Comparison of ADC Values Using Pulsed Field Gradient and Correlation Time Diffusion Techniques in a Murine Model of Steatohepatitis at 11.7T

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Purpose: The purpose of this study was to compare the ADC values obtained using pulsed field gradient (PFG) and correlation time diffusion (CT-D) techniques in a mouse model of steatohepatitis at 11.7T.

Methods: Imaging experiments were performed using 11.7T MRI. 22 male C57BL/6 mice were divided into a control group (n=2) fed normal chow and an experimental group (n=20) fed a methionine-deficient choline-deficient (MCD) diet used to induce steatohepatitis. The experimental diet was continued for a total duration of 81 days and mice were sacrificed intermittently throughout this period for *ex vivo* liver imaging.

For PFG diffusion weighted MRI (DWI), a multi-slice spin echo image pulsed field gradient acquisition (10msTE /2000msTR) was used with three b-values of 21, 301, and 601 s/mm^2. All images of a vial containing the mouse liver sample in a bath of phosphate buffered saline (PBS) were acquired using a Bruker 11.7T scanner (BioSpin^{TM}, Ultra Shield 500MHz) NMR spectrometer with imaging capabilities and temperature control: 23.5°C was used. Within the larger 15mm vial containing the liver specimen and PBS, a 6mm vial containing PBS, free from contamination from hemorrhage, as well as olive oil was placed for use as an internal reference standard. Using the Bloembergen-Purcell-Pound relaxation theory, a formula for the diffusion coefficient as function of the proton density PD and the longitudinal relaxation time T1 was derived and a model conforming algorithm embodying this formula was implemented for computing the ADC values (1, 2, 3). This algorithm used as input PD and T1 qMRI maps generated with the mixed-TSE pulse sequence. We implemented a dual sequence version of the mixed-TSE sequence, termed here as tandem-mixed-TSE with the following parameters: pulse sequence 1, dual-echo RARE: TE_1=14ms, TE_2=27ms, TR=4000; pulse sequence 2, dual-echo RARE with inversion recovery pulse: TE_1=14ms, TE_2=27ms, TI=400ms, TR=4400ms.

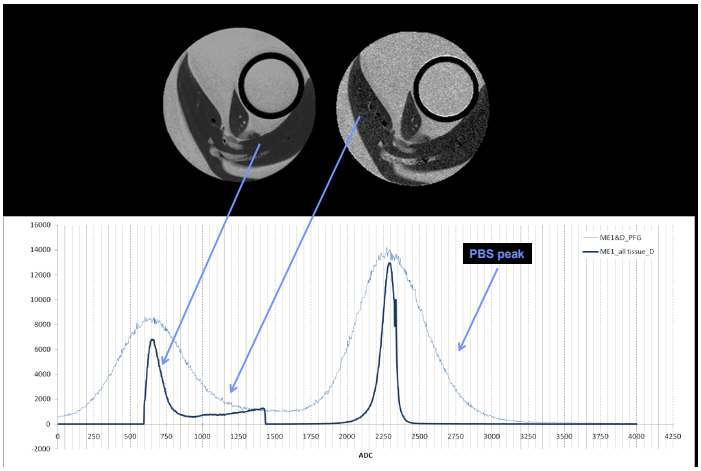

Figure 1. Comparison of ADC maps generated by CT-D (left) and PFG (right) techniques. Comparison of histograms shown below.

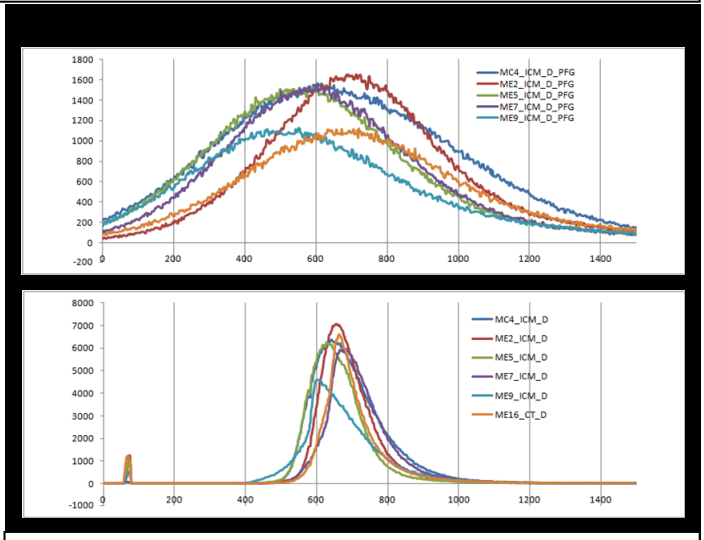

Figure 2. Comparison of whole liver ADC histograms generated by PFG-D (above) and CT-D (below) techniques.

Results: A comparison of the parametric maps and whole sample histograms generated by the PFG and CTD techniques is illustrated in Figure 1, showing excellent agreement between the two diffusion techniques for both the liver tissue centered about 0.7 10^{-3} mm^2/s and PBS centered about 2.3 10^{-3} mm^2/s. In all cases, signal to noise ratio (SNR) of the parametric maps generated by the CT-D technique (liver SNR~14) was higher than those generated by the PFG-D technique (liver SNR~2). PFG-D (top) and CT-D (bottom) histograms of several representative mice at different time points in the disease process are shown in Figure 2. In all cases, the histograms by the two diffusion techniques demonstrate shifts in same directions. CT-D histograms in all cases were found to have smaller width when compared to PFG-D technique.

Conclusion: Correlation time diffusion techniques offer an accurate methodology of generating parametric ADC maps when compared to routinely used PFG technique. Given the improvement in SNR and decreased vulnerability to non-diffusive motions, precluding the necessity of utilizing ultra-fast imaging acquisition (2), correlation time diffusion techniques offer a potential for future high-resolution *in vivo* imaging.

References

1. Bloembergen N, Purcell EM, Pound RV. Relaxation effects in nuclear magnetic resonance absorption. Phys Rev. 1948 73(7):679-1202.
2. Jara H. High spatial resolution diffusion-MRI of the human brain with the mixed-TSE pulse sequence: a non-Pulsed Field Gradient technique. Proceedings of the RSNA. Chicago, IL. 2005.
3. Jara H. Correlation time diffusion coefficient brain mapping: combined effects of magnetization transfer and water micro-kinetics on T1 relaxation. Proceedings of the ISMRM. Toronto, Canada. 2008.