Evaluating water selective DWI of the breast: A test-retest study

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Target Audience: Investigators interested in development and application of quantitative DWI of breast cancer

Purpose: Diffusion weighted imaging (DWI) provides quantitative and non-invasive assessments of cell density in breast tissue. They are valuable for the diagnosis and monitoring of treatment of breast cancer and have significant advantages over other MR metrics because they are robust and readily implemented. However, unwanted signals from abundant fatty tissue in the breast, if not suppressed adequately, can contaminate DWI measurements. This can be particularly troublesome in the context of monitoring treatment response as patients often lose weight in the course of a treatment so significant changes in fatty tissues may occur. To minimize this erroneous contribution to DWI measurements, we recently developed a water selective DWI acquisition [1] obviating the need for fat suppression using inversion recovery or pre-saturation. Instead, our method relies on image-based shimming to identify the water resonance during a pre-scan and then applies frequency selective excitation on the water resonance. In this abstract, we report a test-retest study to investigate if the added complexity of this water selective DWI method compromised reproducibility.

Methods: All *in vivo* scans were performed on a 3T whole body scanner with a 16 channel phased array breast coil (Achieva, Philips Healthcare, Best, the Netherlands). 10 healthy volunteers, with informed consent, were scanned on two separate visits for this study; 8 subjects returned for their 2nd scan in 1 or 2 days while 2 subjects returned after 7 days as permitted by their schedules. Spectrally selective excitation was implemented in a diffusion weighted spin echo (SE) sequence with a Gaussian excitation pulse (BW=200 Hz) and two adiabatic full passage (AFP) pulses. The arrangement of the diffusion gradients was adapted to one extra 180° pulse and increased crusher gradients. Other parameters were: TE/TR=76ms/1s, slice thickness=3mm, FOV=(192 mm)^2 (FH×AP), resolution=(2 mm)^2, b-factors=0, 50, 600 s/mm^2, NSA=10, scan time=1:41 min. For image-based shimming, we relied on a 3D sagittal B_0 mapping method and a numerical optimization procedure. Shimming and center frequency conditions for every scan were confirmed during pre-scan where water peak and various fat peaks were assigned according to their respective spectral locations [2].

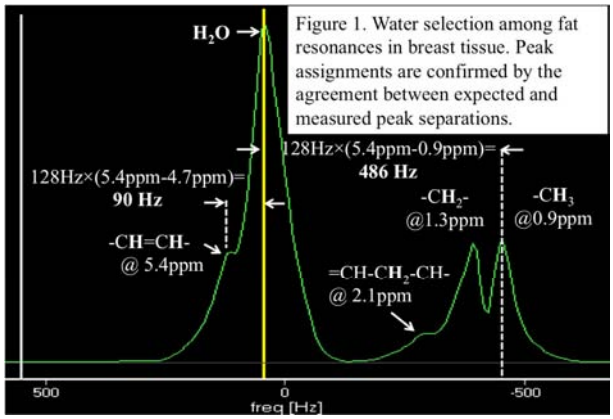

Figure 1. Water selection among fat resonances in breast tissue. Peak assignments are confirmed by the agreement between expected and measured peak separations.

Results: Figure 2 shows DWI images and ADC (mm^2/s) maps of 2 scans from one subject. Regions of interests (ROI) in ADC maps were masked using DW images. Both mean and median ADC values were calculated within the ROI for each subject. Measurements from 10 subjects are shown in 2 Bland-Altman plots in Figure 3. Mean differences, 95% CI and repeatability ranges are displayed as solid, dotted and dashed lines, respectively. Details of the statistical method can be found in [3,4].

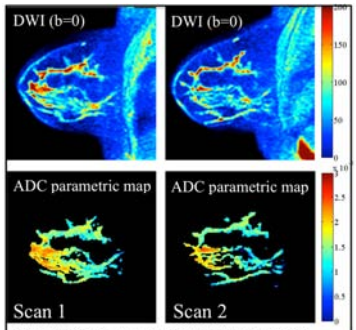

Figure 2. Example images and ADC maps of water selective DWI

Discussion: The selectivity of the water signal by this new method depends on the bandwidth of the excitation pulse and the spectral separations of various fat resonances from the water resonance relative to the residual field inhomogeneity. Human adipose tissues consist of several resonances at 0.9ppm, 1.3ppm, 2.1ppm, 2.8ppm and 5.4ppm[2]. With an excitation bandwidth of 200Hz, strong fat signals except those from olefinic protons "-C**H**=C**H**-" at 5.4ppm are excluded. The frequency separation between 5.4ppm and 4.7ppm at 3T is approximately 90Hz, which is comparable to the line width of water from a breast. This is evident in Fig.1 where the fat peak at 5.4ppm falls within the frequency range of the water signal. Therefore, excluding this fat resonance without compromising water selectivity is not feasible with our method or any fat suppression method at 3T. In addition, human adipose tissue also consists of a non-negligible amount of water [5] so we do not expect zero signal from fat regions (as shown in upper panels in Fig.2).

Regarding the ADC variations we observed, we expect the main source results from the difference between slice locations from 2 visits. As slimmer subjects have considerable room to position themselves in the coil used, duplicating the exact slice position and angle in the 2nd visit was difficult. This probably caused the small ADC variations for 8 subjects that returned in less than 2 days. For the 2 subjects that returned after 7 days, we observed the 2 highest variations in both mean and median ADC. This finding is consistent with a previous study of ADC changes with phase of the menstrual cycle [6].

Most importantly, our method differs from current DWI methods in terms of the non-spatial selective nature of the excitation. This fact eliminates the possibility of multi-slice imaging that is used in conventional DWI methods. Therefore, expanding our method to 3D acquisitions with a navigator echo such as IRIS [7] is a requirement before the water selective approach can be efficiently adopted in a clinical setting.

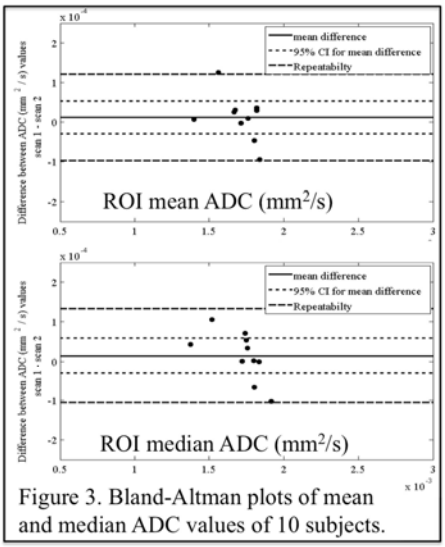

Figure 3. Bland-Altman plots of mean and median ADC values of 10 subjects.

Conclusion: The reliability of our water selective DWI method was evaluated in a test-retest study consisting 10 healthy volunteers in 2 separate visits. These results demonstrated water selective excitation as a feasible alternative to existing methods of fat suppression and the added complexity of the sequence did not reduce the reliability of the diffusion measurements.

References: [1] Zhu et al ISMRM: 3376 (2013) [2] Singer et al. J. Clin. Invest. 98: 244-250 (1996) [3] Dula et al MRM 70: 216-224 (2013) [4] Whisenant et al MRI. (In Press) [5] Baker Am. J. Clin. Nutr. 22: 829-835 (1969) [6] Elizabeth et al Eur. Radiol. 22: 1512-1518 (2012) [7] Jeong et al. MRM 69: 793-802 (2012) **Acknowledgments:** NCI 1U01CA142565 and NCI P30 CA68485