Reproducibility of Chemical Exchange Saturation Transfer (CEST) MRI of the Breast at 7 Tesla

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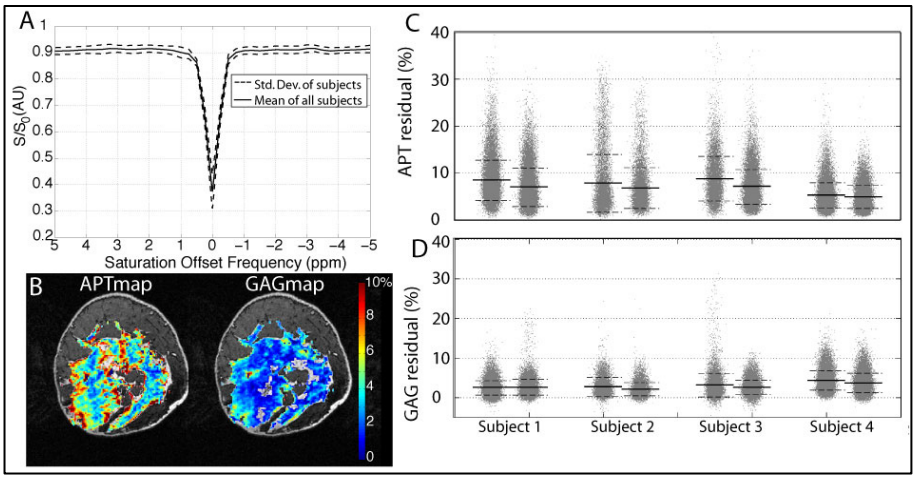
Purpose: Conventional magnetic resonance imaging (MRI) markers, such as T_1- and T_2-weighted and Gadolinium- (Gd) enhanced imaging reveal structural information, but are unable to report on the biochemical composition of tissues. Advanced MRI methods, such as dynamic contrast-enhanced imaging[1, 2], diffusion-weighted imaging[3], and spectroscopy[4] have recently been incorporated in cancer imaging protocols have resulted in potentially more specific measures of tumor pathology; however, they are limited in sensitivity, specificity, and spatial resolution. The goal of this study was to establish reproducibility of the potentially more sensitive technique of chemical exchange by saturation transfer (CEST) MRI and processing techniques for evaluation in healthy breast at 7 T.

Methods: *Image Acquisition*: A 7 T whole body MR system (Achieva, Philips Health Care, Cleveland, OH) was used for all experiments. A local transmit and receive quadrature breast coil[5] was used and the study was approved by the local IRB. Nine healthy female volunteers were scanned with four returning for a second study to assess repeatability. CEST saturation was achieved using a 25 ms windowed Gaussian pulse with 1 μT amplitude randomly arrayed between ±40 ppm. Imaging was performed using a multi-shot turbo field echo (TFE echo spacing/TE/α = 9.1 ms/2.7 ms/3.6°), over 12 slices at a resolution of 0.9 × 0.9 × 6.0 mm^3, resulting in a dynamic scan time of 10 s. Fat suppression was achieved using a 121 binomial pulse. The overall scan time was 9 min 23 s.
Data Processing: Fibroglandular (FG) tissue was masked and slices were corrected for shift, shear and scale while dynamics were registered using a 3-D affine transformation.[6] The signal intensities of S_0 ($\Delta\omega$ = 80 ppm) images, which were interspersed every 70 s, were fit and each dynamic normalized by this corrected S_0. Voxel-wise pectra were fit to a single Lorentzian and the minima of fit were used as water frequency ($\Delta\omega$ = 0 ppm). The CEST effect was quantified as the difference between the Lorentzian fit and the acquired CEST spectra. Two resonances were examined, those around the amide (3-4 ppm) and hydroxyl (1-2 ppm) protons for amide proton transfer (APT) and glucosaminoglycans (GAG), respectively.



Results – Comprehensive results are shown in Figure 1 depicting A) the mean spectra obtained from masked FG tissue over all 9 volunteers (solid line) with intra-subject standard deviation indicated by the dashed lines, B) representative APT and GAG maps, and repeatability results for C) APT and D) GAG measures. Mean (± std) for APT and GAG CEST metrics were 5.3% ± 1.6% and 2.4% ± 1.1%, respectively. The increased std in the APT measures is likely due to the low concentration of amide protons which results in noise contributing to the measured APT effect.

Discussion - These preliminary results suggest that CEST MRI measures of APT and GAG are feasible in healthy FG tissue of the breast. The overall reproducibility of the APT and GAG measures indicated no significant difference on repeated measures. The increase in SNR as well as spectral dispersion at 7 T creates a better regime for gagCEST of the breast, which has not been previously reported at lower field strengths. Furthermore, the average APT values were not significantly different from those at 3 T.[6]

Conclusion – In summary, we were able to establish the reproducibility of APT and GAG imaging of the breast at 7 T. These results ensure confidence for future studies accounting for the effects of age and stage of menstrual cycle (as potential sources of changes in breast biochemistry) on CEST-derived metrics. Using the increased information density that can be obtained at 7 T (i.e. APT and GAG), multi-parametric studies of treatment assessment in breast cancer may help to assess the prognostic value of CEST MRI.

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