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Diagnostic performance of apparent diffusion coefficient and quantitative kinetic parameters for predicting additional malignancy in patients with newly diagnosed breast cancer

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ABSTRACT

Purpose: To evaluate the diagnostic performance of an apparent diffusion coefficient (ADC) and quantitative kinetic parameters in patients with newly diagnosed breast cancer.
Materials and Methods: We enrolled 169 lesions in 89 patients with breast cancer who underwent dynamic contrast-enhanced MRI (DCE-MRI) and diffusion-weighted imaging (DWI). Comparisons between benign and malignant lesions were performed for lesion type (mass or nonmass-like enhancement), size (≥1 cm or <1 cm), ADC, kinetic parameters and the presence of a US correlate.
Results: There were 63 benign and 106 malignant lesions. The mean size and initial peak enhancement of the benign lesions were significantly lower than those of malignant lesions ($P < 0.001$ for both). The ADC of the benign lesions was significantly higher than that of malignant lesions (1.42×10^{-3} mm^2/sec vs. 1.04×10^{-3} mm^2/sec; $P < 0.001$). The area under the receiver operating characteristic curve (AUC) for predicting malignancy was 0.87 for the combined parameters of size, ADC, and initial peak enhancement, which was higher than those of each parameter.
Conclusions: Combination of quantitative kinetic parameters and ADC showed higher diagnostic performance for predicting malignancy than each parameter alone for the evaluation of patients with breast cancer.

1. Introduction

Magnetic resonance imaging (MRI) is increasingly being used to examine patients with suspected breast cancer. More specifically, breast MRI has influenced the surgical staging of breast cancer by enabling the identification of multifocal and multicentric cancers of the ipsilateral and/or contralateral breast [1]. Dedicated 1.5-T breast MRI is reported to have a high sensitivity (92%) and relatively high specificity (88.8%). However, there was still relatively high false-positive rate of 11.2% [2]. To improve the specificity of breast MRI, several strategies have focused on either lesion morphology [3] or enhancement kinetics [4]. Higher specificity has been achieved by integrating the morphologic and kinetic information obtained with MRI [5].

In addition, several studies have investigated the role of advanced MRI techniques, such as diffusion-weighted imaging (DWI), to improve the specificity of MRI for the evaluation of breast lesions [6–11]. DWI is a useful non-contrast-enhanced MRI sequence that measures the mobility of water molecules in vivo and provides functional information complementary to dynamic contrast-enhanced MRI (DCE-MRI). Several studies have reported that there were differences in the apparent diffusion coefficients (ADCs) between benign and malignant breast lesions [7,9–15]. However, the results were inconsistent among the various reports and suffer from the lack of standardization [7,9–15].

Houssami et al. [16] reported in their meta-analysis of 19 previous studies that MRI staging of breast cancer caused more extensive breast surgery in a significant proportion of women by identifying additional cancer. Recently, there has been a growing interest in reducing the numbers of unnecessary and extensive surgeries by improving the specificity of DCE-MRI in patients with newly diagnosed breast cancer. To our knowledge, few previous studies have assessed the role of DWI in addition to DCE-MRI in

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evaluating preoperative patients with newly diagnosed breast cancer [13,15,17]. We hypothesize that DWI could improve the specificity of DCE-MRI and reduce the number of false positives, particularly in the preoperative staging of breast cancer. Therefore, the purpose of our study was to evaluate the diagnostic performance of the apparent diffusion coefficient (ADC) on diffusion-weighted imaging (DWI) and quantitative kinetic parameters on DCE-MRI for predicting malignancy in patients with newly diagnosed breast cancer.

2. Materials and methods

2.1. Patients

Our institutional review board approved this retrospective study and the requirement for patients' informed consent was waived because of the retrospective design. From June 2010 to January 2011, a total of 1178 patients with breast cancer underwent preoperative DCE-MRI. There were 94 patients (94/1178, 8%) who had additional suspicious lesions detected on DCE-MRI. When additional suspicious lesions were found on DCE-MRI, we performed second-look ultrasound (SLUS). If additional suspicious lesions were visible on SLUS, the patient underwent a core biopsy or surgical excision. In this case, we considered that this lesion had a US correlate on SLUS. However, if these lesions were not visible on SLUS, we performed a follow-up examination because our institution does not routinely undergo MR-guided biopsy. We included only patients with at least 12-month follow-up. We excluded patients from the study who (a) were not evaluated with SLUS even if there were additional suspicious lesions on DCE-MRI, (b) who underwent neoadjuvant chemotherapy or a recent surgical procedure in the breast that harbored the lesion(s) within 3 months, or (c) those whose metallic clips from the previous surgery were present in the breast harboring the lesion. Among 94 patients, 89 patients (89/94, 95%) had SLUS results while 5 patients (5/94, 5%) did not have SLUS results. Finally, we selected 89 patients (mean age, 44 years; range, 18–69 years) with 169 lesions who underwent DCE-MRI and DWI for preoperative staging of newly diagnosed breast cancer and also performed SLUS (Fig. 1). Of 169 lesions, pathologic results were available in 164 (97%) lesions, and follow-up information was available in the remaining 5 (3%) lesions (mean, 16 months; range, 13 to 20 months). Among them, 17 (17/169, 10%) lesions were biopsy-proven malignant masses, 79 (79/169, 47%) lesions were additionally detected on preoperative DCE-MRI, and 63 (63/169, 37%) lesions were benign. A total of 90 lesions were histologically proven malignant lesions through biopsy or surgery.

2.2. DCE-MRI and diffusion-weighted imaging acquisition

DCE-MRI was performed using a 1.5-T MR scanner (Magnetom Avanto; Siemens Medical Solutions, Erlangen, Germany). The body coil was used as the transmitter, and a dedicated 16-channel phased-array breast coil (Siemens Medical Solutions, Erlangen, Germany) was used as the receiver. Bilateral breast imaging was performed with the following protocol: an axial short inversion time inversion–recovery (STIR) sequence (TR/TE, 4400/74 msec; inversion time, 130 msec; 5 mm thickness; field of view, 340×340 mm^2; matrix size, 224×448; acquisition time, 134 seconds); a 3D T1-weighted fast low-angle shot (FLASH) dynamic gradient-echo sequence (TR/TE, 5.0/2.4 msec; flip angle, 10°, 0.9 mm thickness; $0.9 \times 0.9 \times 0.9$ mm^3 isotropic voxel; one non-contrast-enhanced and five contrast-enhanced acquisitions with a temporal resolution of 61 seconds, and an IV bolus injection of 0.2 mL/kg gadopentetate dimeglumine (Magnevist, Bayer Schering Pharma, Berlin, Germany) was administered using an MR-compatible power injector (Spectris; Medrad, Pittsburgh, PA) with a flow rate of 1 mL/sec followed by a 20-mL saline flush. An axial 3D delayed contrast-enhanced turbo spin echo pulse sequence (TR/TE, 767/12 msec, FOV 350×350 mm^2, matrix size, 250×384, slice thickness 5 mm) was used for the evaluation of supraclavicular and axillary lymph nodes.

Postprocessing consisted of standard subtraction (enhanced minus non-contrast-enhanced images) for all the dynamic phases and maximum-intensity projection images. Lesion diameters were measured on the first or second subtracted axial image and on the sagittal reconstruction image. The largest of these diameters was considered to be a measure of lesion size on MR.

DWI was performed before the DCE-MRI acquisition in an axial plane using a 2D spin echo–echo planar imaging (SE-EPI) sequence with a parallel acquisition technique (generalized autocalibrating

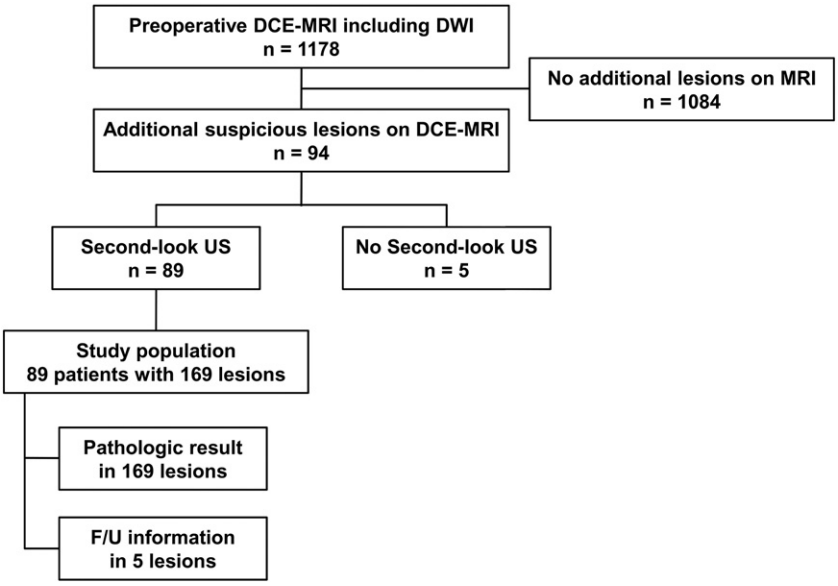

Fig. 1. Flowchart of study population selection.