

Magnetization transfer imaging of the healthy breast at 3T

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Introduction

Magnetization transfer (MT) is sensitive to changes in the macromolecular content of tissue and imaging techniques that are sensitive to MT are gaining increased attention as a noninvasive approach to probe the complex tumor environment in cancer. Very few studies have examined the relationship between MT effects and breast cancer [1-2]. Bonini et al. [1] examined differences in MT effects between benign and malignant lesions at 1.5T [1]. They were able to discriminate between benign and malignant lesions but not between benign and normal-appearing fibroglandular (FG) tissue on a population level. We hypothesize that improved MT imaging performed at higher field strength will better distinguish lesions from normal tissue and between lesion types. In this study, we explore the use of MT imaging at 3T in healthy controls in the absence of exogenous contrast to establish variability in a normal population as a benchmark for future patient studies.

Methods

Six women with no history of breast disease (mean age = 32 years and age range = 24 – 44 years) were scanned. One subject was scanned twice, resulting in a total of 7 data sets. Images were acquired with a 3T Achieva MR scanner (Philips Healthcare, Best, The Netherlands), using a double-breast 4-channel sensitivity encoding (SENSE) receive coil (Invivo Inc., Gainesville, FL). MT images were acquired with a 3D gradient echo (GE) sequence with TR = 76 ms, TE = 6.9 ms, flip angle = 13°, SENSE parallel imaging (acceleration factor = 2), NSA = 3, and a 1-3-3-1 binomial pulse was applied for fat suppression. Twelve unilateral, sagittal slices were acquired with slice thickness = 5 mm (no gap), FOV = 192 x 192 mm², and in-plane resolution = 1.33 x 1.33 mm². Two image volumes were acquired in a total scan time of 2 min 17 s: a reference image with no saturation pulse applied (MT_{off}) and an MT-weighted image with a saturation pulse applied (MT_{on}) (RF offset = 1.5 kHz, duration = 25 ms, angle = 90°).

MT ratio (MTR) maps were calculated: $MTR = 1 - (MT_{on} / MT_{off})$. Regions of interest (ROIs) were defined for each slice in the MT_{off} image using a semi-automated thresholding scheme to reduce the involvement of voxels with severe partial volume averaging. Mean MTR values were calculated for the ROI covering all slices and for a single slice through the largest portion of FG tissue.

Results

Representative results from a single subject are shown: the MT_{off} image through the slice with the most FG tissue (A) and an overlay of the corresponding MTR map (B). MTR values for the single slice ROI are also plotted for each data set (C). The mean and standard deviation (SD) for each ROI are listed in the table.

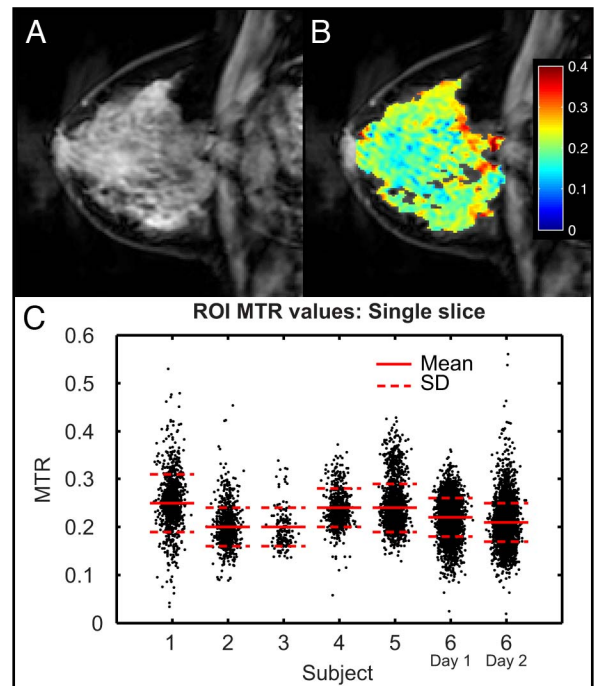
Discussion

MT imaging is potentially sensitive to microstructural changes that occur prior to macroscopic changes in gross morphology and traditional contrast mechanisms, such as T_1 and T_2 relaxation rates. In particular, the magnitude of the MT effect depends on the interaction between large, relatively immobile, semi-solid like macromolecules and bulk water. If there is a change in the macromolecular concentration of the tissue, then the MTR may reflect the change. The assessment of the variability of breast MTR imaging at 3T in healthy volunteers will allow for further studies of pathology. Additionally, it has been shown in the brain that the MT effect, while sensitive to field strength, RF irradiation, and offset frequency, when applied at higher field can provide contrast that is superior to lower field, primarily due to the increased longitudinal relaxation rate [3].

We were able to reliably produce MTR maps of healthy FG tissue with good fat suppression. Future work includes controlling for the subjects' stage within the menstrual cycle to reduce potentially confounding effects of changes in breast water content, increasing the power of the off-resonance RF pulse to increase MT effects, reducing the voxel size to reduce partial volume averaging effects, using a 2D sequence to reduce sensitivity to subject motion, and applying the technique in an ongoing longitudinal, multiparametric study of treatment assessment in breast cancer.

Acknowledgements NCI 1R01CA129961, 1U01CA142565

References 1) Bonini et al., MRM 2008; 59:1030. 2) Kim et al., ISMRM 2010, 4745. 3) Smith et al., MRM 2006; 56:866.



Subject	MTR (mean \pm SD)	
	Single slice	All slices
1	0.25 \pm 0.06	0.26 \pm 0.05
2	0.20 \pm 0.04	0.20 \pm 0.04
3	0.20 \pm 0.04	0.22 \pm 0.04
4	0.24 \pm 0.04	0.25 \pm 0.04
5	0.24 \pm 0.05	0.25 \pm 0.05
6 (Day 1)	0.22 \pm 0.04	0.23 \pm 0.04
6 (Day 2)	0.21 \pm 0.05	0.22 \pm 0.05
All	0.22 \pm 0.05	0.23 \pm 0.05