New Technique for Simultaneous Acquisition of Metabolite and Water Signals in ^{1}H-CSI

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Introduction

^{1}H chemical shift imaging (CSI), which can visualize spatial distribution of metabolites, is very useful for clinical diagnosis of tumors in early stages. However, CSI measurements are very sensitive to temporally and spatially dependent frequency shifts caused by eddy currents, and the spectrum of metabolites can be easily distorted by these frequency shifts. In order to correct the phase of metabolites, it is necessary to measure water signal as well as water-suppressed metabolite signal, which increases the measurement time. Therefore, simultaneous acquisition of metabolite and water signals is preferable. To acquire both signals simultaneously, we propose a new pulse sequence with a chemical shift selective (CHESS) pulse whose amplitude is switched alternately in accordance with phase encoding steps. In this paper, the results of phantom measurements utilizing the proposed method are presented.

Method

The pulse sequence used to detect metabolite and water signals simultaneously is shown in Fig. 1. Prior to a point-resolved spectroscopy (PRESS) CSI sequence, the polarity of each water signal is alternately reversed by a CHESS pulse, whose amplitude is switched in accordance with phase encoding steps. Only the water signal is modulated in k-space, while the metabolite signal is not affected (Fig. 2(a)). As a result, only the water signal is shifted to the top and bottom of the image that is reconstructed from the k-space data (Fig. 3(a)). Therefore, the metabolite signal is separable from the water signal by selecting a region of interest (ROI), as shown in Fig. 3(a) (red square). To prevent the aliasing of the water signal, the field of view (FOV) and the number of phase encodes of the axis along which the CHESS amplitudes are modulated should be increased twice. Next, the method for calculating the water data for the eddy current correction from k-space data is explained. First, water signals are separated according to their polarity, as shown in Fig. 2(b) and (c), and are Fourier transformed into spatial-time domain data. Then, linear phase shifts of these data are corrected. By combining these corrected data, the water signal for eddy current correction can be obtained (Fig. 3(b)). The FOV of the water image corresponds to the ROI of the metabolite image. The phase distortion of the metabolite signal caused by the eddy currents is corrected by using the calculated water signal (Fig. 3(c)).

The proposed method was applied to a phantom measurement using a round-bottom flask (17 cm dia.) containing a solution of 10 mM N-acetylalanine. All experiments were performed on a 1.5T Echelon (Hitachi, Japan). The main parameters were: TR = 1.5 s, TE = 35 ms, 2048 data points, bandwidth: 2 kHz, number of voxels: 24 x 12, FOV: 240 x 120 mm, thickness: 15 mm, voxel size: 1.5 cc, ROI after eddy current correction: 120 x 120 mm, number of voxels after eddy current correction: 12 x 12, and acquisition time: 7.2 min. The signal amplitude was evaluated by using the absolute spectra without filtering.

Results and Discussion

Figure 4(a) and (b) show spectra of metabolites with and without the water suppression technique, respectively. Each spectrum was selected from the ROI as shown in Fig. 3(a) and (b) (red square). In Fig. 4 (a), the water signal was sufficiently reduced to clearly reveal the N-acetylalanine spectrum. Figure 5(a) and (b) respectively show the N-acetylalanine spectra of the six voxels shown in Fig. 3(c) with and without eddy current correction. In Fig. 5(b), the peak shifts of the spectra were sufficiently corrected. These results demonstrate that this technique is useful for simultaneous acquisition of metabolite and water signals. Although this technique is mathematically equivalent to subtraction techniques [1,2], the simultaneous acquisition of signals has the advantage of reducing the effect of human motion on water suppression.

Conclusion

In this study, we proposed a new technique for simultaneous acquisition of metabolite and water signals in CSI. The results of phantom experiments showed the effectiveness of this technique in suppressing water signal and correcting spectrum frequency shifts caused by eddy currents, which suggest the usefulness of the proposed method.

References

[1] W. Dreher, et al., *Magn. Reson. Med.*, **54**, 190-195, 2005. [2] C. Domenig, et al., *Proc. Intl. Soc. Mag. Reson. Med.*, 14, 2006.

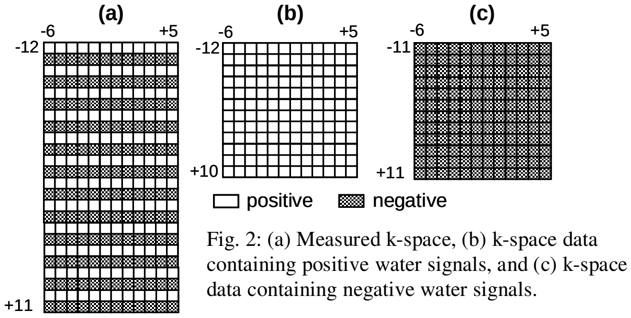

Fig. 2: (a) Measured k-space, (b) k-space data containing positive water signals, and (c) k-space data containing negative water signals.

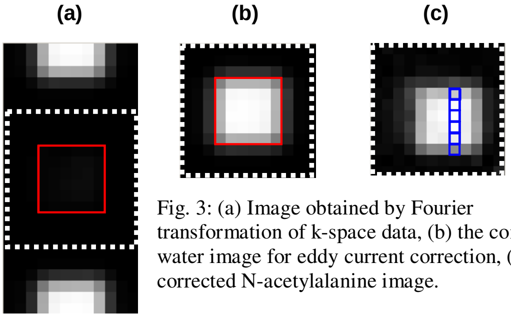

Fig. 3: (a) Image obtained by Fourier transformation of k-space data, (b) the combined water image for eddy current correction, (c) corrected N-acetylalanine image.

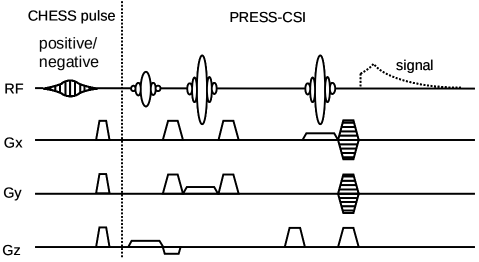

Fig. 1: Pulse sequence for simultaneous acquisition of metabolite and water signals implemented in a 1.5T head scanner.

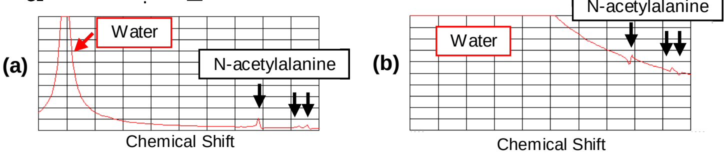

Fig. 4: CSI spectrum from region shown in Fig. 3(a) and (b). (a) Water-suppressed spectrum, (b) water-unsuppressed spectrum.

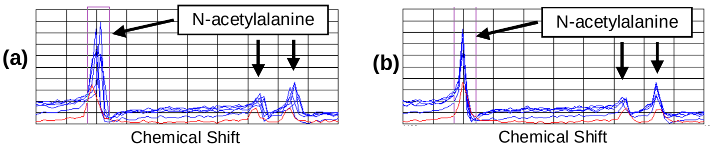

Fig. 5: CSI spectra from 6 voxels as shown in Fig. 3(c). (a) Spectra before correction, (b) spectra after correction.