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Original Article

The role of Diffusion-weighted magnetic resonance imaging and apparent diffusion coefficient (ADC) values in the evaluation of solid breast lesions

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Abstract

Aim: To investigate the role of Diffusion-weighted magnetic resonance imaging and apparent diffusion coefficient (ADC) values in the differential diagnosis of solid lesions of the breast.

Materials and Methods: Diffusion-weighted images and ADC values from 36 women with 37 solid lesions definitely diagnosed through breast biopsy and post-surgical histopathology were evaluated retrospectively. ADC values obtained from malignant and benign solid lesions of the breast were compared using the t-test. The optimum threshold value for use in differentiating benign and malignant lesions was determined using ROC analysis, and sensitivity and specificity values were calculated.

Results: Histological analysis identified 23 lesions and 14 benign lesions. Mean age (49 ± 7.8 years) was higher in the group with malignant breast lesions than in the group with benign breast lesions (37.3 ± 8.2) ($p < 0.05$). The mean ADC value ($1.1 \pm 0.2 \times 10^{-3}$ mm2/s) in the patients with malignant breast lesions was significantly lower than in the group with benign breast lesions ($1.49 \pm 0.18 \times 10^{-3}$ mm^2/s) ($p < 0.05$). When the threshold value to be used in the ROC curve was applied the differentiation of benign and malignant solid lesions, the sensitivity was 78.3% and specificity was 100%.

Conclusions: Diffusion-weighted MRI and ADC values have the potential to contribute to the diagnosis of solid lesions in the breast at conventional MR examination by differentiating between benign and malignant tumors.

Keywords: ADC value; breast lesions; diffusion-weighted MRI

INTRODUCTION

Breast cancer is the most commonly diagnosed malignancy in women. It is also the principal cause of cancer-related deaths among women worldwide and the second main cause after lung cancer in Turkey (1). Breast cancer is also reported to be the most important cause of death among women aged 40-55, and the lifetime risk of breast cancer in women is 3.6% (2). The detection and differential diagnosis of breast mass lesions are the primary tasks of imaging methods including mammography, ultrasonography (USG), and magnetic resonance imaging (MRI) of the breast. Dynamic contrast-enhanced MRI (DCE-MRI) has become an integral component of imaging in the differential diagnosis of breast masses. It is crucially important to determine both morphological features and dynamic contrast enhancement characteristics for the diagnosis of breast lesions (3).

Diffusion-weighted MRI (DWI) has recently acquired considerable importance, in addition to DCE-MRI, in the differential diagnosis of breast lesions. Several studies have investigated the use of apparent diffusion coefficient (ADC) values for differentiating malignant lesions from benign ones, based on the relationship between ADC values and cellularity (4). While malignant breast lesions exhibit low ADC values due to high cellularity, benign breast lesions have been reported to exhibit higher ADC values (5 -11).

The purpose of this study was to investigate the accuracy of ADC values, and the sensitivity and specificity of a threshold value for use in the differentiation of malignant and benign solid breast lesions in histopathologically diagnosed patients.

MATERIALS and METHODS

Thirty-six women were evaluated using DCE-MRI and DWI. Patients with BIRADS 3 and 4 lesions at mammography and USG, undergoing MRI to detect multi-centricity, with invasion into surrounding tissues and preoperative

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staging, and who received a definitive histopathological diagnosis after surgery were included. Patients who were examined to evaluate postoperative recurrence after breast cancer surgery, for the results of neoadjuvant chemotherapy, and for breast implants were excluded.

All MRI examinations were performed using a dedicated breast coil with a 1.5 T MR scanner (Signa Excite 2.0, GE MEDICAL SYSTEMS, Milwaukee, WI, USA). MRI examinations were performed before histopathological diagnosis. Diffusion-weighted images were acquired in the sagittal plane using single-shot Spin-echo Echo-planar sequences with the following parameters: field of view, 160×160 mm; time-to-repetition (TR) / Time-to-echo (TE), 10000/120 ms; matrix, 126×126; and slice thickness, 6 mm. The "b" value was taken as 0 and 600 mm^2/s for each section.

Diffusion-weighted images were evaluated using post-processing software on the workstation in our clinic. ADC measurements were performed manually by placing the standard region of interest (ROI) on the lesions with definite histopathological diagnoses after biopsy and / or surgery.

Nominal variables were compared using Fisher exact test, quantitative variables using Student's test, and ordinal variables using the Mann Whitney U test. $p < 0.05$ was considered statistically significant. A threshold value for the differentiation of benign and malignant lesions was determined using ROC curve analysis, and sensitivity and specificity values were then calculated.

RESULTS

Thirty-six patients with 37 lesions, 14 benign and 23 malignant, were included in the study. The mean age of the patients was 44 ± 8 years (range 20 to 62). The mean age (49 ± 7.8) of the group with malignant breast lesions was higher than that of the benign breast lesion group (37.3 ± 8.2) ($p < 0.05$). Histopathological diagnoses of the 14 benign lesions were six fibroadenomatoid changes, five fibroadenoma, one juvenile fibroadenoma (Figure 1), one focal atypical hyperplasia, and one adenosis. Of the 23 malignant lesions, 20 were invasive ductal carcinoma (IDC) (Figure 2), two were invasive lobular carcinoma (Figure 3) and one was tubulolobular carcinoma (Table 1).

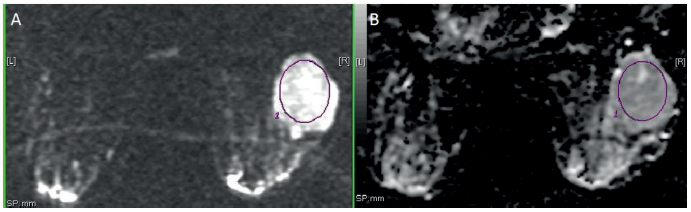

Figure 1. Diffusion-weighted MRI of a solid lesion measuring 41×52×74 cm in the upper right outer quadrant, evaluated as BIRADS-4B. The Diffusion-weighted images exhibited marked hyperintensity (A), and ADC mapping was hypo-isointense (B). The ADC value was 1.49 × 10^{-3} mm^2/s. Histopathological diagnosis of breast biopsy was juvenile fibroadenoma

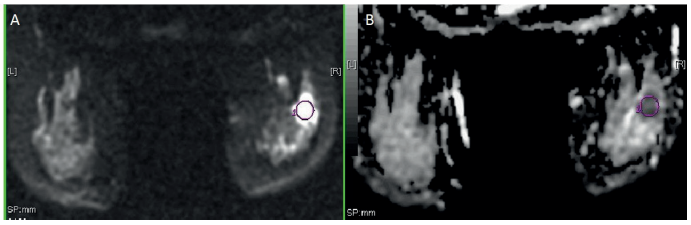

Figure 2. Diffusion-weighted MRI and ADC measurement of a patient with BIRADS-5 mass lesion in the right breast. The lesion was markedly hyperintense on the diffusion-weighted image (A), and hypointense on ADC mapping (B), with an ADC value of 0.98 × 10^{-3} mm^2/s. The case was diagnosed as invasive ductal carcinoma following breast biopsy

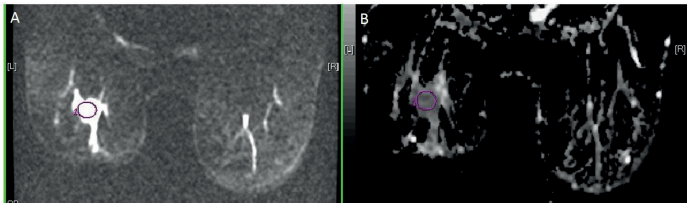

Figure 3. Diffusion-weighted MRI of a 32×37 mm BIRADS-5 mass lesion in the retroareolar area of the left breast. Diffusion-weighted MRI were prominently hyperintense (A), and hypointense on ADC mapping (B). The ADC value was 1.01 × 10^{-3} mm^2/s. Histopathological diagnosis via breast biopsy was invasive lobular carcinoma

Table 1. Histopathological diagnosis distribution of 37 lesions number and percentages

Benign lesions	14 (38%)
Fibroadenomatoid changes	6 (16%)
Fibroadenoma	5 (13%)
Juvenile fibroadenoma	1 (2%)
Focal atypical hyperplasia	1 (2%)
Adenosis	1 (2%)
Malignant lesions	
Invasive ductal carcinoma	20 (54%)
Invasive lobular carcinoma	2 (5%)
Tubulolobular carcinoma	1 (2%)

The mean ADC value (1.49 ± 0.18 × 10^{-3} mm^2/s) of the benign lesions was significantly higher than that of the malignant lesions (1.1 ± 0.2 × 10^{-3} mm^2/s) ($p < 0.05$). When an optimum threshold value of 1.20 × 10^{-3} mm^2/s was adopted for benign-malignant differentiation, the sensitivity of the ADC value was 78.3% and specificity was 100%.

DISCUSSION

This study evaluated the ADC values of solid breast lesions obtained prior to biopsy procedure for the differentiation of malignant and benign lesions. MRI has been shown to be the most sensitive method for detecting malignant lesions of the breast. Several publications have reported sensitivity values of 90-95% and specificity ranging from 37% to 97% (12, 13). At dynamic contrast-enhanced MRI, time-signal intensity curves have revealed a wide range

of sensitivity (56-83%) and specificity (46-91%) values for the detection of malignant breast lesions (14,15). Some previous publications have shown that ADC values assist the differentiation of malignant-benign breast lesions based on the relationship between ADC values and cellularity (4,5). Diffusion-weighted MRI supports the diagnostic performance of DCE-MRI in solid breast lesions (16,17). Malignant breast lesions exhibit low ADC values due to high cellularity; however, benign breast lesions have been reported to show higher values than malignant ones at diffusion-weighted MRI (5-9,18) (Table 2).

Park et al.'s study of 41 patients with 46 lesions reported significantly lower mean ADC values in invasive ductal carcinoma lesions ($0.89 \pm 0.18 \times 10^{-3}$ mm^2/s) than in benign breast lesions ($1.41 \pm 0.5 \times 10^{-3}$ mm^2/s). Those authors also observed a significant difference between the mean ADC values of invasive ductal carcinoma lesions ($0.89 \pm 0.18 \times 10^{-3}$ mm^2/s) and ductal carcinoma in situ lesions ($1.17 \pm 0.18 \times 10^{-3}$ mm^2/s) (8). Yabuuchi et al. retrospectively evaluated breast MRI examinations of 270 patients and observed 75 contrast enhancing lesions in 71 patients. A threshold value of 1.1×10^{-3} mm^2/s exhibited sensitivity of 92% and specificity of 86% in terms of benign-malignant differentiation (10). Lo et al. evaluated DCE MRI and DWI of breast lesions suspected of malignancy in 31 patients and reported higher mean ADC values in benign lesions ($1.47 \pm 0.30 \times 10^{-3}$ mm^2/s) than in malignant lesions ($1.01 \pm 0.25 \times 10^{-3}$ mm^2/s). They determined that an ADC value exhibited 90% sensitivity and 91% specificity for benign-malignant lesion distinction (11).

Tezcan et al.'s recent study of 116 breast lesions (79 malignant vs. 37 benign), reported a significantly lower ADC value in malignant tumors (median ADC, 0.72×10^{-3} mm^2/s) than in benign lesions (median ADC, 1.03×10^{-3} mm^2/s; $p < .000$). The sensitivity and specificity of an ADC cutoff value of 0.89×10^{-3} mm^2/s were 92% and 95%, respectively. Those authors reported that DCE MRI alone exhibited 100% sensitivity and 59.4% specificity. However, adding an ADC cutoff value of 0.89×10^{-3} mm^2/s yielded 100% sensitivity and 81% specificity, which would have prevented biopsy being performed in 21.6% cases of benign lesions without any malignancies being missed (19).

Thirty-six patients with 37 lesions were evaluated using breast MRI examination in the present study. The mean ADC value of malignant breast lesions ($1.1 \pm 0.2 \times 10^{-3}$ mm^2/s) was significantly lower than that of benign breast lesions ($1.49 \pm 0.18 \times 10^{-3}$ mm^2/s) ($p<0,05$). When an optimum threshold value of 1.20×10^{-3} mm^2/s was adopted for ROC curve analysis, sensitivity was 78.3%, and specificity was 100% in benign-malignant lesion differentiation.

Table 2. Breast MR Diffusion-weighted imaging results

			Benign		Malignant		Sensitivity (%)/Specificity (%)
Author	b-value	n	n	ADC value	n	ADC value	
Woodhams (5) 2005	0, 750, 1000	191	24	1.67±0.54	167	1.22±0.31	95/-
Rubesova (6) 2006	400, 1000	87	22	1.4±0.07	65	0.99±0.02	82/86
Park (8) 2007	0, 1000	54	4	1.41±0.56	43(IDK)	0.89±0.18	-/-
					7(DCIS)	1.17±0.8	
Marini (9) 2007	1000	63	21	1.48±0.37	42	0.95±0.18	100/67
Hatekenaka (4) 2008	0, 500, 1000	140	16	1.57±0.23	124	0.97±0.20	83/81
Lo (11) 2009	0, 1000	31	11	1.47±0.30	20	1.01±0.25	90/91
Tezcan (20) 2020	800	116	37	1.03	79	0.72	100/81
Bozkurt (17) 2016	750	53	28	1.61±0.50	35	1.04±0.29	89.1/100

ADC value = x10^{-3} mm^2/s ; b value = s/mm^2 ; ADC = Apparent Diffusion Coefficient ; n; number of lesions ; IDK= invasive ductal carcinoma; DCIS = Ductal carcinoma in situ

CONCLUSION

Diffusion-weighted MRI makes a significant contribution to the distinction of benign and malignant breast lesions. The findings of the present study show that ADC values exhibit high levels of specificity and sensitivity in the benign-malignant differentiation of solid breast lesions.

Competing interests: The authors declare that they have no competing interest.

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