Saturation recovery during whole brain CEST multi-band acquisitions

Qing Zeng[1,2], Sandeep Ganji[1,2], Joseph Gillen[1,2], David Unobskey[1,2], Linda Knutsson[2,3], Peter C. M. van Zijl[1,2], Nirbhay N. Yadav[1,2]

[1]Russell H. Morgan Department of Radiology and Radiological Science, Johns Hopkins University School of Medicine, Baltimore, MD, US, [2]F.M. Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, US, [3]Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, US

INTRODUCTION:

CEST is a powerful tool for detecting low-concentration metabolites *in vivo* with enhanced sensitivity.[1] However, the long scan time required to acquire full Z-spectra limits its wide application and this drawback deteriorates in multi-slice or 3D acquisitions. Several strategies to speed up CEST experiments of whole organs have been proposed[2] including multi-band acquisitions. However, an important consideration during these measurements is the change in saturation across the slices during the prolonged image readout. This work studies the effect of saturation recovery during a multi-band CEST experiment in the brain and proposes a solution for normalizing CEST maps based on the saturation recovery curve.

METHODS:

A 1.5 s long saturation pulse train was applied prior to a multi-band EPI readout. The pulse train consisted of 50 ms long Gaussian-shaped pulses with 0.9 μT amplitude. Scan parameters were: FOV = 220×220×118.8 mm, voxel size = 2.2×2.2×4.4 mm, TE/TR = 9.3/4000 ms. The number of slices was 27 and the multi-band factor was 3, and nine excitations were conducted. A total of 55 saturated images were acquired from -10 to 20 ppm, followed by 3 unsaturated images (S_0). The total scan time was approximately 4 min and 16 s. The B_0 inhomogeneity was corrected using the frequency of the direct water saturation. Saturation recovery was assumed to result from water T_1 relaxation, which was estimated by least-squares mono-exponential fitting of the Z-spectral signal intensities of grey matter, white matter and CSF across the slices. The fitted relaxation parameters were then used to correct the Z-spectral signal. The acquisition interval of each slice was approximately 37.2 ms, which was used in the T_1 fitting. The T_1 relaxation was fitted according to $S/S_0 = S_{max} - (S_{max} - S_{t=0})e^{-t/T1}$. Amide signal was estimated by using a Lorentzian and polynomial hybrid fitting model based on the $R_{1\rho}$ relaxation theory.[3]

RESULTS:

Figure 1 shows that the saturation changes across the slices. In Figure 1A, the maps of the fitted minima of direct water saturation show 3 groups with 9 images in each. Perhaps due to the lack of signal near the brain edge, the last 2 images are barely seen. Figure 1B shows that the signal for white matter increases within each group, indicating the loss of saturation due to water relaxation. Figure 2 shows amide maps for slice with moderate (A, B) and much (C, D) saturation loss before (A, C) and after (B, D) relaxation correction. Figures 2A-B do not show much change of amide contrast, while Figures 2C-D show significant change of amide contrast after relaxation correction.

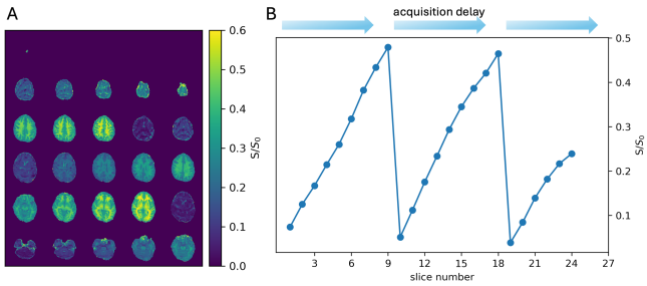

Figure 1. A. Maps of minima of the Z-spectra for all slices. B. Direct water saturation of white matter changes across the slices.

DISCUSSION:

The results show that relaxation correction improves CEST contrast in multi-slice CEST experiment. However, other factors may also contribute to the saturation loss, thus further investigation is needed. For example, the relatively high amide contrast for white matter in Figure 2D may be partially due to the MTC effect which contributes to the water relaxation.

CONCLUSION:

Saturation loss in multi-slice CEST experiment due to acquisition delay can be alleviated by relaxation correction, greatly recovering CEST contrast.

REFERENCES:

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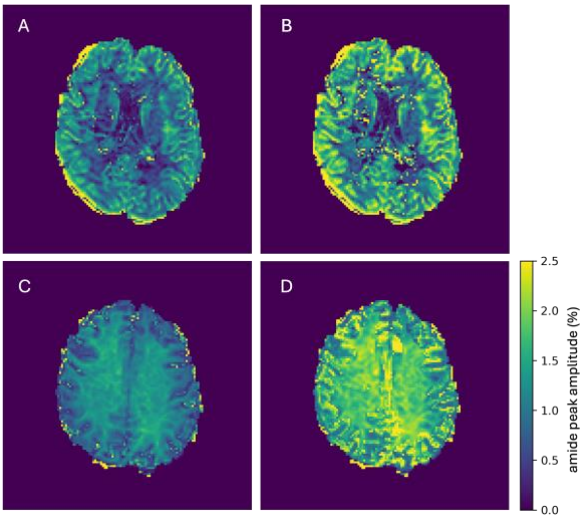

Figure 2. Amide maps for slice with little (A, B) and much (C, D) saturation loss before and after relaxation correction.