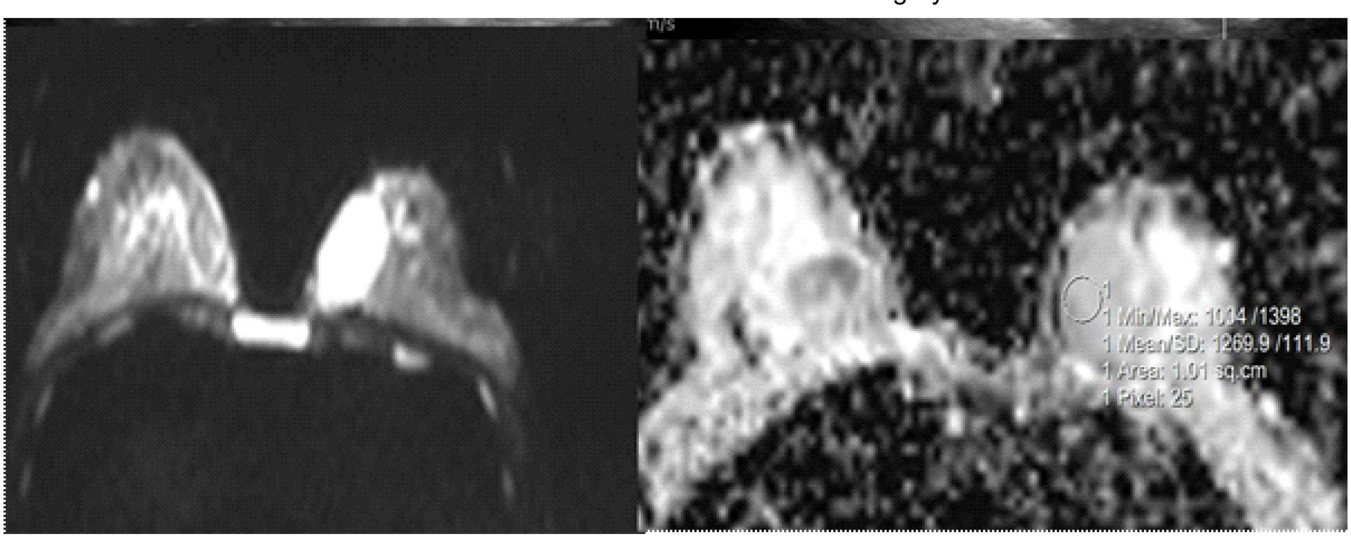

Fig 1. MRI diffusion-weighted and corresponding ADC image shows ADC - value of 1.26 x10^{-3} mm^2/s. FNAC report of the lesion was Fibroadenoma.

Results

The majority of the 82 individuals in this study, who had been diagnosed with breast masses, were between the ages of 55 and 60. Fisher's exact & chi-square tests have been then applied appropriately for the significance test. It was decided that P-values below the 0.05 threshold were statistically significant. In comparison to 40.23 (± 14.62) for Benign, the mean age (years) for Malignant was 51.18 (± 9.65), a statistically significant increase of 10.95 (table 1). The majority of the patients had findings on the left side (table-2) with breast lump being the commonest presentation followed by breast pain and discharge (table 3). In correlation with FNAC and HPE diagnosis, Among the subjects, 43 (52.44%) were Benign and 39 (47.56%) were malignant with fibroadenoma being the commonest benign lesion - 39 (45.12%) followed by Invasive Ductal Carcinoma -33 (40.24%) which was commonest malignant lesion (table 4) The mean ADC value among malignant was 0.89 (±0.13) x10^{-3} mm^2/s which is lower by 0.41 and statistically significant compared to 1.3 (±0.13) x10^{-3} mm^2/s in Benign (table 5). With a sensitivity of 92.30%, specificity of 93.00%, PPV of 92.28%, NPV of 93.02%, and diagnostic accuracy of 92.67%, the cut-off of ADC value for predicting benign & malignant lesions was 1.05x10^{-3} mm^2/s (table 6).

Table 1. Age (Years) With Diagnosis

	Diagnosis	Mean	Std. dev	Mean diff	P value by T-test
Age (Years)	Malignant	51.18	9.65	10.947	0.001
	Benign	40.23	14.62		

Table 2. Impacted Side

Impacted side	Frequency	Percent
RIGHT	39	47.56
LEFT	43	52.44
TOTAL	82	100. 00

Table 3. Clinical findings, number of lumps frequency, and percentage

Clinical findings	Frequency	Percent
Breast Lump	43	52.44
Breast Lump & Discharge	1	1.22
Breast Lump & Pain	2	2.44
Breast Lump, Peau D Orange	1	1.22
Breast Pain	20	24.39
Breast Pain & Discharge	8	9.76
Fungating Proliferative Mass Bleeds onTouch	1	1.22
Multiple Lumps	3	3.66
Nipple Retraction & Discharge	1	1.22
Post MRM Right Status, Axillary tailpain and lump	1	1.22
Skin Retraction	1	1.22
Total	82	100. 00

Table 4. Number Of Benign and Malignant Lesions with FNAC And HPE Findings

Diagnosis	Frequency	Percent
Malignant•	39	47.56
Infiltrating lobular	2	2.44
carcinoma•	33	40.24
Invasive ductal carcinoma•	1	1.22
Metastatic node•	3	3.65
Mucinous carcinoma		
Benign•	43	52.44
Abscess•	2	2.44
Fibroadenoma•	39	45.12
Phyllodes Tumour	2	2.44
Total	82	100. 00

Table 5. Mean ADC of Benign and Malignant Lesions

	Diagnosis	N	Mean	Std. dev.	Mean diff.	p-value by 't' test
ADC value(N x 10 3 mm2/s)	Malignant	39	0.89	0.12	0.408	0.001
	Benign	43	1.30	0.13		

Table 6. Cut Off ADC Value for Benign and Malignant Lesions Using ROC Curve

Test Result Variable(s)	Cut off	Sensitivity	Specificity	PPV	NPV
ADC value	1.050	92.30%	93.00%	92.28%	93.02%

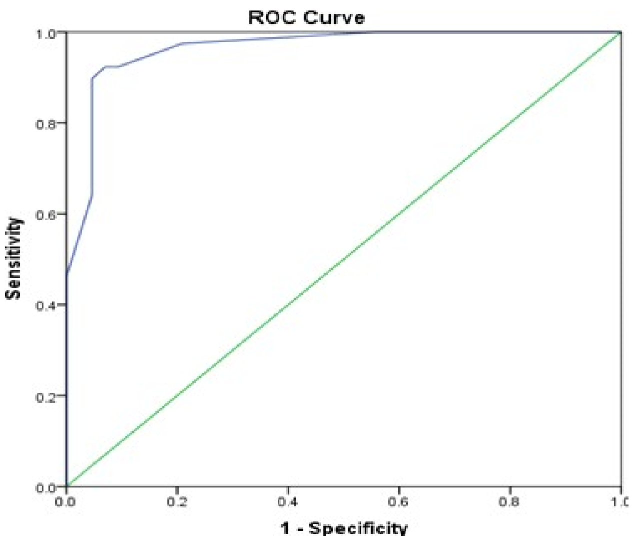

Fig 2. Cut Off of ADC Value for Benign and Malignant Lesions Using ROC Curve

Table 7. Comparison of our study with previously published papers showing the sensitivity and specificity of MRI ADC values

Study	Cut off ADC Value (Nx10 $^{-3}$ mm^2/s)	Sensitivity	Specificity
Tsvetkova S et al.[12] (2022)	1.1	94.23%	94.29%
Fathima Hana et al.[11]-(2020)	1.1	100%	92.8%
Eesha Rajput et al.13 (2018)	0.95	97.3%	95.5%
Richa Bansal et al.14 (2015)	1.1	92.80%	80.23%
SebnemOrgucet et al.15 (2012)	1.46	95%	85%
Yabuuchi et al. 16 (2008)	1.23	89%	77%
Rajalakshmi Preethi G et al.17 (2007)	1.31	96.20 %	100 %
Marini et al.18 (2007)	1.1	81%	79%
Rubesova et al. 19 (2006)	1.13	85%	86%
Present Study	1.05	92.30%	93.00%

Discussion

This was a cross-sectional study among 56 Patients with 82 breast lesions. In our study out of 82 cases, 81 patients were female and one male patient showing carcinoma breast was involved. The most frequent lesion found on HPE/ FNAC was fibroadenoma (47.12%) which is the commonest benign lesion followed by abscess and phyllodes tumor. The commonest malignant lesion was invasive ductal carcinoma (40.24). Our research was similar to the studies performed by Pradhan et al[9], and Xinchen et al[10], in which fibroadenoma was the most commonly detected benign. Our study cut-off ADC value was 1.050 x10^{-3}mm^2/sec which was similar to the study conducted by Sahar Basim Ahmed Fareed et al[11] (2021), who did a qualitative and quantitative assessment, and compared the ADC values of Diffusion-weighted MRI of the breast for the distinction of benign breast lesions from malignant breast lesions. They did this study among 56 Breast tissue lesions of Iraqi women. In their study, they observed that the cut-off value of 1.31×10^{Š3} mm^2/s for ADC values in ROC analysis yielded a value of 100% sensitivity and 72.1% specificity. It was also similar and comparable to the research done by Tsvetkova S et al.[12] (2022), who studied 87 patients (35 benign cases and 52 malignant cases) and got the best cut-off 1.11×10^{Š3} mm^2/s. Hana et al.[11] (2020), investigated the ADC value's role in breast diffusion-weighted MRI in differentiating between benign & malignant breast lesions. They performed this study on 26 lesions in 26 women from Mangalore, Karnataka. They observed a sensitivity of DWI -100%, while the specificity was 92.8% when the ADC values cut-offs were between 1.1- 2.2x10^{-3} mm^2/sec. Our study cut-off value was also comparable to studies, by Eesha Rajput et al.[13], Richa Bansal et al.[14], Sebnem et al.[15], Yabuuchi et al.[16], Rajalakshmi Preethi G et al[17]. Marini et al.[18], Rubesova et al.[19], in which the ADC cut of values was of 0.95 ×10$^{"3}$ mm^2/s, 1.1 x10^{-3} mm^2/s, 1.46 x10^{-3} mm^2/s, 1.23 x10^{-3} mm^2/s, 1.31x10^{-3} mm^2/s, 1.1x10^{-3} mm^2/s, 1.13x10^{-3} mm^2/ s respectively.

The results of our study indicate that the cut-off ADC 1.05 x 10-3mm 2/s. This led to the detection of breast masses with a sensitivity of 92.30%, specificity of 93.00%, PPV of 92.28%, NPV of 93.02%, and diagnostic accuracy of 92.67%. The results of Richa Bansal et al. showed a sensitivity of 92.80% and a specificity of 80.23%[14].

Rajalakshmi Preethi G et al. reported sensitivity and specificity of 96.20% and 100% which was comparable to our research[17]. The specificity, sensitivity, and accuracy of the ADC score are good, despite the fact that the cut-off value varies between studies, indicating that it is a helpful tool for differentiating between benign and malignant thyroid nodules (Table/Fig-9). The various ADC readings could result from using different b values and a different MRI machine.

When the cut-off in our study was increased to 1.15 $x10^{-3}$ mm^2/s sensitivity remained the same but specificity decreased to 90.70%. If cut off was reduced to $0.98x10^{-3}$ mm^2/s sensitivity was reduced to 89.70% and specificity increased to 95.30%.

In our study out of the 37 malignant lesions diagnosed on MRI, 3 (8.1%) cases were false positive for malignancy and 34 (82.9%) cases were true positive for malignancy. Out of the 45 benign lesions diagnosed on MRI, 3 (6.6%) cases were false negative for malignancy and 42 (98.33%) cases were true negative.

Three of the false negative results in our investigation were due to mucinous carcinoma, for which a high ADC value was achieved, hence lowering specificity. Similar outcomes were found in a study done by Richa Bansal et al., where out of 232 cases the false negative value was obtained for 6 mucinous carcinoma cases, and by Reiko Woodhams et al.[20], in which the ADC value of the mucinous carcinoma (11 mucinous carcinomas out of 277 cases) was higher than other malignant lesions. The 2 false positive cases were abscess mimicking masses which showed very low ADC values which made the cut-off ADC value become on the lower side which is well described in literature as abscess can show low ADC values.

The influence of Confounding factors inducing bias into the associations in the study results cannot be ruled out. The sample size was relatively smaller. This is a hospital-based study in a tertiary care setting, and hence the study results will be slightly variable in the primary and secondary care settings, where the prevalence of malignant breast lesions will be less. We did not study the cost-effective analysis of the diffusion-weighted MRI in the management of breast lesions. The addition of MRI ADC value can provide a useful adjunct to biopsy. Patients with breast lesions and co-morbidities, for whom the possible risk of surgery exceeds the survival benefit, may be able to postpone surgery by using ADC value in MRIs. Moreover, further progress on various cut-offs of ADC values indicating the grades of malignancy and dysplastic or anaplastic changes in a lesion could be stressed.

Conclusion

ADC value can be used as an efficient tool in the characterization of the breast lesions with 1.05 $x10^{-3}$ mm^2/s as the best cut-off value for differentiating the malignant tumors.

Conflict Of Interest: None

Disclaimer: None

Source of Funding: None

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