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Original contribution

# Differentiating benign and malignant inflammatory breast lesions: Value of T2 weighted and diffusion weighted MR images

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ABSTRACT

*Objectives:* Benign and malignant inflammatory breast lesions demonstrate similar findings on both T2 weighted imaging (T2WI) and dynamic contrast enhanced (DCE) images. We hypothesized that benign inflammatory lesions might be differentiated form malignancies using a combination of apparent diffusion coefficient (ADC) values derived from diffusion weighted images (DWI) and T2WI.

*Materials and methods:* We retrospectively reviewed 162 patients undergoing breast MRI (T2WI, DWI and DCE images) between 2008 and 2015 who had breast lesions with high T2WI signal intensity (High T2 SI) including 14 benign inflammatory lesions, 69 benign non-inflammatory lesions, 16 malignant inflammatory lesions and 63 malignant non-inflammatory lesions. On the High T2 SI and low T2WI signal intensity (Low T2 SI) areas in these breast lesions, we calculated ADC values from b values of 0 and 1000 s/mm$^2$.

*Results:* The mean ADC values ± standard deviation ($10^{-3}$ mm$^2$/s) of the High T2 SI areas in benign inflammatory, benign non-inflammatory, malignant inflammatory and malignant non-inflammatory breast lesions were 0.75 ± 0.18, 1.77 ± 0.33, 2.06 ± 0.32 and 1.88 ± 0.41, respectively. Those of the Low T2 SI areas in benign inflammatory, benign non-inflammatory, malignant inflammatory and malignant non-inflammatory lesions were 0.89 ± 0.15, 1.31 ± 0.28, 0.87 ± 0.20 and 0.94 ± 0.27 respectively. ADC values of High T2 SI areas of the benign inflammatory lesions were significantly lower than those of benign non-inflammatory, malignant inflammatory, and malignant non-inflammatory lesions ($p < 0.001$). ADC values of Low T2 SI areas in benign inflammatory lesions were not significantly different from those of malignant inflammatory ($p = 0.99$) or malignant non-inflammatory lesions ($p = 0.72$).

*Conclusion:* For breast lesions with High T2 SI, segmenting the High T2 SI for ADC mapping distinguishes benign from malignant inflammatory conditions. Using ADC mapping of the Low T2 SI areas will not result in this distinction.

## 1. Introduction

There are benign and malignant inflammatory lesions of the breast. One benign inflammatory breast lesion is idiopathic granulomatous mastitis (IGM), also known as granulomatous lobular mastitis or granulomatous mastitis. IGM is a chronic inflammatory disease of unknown etiology [1–3], presenting with galactorrhea, inflammation, breast mass, tumorous indurations, and skin ulcerations. IGM has clinical, radiological and dynamic contrast enhanced magnetic resonance image (DCE-MRI) findings similar to breast cancer [4]. Another benign inflammatory breast entity is infectious mastitis, usually caused by *Staphylococcus aureus* [5]. Inflammatory breast carcinoma (IBC), is a rare, aggressive cancer in which tumor cells embolize and are found in dermal lymphatics [6–8]. The term “inflammatory” comes from the clinical findings of a swollen, red, or inflamed breast with skin induration caused by the tumor, which simulates mastitis.

DCE-MRI is the most sensitive imaging modality for detecting breast cancer, and is a valuable tool for breast care [9]. Breast lesion morphology and dynamic contrast enhancement patterns from high-resolution DCE-MRI post-contrast images are used to diagnose breast

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**Table 1**
Patient and lesion characteristics of 162 breast lesions with and without high T2-weighted signal intensity on breast MRI scans.

| Type of lesion | Benign inflammatory lesions | Benign non-inflammatory lesions | Malignant inflammatory lesions | Malignant non-inflammatory lesions | Remarks |
|---|---|---|---|---|---|
| Number of Patients | 14 | 69 | 16 | 63 | |
| Age, years ± SD | 42 ± 13 | 44 ± 13 | 51 ± 11 | 59 ± 15 | |
| Size cm ± SD | 4.3 ± 2.3 | 2.0 ± 1.6 | 9.1 ± 2.2 | 3.4 ± 1.7 | |
| Edema | 71.4% (10/14) | 2.9% (2/69) | 100% (16/16) | 52.4% (33/63) | |
| Skin Edema | 71.4% (10/14) | 0.0% (0/69) | 100% (16/16) | 23.8% (15/63) | [a] |
| Type, *n* | | | | | |
| NME | 4 | 18 | 4 | 24 | |
| Mass | 10 | 51 | 12 | 39 | |
| Source of diagnosis, *n* | | | | | |
| Operation | 3 | 20 | 0 | 30 | |
| Biopsy | 10 | 49 | 16 | 33 | |
| Cytology | 1 | 0 | 0 | 0 | |
| Cause of T2 high signal, *n* | | | | | |
| Myxoid matrix | 0 | 60 | 0 | 30 | |
| Necrosis | 0 | 0 | 12 | 23 | |
| Fluid | 0 | 9 | 0 | 10 | |
| Abscess/inflammation | 14 | 0 | 0 | 0 | |
| Edema | 0 | 0 | 4 | 0 | |
| Histological diagnosis (*n*) | IGM (12)<br>Infection (2) | FA (47)<br>IDP (8)<br>Benign PT (6)<br>FCC (4)<br>PASH (3)<br>Adenolipoma (1) | IDC (16) | IDC (27)<br>MBC (26)<br>IPC (5)<br>MPC (2)<br>ACC (1)<br>Malignant PT (1)<br>Sarcoma (1) | |

Abbreviations IGM: Idiopathic Granulomatous Mastitis. FA: Fibroadenoma. IDP: Intraductal Papilloma. PT: Phyllodes tumor. FCC: Fibrocystic change. PASH: Pseudoangiomatous Stromal Hyperplasia. IDC: Invasive Ductal. MBC: Mucinous Breast Carcinoma. IPC: Intraductal Papillary Carcinoma. MPC: Metaplastic Carcinoma. ACC: Adenoid cystic carcinoma.
[a] Benign and malignant inflammatory lesions showed significantly higher rate of skin edema than non-inflammatory lesions.

cancers and differentiate them from benign lesions [10,11]. Authors also report the value of using non-contrast T2 weighted imaging (T2WI) in this context [12–14].

DWI is another promising MR imaging tool for the diagnosis of breast lesions [15]. DWI is usually evaluated combined with T2WI or short tau inversion recovery (STIR) sequences [16,17]. Benign inflammatory lesions usually contain abscesses or inflammatory fluid components showing high signal intensity (SI) on T2WI (High T2 SI) with a low apparent diffusion coefficient (ADC) value calculated from DWI scans [18]. While breast cancers may have High T2 SI components due to necrosis, extracellular matrix, edema or cystic components [19,20], the ADC value of the necrotic/edematous/cystic component is not predicted to be as low as an abscess or cystic fluid. Therefore, the ADC value of High T2 SI areas within breast lesions may help distinguish inflammatory breast lesions as benign or malignant, reasoning that the ADC value of the T2 bright region would be low in benign inflammatory lesions and high in malignant inflammatory lesions.

The purpose of our study is to evaluate the diagnostic performance of T2 weighted and diffusion weighted MR images to distinguish benign inflammatory lesions from other breast lesions, especially from malignant inflammatory lesions.

## 2. Materials and methods

### 2.1. Patient population

This study was approved by our institutional review board. Written informed consent was waived because of its retrospective observational nature. We retrospectively searched our 2028 consecutive breast reports from June 2008 to December 2015. Among them, there were 652 lesions with pathologically confirmed diagnosis and without presurgical systemic therapy, including 17 benign inflammatory, 174 benign non-inflammatory, 16 malignant inflammatory and 445 malignant non-inflammatory lesions. Among the 652 lesions, we identified 162 (24.8%, 162/652) lesions that met the following criteria; 1) contains an evaluable (> 1.0 cm in diameter) component of T2WI high signal intensity (High T2 SI), i.e. equal to water signal intensity on T2WI, and 2) the High T2 SI area demonstrated signal intensity equal to or lower than surrounding breast tissue on non-contrast T1 weighted images (T1WI) to exclude fat containing lesions and subacute hematomas. These 162 lesions comprise the study. They were an average of 3.5 cm in size, range 1.0 cm to 14 cm, median size 2.5 cm.

### 2.2. MRI acquisition

MRI was performed on Trio Tim 3.0 Tesla Scanner (Siemens AG, Erlangen, Germany) with 16 channel dedicated breast coil or Avanto 1.5 Tesla Scanner (Siemens AG, Erlangen, Germany) with 4 channel dedicated breast coil.

The 3.0-T MRI with 16 channel coil parameters were as follows: T2WI (axial orientation; 2D-turbo spin echo with fat suppression; repetition time/echo time [TR/TE], 5500/77 ms; FOV, 330 × 330 mm; matrix, 448 × 336; thickness, 3.0 mm), T1WI (axial orientation; volumetric interpolated breath-hold examination [VIBE]; TR/TE, 4.83/2.45 ms; FOV, 330 × 330 mm; matrix, 448 × 399; thickness, 1.5 mm), diffusion-weighted images (DWI) (axial orientation; single-shot echo planar imaging [EPI]; TR/TE, 7000/62 ms; FOV, 330 × 160 mm: matrix, 166 × 80; thickness, 3.0 mm; NEX, 3), T1-weighted DCE images scanning at pre-contrast state and at 0–1, 1–2 and 5–6 min after gadolinium injection (axial orientation; VIBE with fat suppression; TR/TE, 3.70/1.36 ms; flip angle [FA], 15°; FOV, 330 × 330 mm; matrix, 384 × 346; thickness, 1.0 mm).

The 1.5-T MRI with 4 channel coil parameters were as follows: T2WI (axial orientation; 2D-turbo spin echo with fat suppression; TR/TE, 5500/83 ms; FOV, 330 × 330 mm; matrix, 448 × 336; thickness, 3.0 mm), T1WI (axial orientation; VIBE; TR/TE, 7.33/4.76 ms; FOV, 330 × 330 mm; matrix, 448 × 358; thickness, 1.5 mm), DWI (axial orientation; single-shot EPI; TR/TE, 9000/78 ms; FOV, 330 × 165 mm: matrix, 150 × 72; thickness, 3.0 mm; NEX, 3), T1-weighted DCE images scanning at pre-contrast state and at 0–1, 1–2 and 5–6 min after gadolinium injection (axial orientation; VIBE with fat suppression; TR/TE, 4.00/1.43 ms; FA, 15°; FOV, 330 × 330 mm; matrix, 448 × 336;