Magnetization transfer imaging of breast cancer at 3T

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Introduction: Magnetization transfer imaging (MTI) has been used to study various pathologies associated with changes in macromolecular contents, such as demyelination in the white matter (1). It has also been used to characterize breast tissues (2). Recently, it was reported that the MT ratio (MTR) of malignant breast cancer lesion was significantly lower than that of benign lesion at 1.5T (3). Since the contribution of MT effect in MTR increases with the magnetic field strength (4), it can be expected to observe bigger differences between the tissues at higher fields, such as 3T which becomes more popular worldwide. However, to our knowledge, there has not been a report on in vivo MTI of the breast at 3T. Hence, the purpose of our study was to investigate the feasibility of using MTR to differentiate different breast tissues with the patients undergoing diagnostic MRI scans.

Materials and Methods:

MRI data were acquired using a whole body Siemens 3T Tim Trio system and a 7-element breast coil. Following routine diagnostic scans including contrast-enhanced MRI (approximately 15 min after contrast injection), MTI and 3-point Dixon imaging were conducted for patients (n = 18) who had an abnormality detected on mammography. For MTI, a 3D FLASH sequence was used with TR = 32 ms, TE = 2.37 ms, FA = 10º, iPAT = 2 and spatial resolution = 1.2 x 1.2 x 2 mm covering the entire breast. This sequence was run three times; first one without a MT saturation pulse, second one with a MT saturation pulse (500º effective pulse angle at 1.2 kHz off-resonance for 10 ms), and third one without a MT saturation pulse, for a total of 5 min. The average of the first and third scans was used as the MT-off image, in order to minimize the effect of the slow washout of the contrast agent. MTR was calculated as the difference between MT-on and MT-off, divided by MT-off.

Three-point Dixon imaging was performed to have water image with good fat suppression and to select the lesions with similar degree of water/fat ratio as the breast density varies substantially from patient to patient. A 3D FLASH sequence was used with TR=7.6 ms, FA=10º, iPat=2, bandwidth = 680 Hz/pixel, and spatial resolution = 1.2 x 1.2 x 2 mm covering the entire breast. This sequence was run three times with three different TEs; 3.37 ms, 4.17 ms, and 4.96 ms. The water and fat images were reconstructed using Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares (IDEAL) method (5). The total scan time for both MTI and Dixon imaging was approximately 9 min.

The Dixon images were co-registered to MT images using SPM (UCL, UK). Regions of interest (ROI) were drawn on the Dixon water images for fat, muscle (pectoralis major), fibroglandular (FG), fibrocystic (FCC, n=10), and breast cancer (BC, n=14) tissues. The significance of the difference between ROIs was tested using a two-tailed t-test with unequal variance. The institutional review board approved this study, and written informed consent was obtained from all subjects before the scans.

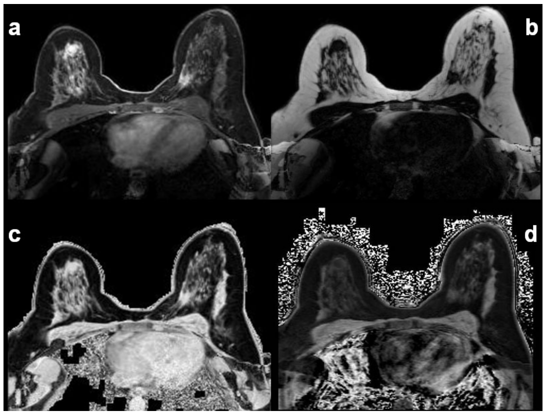

Figure 1. Representative images acquired from a 48-year-old woman with known metastatic left breast cancer. (a) water, (b) fat, (c) water fraction, (d) magnetization transfer ratio (MTR).

Results and Discussion:

Fig.1 shows representative images used in this study. Fig.1a and 1b show good separation of water and fat across the entire breast and surrounding regions. Water fraction shown in Fig.1c was estimated as water/(water+fat). Fig.1d shows an MT ratio map.

Comparisons of different breast tissues in terms of water fraction and MTR are shown in Fig.2. Fat tissue had less than 10% of water fraction as well as MTR. The water fractions of the other four tissues (muscle, FG, FCC, and BC) were about 80 ~ 90% and did not show any significant ($p > 0.05$) difference between them, as shown in Fig.2a. Fig.2b shows the MTR of the breast tissues. The MTR of muscle (41.8 ± 8.1 %) was significantly ($p < 0.01$) higher than that of FG (33.1 ± 5.6 %). The MTR of FG was significantly ($p < 0.01$) higher than that of FCC (23.6 ± 3.4 %). The difference in MTR between FCC and BC (20.1 ± 4.2 %) was marginally significant ($p=0.04$). In addition, MT images were able to accentuate the differences in signal intensities in normal structures in the breasts.

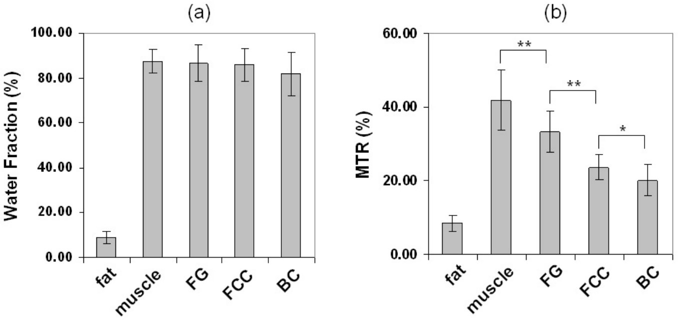

Figure 2. Comparison of water fraction (a) and magnetization transfer ratio (b) in fat, muscle, fibroglandular (FG), fibrocystic change (FCC) and breast cancer (BC) regions. ** and * denote $p < 0.01$ and $p < 0.05$, respectively, from a two-tailed t-test with unequal variance.

The result of this study with a small cohort of patients (n = 18) is consistent with that reported by Bonini et al. (3). The Diagnostic value of MTR at 3T will be assessed further with a larger number of patients in future.

Reference: **1**. Grossman et al., Radiographics1994; 14:279-290. **2**. Callicott et al., Phys. Med. Biol. 1999; 1147-1154. **3**. Bonini, MRM 2008; 59:1030-1034. **4**. Henkelman, NMR Biomed 2001; 14:65-76. **5**. Reeder et al., MRM 2005; 54:636-644.