

# Multiparametric MR measurement of menstrual variation in the breast

S. Kim<sup>1</sup>, L. Moy<sup>1</sup>, M. C. Pike<sup>2</sup>, A. Zeleniuch-Jacquotte<sup>3</sup>, and T. Clendenen<sup>4</sup>

<sup>1</sup>Center for Biomedical Imaging, Radiology, NYU School of Medicine, New York, NY, United States, <sup>2</sup>Preventive Medicine, USC Keck School of Medicine, Los Angeles, CA, United States, <sup>3</sup>Environmental Medicine, NYU School of Medicine, New York, NY, United States, <sup>4</sup>Epidemiology, NYU School of Medicine, New York, NY, United States

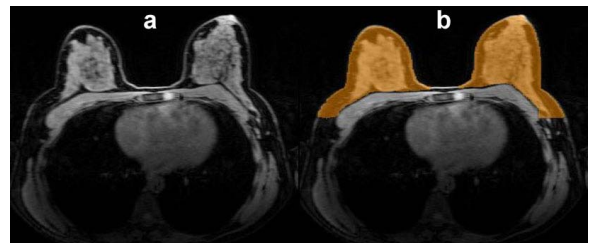
## Introduction:

MRI has been used to study variation in breast volume (1), T2 relaxation time (2), and apparent diffusion coefficient (ADC) (3) throughout the natural menstrual cycle, often with the goal of identifying the optimal time for diagnostic imaging. However, in light of the strong association between mammographic density and breast cancer risk, characterization of the MRI breast changes observed during the menstrual cycle may allow us to assess the effect of hormones on breast tissue composition. MRI is an ideal tool for collecting multiple images from the same woman during each week of a single menstrual cycle, especially from young average-risk women (<40 years of age), for whom mammograms are not recommended. The purpose of this study was to develop a multiparametric MRI method to investigate magnitude and timing of various breast changes during the menstrual cycle.

## Materials and Methods:

Five healthy premenopausal women (ages 24-31) were scanned once a week for four weeks. MRI data were acquired using a whole body Siemens 3T Tim Trio system and a 7-element breast coil. Three-point Dixon imaging was performed using a 3D FLASH sequence with TR=7.6 ms, FA=10°, iPAT=2, bandwidth = 680 Hz/pixel, and spatial resolution = 0.9 x 0.9 x 1.5 mm covering the entire breast. Three TEs were 3.37, 4.17, 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 (1). T2 relaxation time was measured using a fast spin echo sequence (TR = 3.15 s) with four echoes at 25, 50, 75 and 100 ms. ADC was measured using a twice-refocused, bipolar gradient single-shot turbo-spin echo (TSE) sequence with TR = 3 s, TE = 103 ms, res = 2.7 x 2.7 x 4 mm, 50 axial slices, and diffusion weighting b = 0, 100, and 500 s/mm<sup>2</sup> in single direction. For magnetization transfer ratio (MTR) measurement, a 3D FLASH sequence was used with TR = 32 ms, TE = 2.37 ms, FA = 10°, iPAT = 2, spatial resolution = 1.2 x 1.2 x 2 mm, and 104 slices of 256 x 256 image matrix covering the entire breast. This sequence was run two times; first with an MT saturation pulse (500° effective pulse angle at 1.2 kHz off-resonance for 10 ms), and again without an MT saturation pulse.

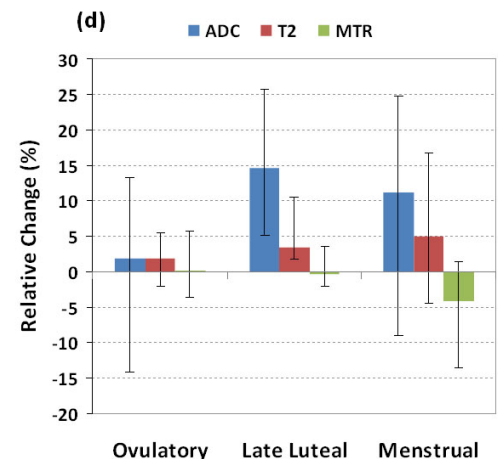
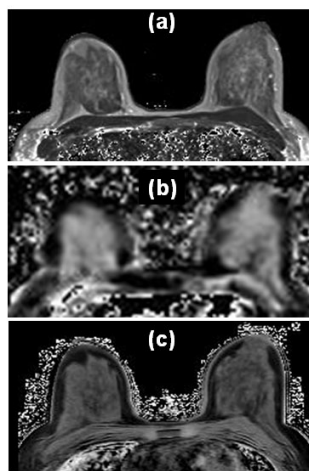
Segmentation of the breast was done with Dixon water images (Fig.1a) using an in-house developed software that detects the skin boundary and the chest wall. For each slice, the boundary of the breast generated by the software was examined by an operator and corrected if not satisfactory (Fig.1b). Within the segmented breast, a weighted average of the fibroglandular tissue per voxel was used to quantify the total amount of fibroglandular tissue. In order to select a same portion of the breast for all scans, segmentation of the breast was performed using data from one visit and the ROI from that visit was co-registered to the other three visits using SPM (UCL, UK). For each MRI scan, the co-registered ROI for the segmented breast was also co-registered to T2, ADC and MTR maps. The median values of the ROI at each week were compared with that of the follicular phase as a reference. The institutional review board approved this study, and written informed consent was obtained from all subjects before the scans.



**Figure 1.** (a) Dixon water images of one subject shows homogeneous fat suppression across the breast. (b) Segmented breast overlaid on the Dixon water image.

## Results and Discussion:

Fig.2 shows representative images (a,c,e) and the summary results (b,d,e) from five subjects. The images in Fig.2 demonstrate the challenge of selecting a region with homogeneous T2, ADC, and MTR characteristics. As a first cut analysis, median of all the voxels with water fraction  $\geq 50\%$  was used to monitor the global changes in the breast during the menstrual cycle. The median (range) of T2 from five control subjects during the reference week (follicular phase) was 63.8 ms (58.3, 76.0). As shown in Fig.2b, T2 gradually increased throughout the cycle and was 5% higher in the menstrual phase than the follicular phase. In contrast, the median ADC was highest in the luteal phase (15% greater than the follicular phase) and began to decline during menses. The median of ADC from five control subjects during the follicular phase was 1.02  $\mu\text{m}^2/\text{ms}$  (0.79, 1.34). The approximate 3-fold increase in the ADC compared with T2 during the luteal phase may suggest that the breast may not only increase in water content, but may also undergo structural changes that reduce the restriction of water diffusion. The median MTR in the follicular phase was 35.6% (29.8, 36.3). The MTR was about 4% lower in the menstrual phase than the follicular phase. This might be due to increased water content indicated by slight increase of T2 as well as other structural changes associated with substantial increase of ADC. We plan to further refine the analysis methods to investigate local changes and apply future analyses to a larger number of women.



**Figure 2.** Representative images of T2 (a), ADC(b), and MTR (c) of a subject. Plot (d) next to the images shows the relative percent difference from follicular (F) phase at the subsequent phases; ovulatory (O), late luteal (L), and menstrual (M). The error bars represents the range of the relative percent difference.

**Reference:** 1. Graham et al., JMRI 1995;5(6):696-701.

2. Hussain et al., Radiography 2008; 14:8-16. 3. Partridge et al., JMRI 2001; 14:433-438.