Magnetization Transfer Imaging and Dynamic Contrast Enhanced Imaging of Breast Cancer at 3T

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Introduction: Dynamic contrast enhanced (DCE)-MRI has been used for breast tumor assessment with promising results (1). But recent studies show that the specificity of DCE-MRI is highly variable (1,2). Hence, the purpose of our study was to evaluate the feasibility of using magnetization transfer imaging (MTI) to improve the differentiation between malignant and benign lesions. MTI has been used to study various pathologies associated with changes in macromolecular contents, such as demyelination in white matter (3). It has also been used to characterize breast tissues (4). Recently, it was reported that the MT ratio (MTR) of malignant breast cancer lesion was significantly lower than that of benign lesions at 1.5T (5). In this study, we investigated the feasibility of using both MTI and DCE-MRI for differentiation of benign and malignant lesions in the same cohort at 3T.

Materials and Methods:
MRI data were acquired from patients (n = 36) who had an abnormality detected on mammography, using a whole body Siemens 3T Tim Trio system and a 7-element breast coil. DCE-MRI using a 3D VIBE sequence (resolution 1.4 x 0.9 x 1.5 mm) was acquired for these patients with five consecutive frames (duration 1:30 each) and administration of Gd-DTPA contrast agent after the first frame. The percent increase of the signal between the first and second images was calculated and referred to as Initial Enhancement Ratio (IER). The percent increase of the signal between the first and the fifth images was calculated and referred to as the delayed enhancement ratio (DER). Following routine diagnostic scans including DCE-MRI (approximately 15 min after contrast injection), MTI was conducted for using a 3D FLASH sequence 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. Dynamic contrast enhanced images were co-registered to MT images using SPM (UCL, UK). Regions of interest (ROI) were drawn on the post-contrast images for adipose tissue (FAT), pectoralis muscle (PM), fibroglandular (FG) benign lesions (BL, n=20), and malignant lesions (ML, n=27). ML include pathology proven invasive ductal carcinoma (n=9), ductal carcinoma in situ (n=8) and mixed pathology (invasive ductal carcinoma and ductal carcinoma in situ, n=10). BL include pathology proven fibrocystic change (FCC, n=18) and fibroadenoma (FA, n=2). The significance of the difference between ROIs was tested using a two-tailed t-test with unequal variance. The total scan time for both MTI and DCE-imaging was approximately 12 min. The institutional review board approved this study, and written informed consent was obtained from all subjects before the scans.

Results and Discussion:
Figure 1 shows representative images used in this study; an ROI was drawn for a known cancer on the post-gadolinium images, and was used to measure MTR, IER, and DER. Figure 2a shows the MTR of the breast tissues. The difference in mean MTR between BL (22.8 ± 4.2) and ML (19.9 ± 3.5) was significant (p=0.01). The mean MTR of muscle (40.6 ± 5.3) was significantly ($p < 0.001$) higher than that of FG (29.4 ± 5.9). The mean MTR of FG was significantly ($p < 0.001$) higher than that of ML (22.8 ± 4.2). In addition, MTR images were able to accentuate the differences in signal intensities in normal structures in the breasts. Figure 2b shows the IER of the breast tissues. The mean IER of ML (77.2 ± 42.8) was significantly ($p<0.001$) higher than both the mean IER of BL (29.3 ± 22.6) and FG (10.3 ± 8.7). Figure 2c shows the DER of the breast tissues. The mean DER of ML (48.8 ±15.3) was significantly ($p<0.001$) higher than both the mean DER of BL (32.6±9.8) and the mean DER of FG (33.3±13.0). The results of this study are consistent with that reported by Bonini et al. (3) and suggest that MTR, as well as DER and IER, may be useful parameters for differentiating between benign and malignant tissues. MTR may be of potential use as the mask image in MRI clinical breast studies, decreasing the confounding factor of physiologic enhancement. Further evaluation of MTR and DCE-MRI is required to determine if these techniques can increase the specificity of breast MRI.

References: 1. **Saslow et al., CA Cancer J Clin 2007;57(2):75-89.** 2. **Kriege et al., N Engl J Med. 2004;351(5):427-37.** 3. **Grossman et al., Radiographics1994; 14:279-290.** 4. **Callicott et al., Phys. Med. Biol. 1999; 1147-1154.** 5. **Bonini, MRM 2008; 59:1030-1034.**

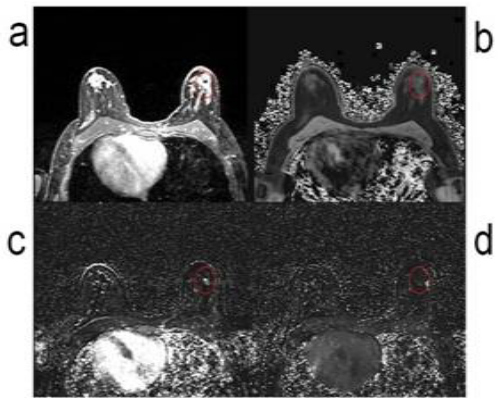

Figure 1 Representative images acquired from a 49-year-old woman with known left breast invasive ductal carcinoma:(a) post-gadolinium image (b) MTR image (c) IER image (d) DER image.

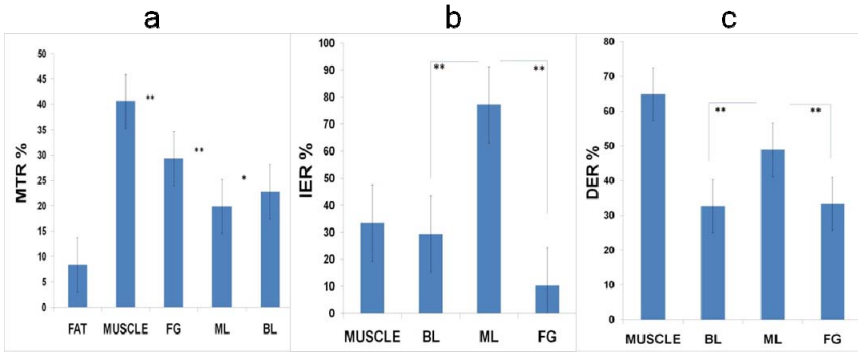

Figure 2 (a) MTR in fat, muscle, FG, ML, and BL. ** and * denote $p < 0.001$ and $p = 0.01$, respectively, from a two-tailed t-test with unequal variance**. (b)** IER in muscle, BL, ML, and FG. ** denotes $p < 0.001$ from a two-tailed t-test with unequal variance. **(c)** DER in muscle, BL, ML, and FG. ** and * denote $p < 0.001$ and $p = 0.019$, respectively, from a two-tailed t-test with unequal variance.