Quantitative Diffusion Weighted Imaging of nonpalpable breast lesions at 3T

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INTRODUCTION

MRI of the breast approaches 100% sensitivity and 70% specificity for the detection of invasive breast tumors. Although many different strategies have been proposed to increase the specificity of breast MRI (calculating morphological, enhancement and perfusion parameters, increasing spatial resolution), noninvasive imaging still does not obviate the need for tissue sampling and analysis. Diffusion Weighted Imaging (DWI) has been used in several studies for lesion detection and evaluation of the effectiveness of chemotherapy. Standard methods for calculating the Apparent Diffusion Coefficient (ADC) are corrupted by perfusion effects in low b-value diffusion scans. In this study, multiple b-values were used to calculate the ADC taking into account perfusion contributions in the attenuation of the diffusion weighted signal intensity. A high field system (3T) was used in conjunction with a parallel acquisition protocol (SENSE). The aim of this study was to assess the feasibility of DWI for the characterization of small, nonpalpable suspicious breast lesions (benign, in situ, malignant).

MATERIALS & METHODS

Subjects Nineteen patients with nonpalpable suspicious breast lesions detected on X-ray mammography were included in this study. All patients underwent biopsy after MRI to confirm the diagnosis by histology. Exclusion criteria were age below 18 or above 75 years, previous breast surgery or radiation therapy of the breast less than 9 months prior to inclusion and contraindications for MRI. Written informed consent was obtained from all patients and the study was approved by the ethical board of our institution.

Data acquisition Images were acquired on a 3-T whole body system (Achieva, Philips, Best, The Netherlands). Patients were scanned in prone position. Signals were acquired using a 4-channel bilateral open breast coil (MRI devices, Würzburg, Germany). From our research MR mammography scan protocol, the post-contrast T1-weighted series covering the whole breast was used in this study to identify and localize the lesions and the DWI series for the ADC calculations. The DWI series was a single-shot echo planar imaging (EPI) sequence with four b-values: 0, 150, 499 and 1500 sec/mm^2. The most important scan parameters are listed in table 1.

Data analysis A region of interest (ROI) was placed in the lesion on the T1-weighted images. This ROI was superimposed on the diffusion weighted images; the signal intensity was averaged over the ROI for each b-value to provide data for calculating the ADC within the lesion. A non-linear least squares fit method (Marquardt–Levenberg) was used to fit the following function $S(b) = S_0 \cdot e^{-b \cdot ADC}$ to the data using data points at three b-values 150, 499 and 1500, with S_0 and ADC as fit parameters (1, 2). To estimate the influence of perfusion effects, the measured signal intensity at b=0 sec/mm^2 (S_m) was compared to the signal intensity at b=0 sec/mm^2 that was predicted by the fitted function (S_p). The difference $S_{diff} = (S_m - S_p) / S_p$ was calculated for all patients.

RESULTS

Quality of the scans One patient was excluded due to motion artifacts. Fat-suppression was not successful in one case but this did not compromise the ADC calculation.

Subjects Twenty lesions were detected in 18 patients. Mean age of the patients was 55 years (range 39 – 73 years). Size of the lesions ranged from 5 mm to 30 mm (mean 11 mm). Histology of the lesions showed 5 invasive carcinomas, 5 in situ carcinomas and 10 benign lesions (4 cysts, 3 fibroadenomas, 3 fibrocystic change).

ADC & S_{diff} The mean ADC value and the S_{diff} for invasive carcinomas, in situ lesions and benign lesions are listed in table 2.

CONCLUSION Quantitative DWI of the breast at 3T is feasible. Our results showed a clear difference in average ADC values and S_{diff} between benign and malignant lesions, therefore we believe that DWI could be of interest to increase the specificity of MR mammography. Judging by our results, characterization of DCIS lesions is more challenging. To evaluate the added value of DWI to contrast enhanced MR mammography, a large clinical study is being performed.

Table 1 Main scan parameters

	DWI	Post-contrast T1w
TE / TR (msec)	61 / 5000	1.77 / 4.7
Flip angle	90	5
FOV (mm2)	320	320
Acq voxel size (mm^3)	2.22 / 2.52 / 4.00	0.63 / 0.63 / 4.00
Rec voxel size (mm^3)	1.33 / 1.33 / 4.00	0.63 / 0.63 / 4.00
scan duration (min)	8.30	2.02

Table 2 Results: ADC values and S_{diff}

	Mean ADC (range)	Mean S_{diff} (range)
Invasive lesions	$0.669 \cdot 10^{-3}$ mm^2/s ($0.508 \cdot 10^{-3}$ – $0.941 \cdot 10^{-3}$ mm^2/s)	0,054 (-0,030 - 0,085)
In situ lesions	$1.120 \cdot 10^{-3}$ mm^2/s ($0.805 \cdot 10^{-3}$ – $1.834 \cdot 10^{-3}$ mm^2/s)	0,094 (0,027 - 0,152)
Benign lesions	$1.390 \cdot 10^{-3}$ mm^2/s ($0.683 \cdot 10^{-3}$ – $2.213 \cdot 10^{-3}$ mm^2/s)	0,122 (-0,050 -0,505)

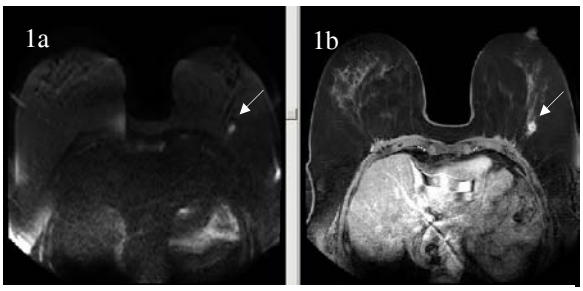

Figure 1a DWI (b=1500) and *1b* post-contrast T1 weighted image of a patient with invasive carcinoma

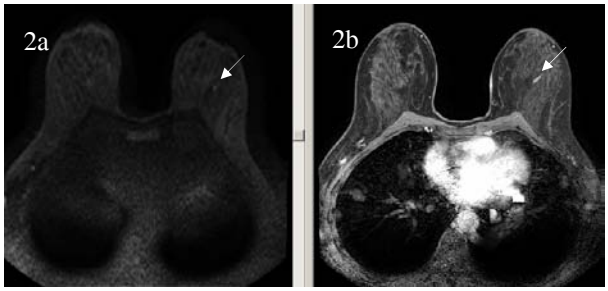

Figure 2a DWI (b=1500) and *2b* post-contrast T1 weighted image of a patient with in situ carcinoma

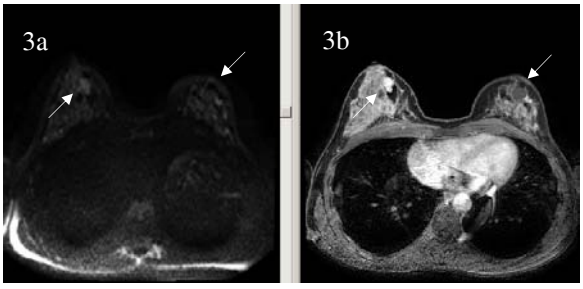

Figure 3a DWI (b=1500) and 3*b* post-contrast T1 weighted image of a patient with benign lesions (left cyst; right fibroadenoma)

References 1. Le Bihan D, Breton E, Lallemand D, Aubin ML, Vignaud J, Laval-Jeantet M. Separation of diffusion and perfusion in intravoxel incoherent motion MR imaging. Radiology. 1988 Aug;168(2):497-505. 2. Thoeny HC, De Keyzer F, Boesch C, Hermans R. Diffusion-weighted imaging of the parotid gland: Influence of the choice of b-values on the apparent diffusion coefficient value. J Magn Reson Imaging. 2004 Nov;20(5):786-90.