



ORIGINAL ARTICLE

# Predictive value of ADC mapping in discriminating probably benign and suspicious breast lesions



Mohamed Hamed Abowarda <sup>a,\*</sup>, Doaa Ibrahim Hasan <sup>a</sup>, Osama Abdelaziz Elteeh <sup>b</sup>

<sup>a</sup> Diagnostic Radiology Department, Zagazig University Hospitals, Egypt

<sup>b</sup> General Surgery Department, Zagazig University Hospitals, Egypt

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## KEYWORDS

Diffusion-weighted imaging (DWI);  
Apparent diffusion coefficient value (ADC);  
American College of Radiology;  
Breast imaging reporting and data system (ACR-BIRADS)

**Abstract** *Purpose:* The purpose of this study was to evaluate the usefulness of apparent diffusion coefficient (ADC value) in differentiating between probably benign breast lesions and, suspicious lesions (ACR-BIRADS categories 3 and 4 respectively).

*Patients and methods:* Breast lesions meeting study criteria were identified on dynamic contrast enhanced (DCE)-MRI examinations in 48 women over the course of the study period for 2 years. We found 27 (56.2%) of the cases probably benign as their BIRADS category 3 and the remaining 21 (43.7%) cases were category 4. Images were obtained with diffusion sensitizing gradients of 0 and 750 mm<sup>2</sup>/s. The apparent diffusion coefficient (ADC) was calculated and correlated with the histological data.

*Results:* The ADC values recorded a sensitivity of 97.9% and a specificity of 80%. The positive predictive value was 95.7% in differentiation between the benign and suspicious breast lesions. The difference in mean ADC for benign breast lesions (BIRADS-3,  $1.45 \pm 0.46 \times 10^{-3}$  mm<sup>2</sup>/s), and suspicious lesions (BIRADS-4,  $1.06 \pm 0.56 \times 10^{-3}$  mm<sup>2</sup>/s) was statistically significant.

*Conclusion:* Including the ADC diffusion coefficient in the diagnostic work up of patients with indeterminate breast lesions can help in the differentiation between benign and malignant breast lesions.

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## 1. Introduction

Magnetic resonance imaging (MRI) is an important tool for diagnosing breast tumors (1–3). Dynamic contrast-enhanced breast MR imaging (DCE-MRI) has been reported to have

high sensitivity for cancer detection, reportedly as high as 88%–100%, but specificity may be relatively low as 68%–96% (4–6). However, the moderate specificity of DCE-MRI using current morphologic and kinetic enhancement criteria can present additional challenges (7,8). To minimize false-positive results without compromising sensitivity, the American College of Radiology (ACR) introduced the breast Imaging-Reporting and Data System (BIRADS) MRI lexicon in 2013 (9), which relies on the combined analysis of morphological appearance and lesion enhancement kinetics and is widely used

\* Corresponding author. Tel.: +20 1147004434.

E-mail address: [mohamedwarda35@yahoo.com](mailto:mohamedwarda35@yahoo.com) (M.H. Abowarda).

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for reporting MRI of the breast at any given field strength, while still debate as to the relative importance of these descriptors as defined in the BIRADS lexicon (10–12). Previous researches indicated a wide range of cancer yields (0.6–10%) among probably benign MRI lesions (13–15).

Diffusion-weighted imaging (DWI) has become widely accepted in body imaging to detect and differentiate benign from malignant tumors using apparent diffusion coefficient (ADC) values. Promising findings from preliminary DWI studies of the breast have shown significantly lower ADC measures for breast carcinomas than for benign breast lesions or normal tissue (16–18). The lower ADC in malignancies is primarily attributed to higher cell density causing increased restriction of the extracellular matrix and increased fraction of signal coming from intracellular water (19,20). The aim of this work was to evaluate the usefulness of ADC value in differentiating between probably benign breast lesions and, suspicious lesions (BIRADS categories 3 and 4 respectively).

## 2. Patients and methods

The study was approved by local ethics committee. It was conducted in the period from June 2012 to June 2014. Dynamic MRI performed in 48 women patients that were detected on MRI and assigned final MRI BIRADS assessment as category 3 (probably benign), or category 4 (suspicious lesion).

### 2.1. MRI acquisition

All MRI was performed on a GE Medical System (Signa Excite; MI, USA), HD 1.5T scanner using a dedicated 4-channel bilateral breast coil. Each MR examination included a T2-weighted fast spin echo (FSE) sequence, T1-weighted non fat-suppressed sequence, T1-weighted DCE-MRI sequence, and DWI sequence. All scans were acquired in the axial and sagittal orientation.

- The T2-weighted acquisition was performed using a fat-suppressed 2D FSE sequence with TR/TE = 6050/85 ms, 32–36 cm field of view (FOV), 1.6–2.2 mm slice thickness, and 320 × 224 matrix.
- A nonfat suppressed T1-weighted 3D fast spoiled gradient recalled echo sequence was acquired using the same imaging parameters as for the DCE-MRI sequence described below, with TR/TE = 6.2/3 ms, flip angle 10, FOV = 32–36 cm, and 1.6–2.2 mm slice thickness.
- The DCE-MRI protocols performed using a T1-weighted 3D fast spoiled gradient recalled echo sequence with parallel imaging; TR/TE = 6.2/3 ms, flip angle = 10, and FOV = 32–38 cm scans were performed with 2.2 mm slice thickness, 350 × 350 matrix, and five postcontrast acquisitions centered at 90, 180, 270, 360, and 450 s were performed with 1.6 mm slice thickness, 420 × 420 matrix, and three postcontrast acquisitions centered at 90, 270, and 360 seconds. The contrast administered was 0.1 mmol/kg-body weight Gd-DTPA (Omniscan, GE).
- DWI was performed using a diffusion-weighted echo planar imaging (EPI) sequence with spectral spatial fat suppression and parallel imaging (reduction factor = 2); TR/TE = 7000/71.5 ms, 3 NEX, matrix = 192 × 192, bandwidth = 1953 Hz/pixel, FOV = 36 cm, slice thickness =

5 mm, gap = 0. Diffusion gradients were applied in six directions with  $b = 0$  and 750 s/mm<sup>2</sup>, and the scan time were 160 s.

- Each lesion was assessed using the American College of Radiology (ACR) BIRADS Breast MRI Lexicon incorporating morphologic and kinetic features (9). Lesion characteristics including size and location, as well as the BI-RADS assessment and recommendation, were recorded at the time of interpretation. BIRADS 3 interpretation is most commonly used for rounded, oval, circumscribed masses with benign kinetics and for focal areas of non-mass-like enhancement with benign kinetics (Type I or II). A BIRADS category 4 was assigned if, in the same setting, a Type III (fast enhancement rate and wash-out) curve was observed. A BIRADS category 4 was also assigned in lesions with a suspicious shape (irregular)

**Table 1** The breast MRI study lesion characteristics.

Size (longest diameter on DCE-MRI)	(No. %)
0.6–1 cm	22(45.8)
1.1–2 cm	17(35.4)
> 2 cm	9(18.7)
<i>Shape</i>	
Oval	18(37.5)
Round	15(31.2)
Irregular	15(31.2)
<i>Margin</i>	
Regular	16(31.2)
Irregular	19(39.5)
Speculated	13(27)
<i>Type of enhancement</i>	
Focus	8(16.6)
Non mass	7(14.5)
Mass	33(68.7)
<i>Internal enhancement</i>	
Homogenous	10(20)
Heterogeneous	8(16.6)
Rim	3(6.2)
Dark internal septations	4(8.3)
Ring enhancement	1(2)
Branching	5(10)
<i>Time intensity curve type</i>	
Type I	18(37.5)
Type II	17(35.4)
Type III	13(27)
<i>BI-RADS assessment</i>	
BI-RADS 3	27(56.2)
BI-RADS 4	21(43.7)
<i>ADC value</i>	
Benign range more than threshold <sup>a</sup>	26(54.1)
Malignant range less than threshold <sup>a</sup>	22(45.8)
<i>Histopathological diagnosis</i>	
Benign	24(50)
Invasive carcinoma	15(31.2)
DCIS	8(16.6)
Intra-cystic papillary Ca	1(2)

BIRADS, breast imaging reporting and data system.

<sup>a</sup> The threshold  $1.21 \times 10^{-3}$  mm<sup>2</sup>/s. DCIS, ductal carcinoma in situ.

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