Eddy Current and Motion Corrections for in vivo 2D Spectroscopy: Improvements for F_1 Noise and F_2 Distortion on 2D Localized CT-COSY Spectra of the Human Brain

H. Watanabe[1], N. Takaya[1], F. Mitsumori[1]

[1]National Institutes for Environmental Studies, Tsukuba, Ibaraki, Japan

Introduction

Two-dimensional (2D) spectroscopy which is widely used in analytical NMR spectroscopy is recently applied to *in vivo* ^{1}H MRS (1). Especially, constant time (CT) methods at high field are promising ones. CT-PRESS can resolve glutamate and glutamine in a rat's brain at 4.7 T (2) and a localized CT-COSY can resolve glutamate, GABA and glutamine in the human brain at 4.7 T (3). In the 2D spectroscopy, motion causes F_1 noise and eddy current causes distortion of spectra along F_2 direction. Since diagonal peaks for singlet have tall peak height on COSY spectra from the brain, they disturb detection of other metabolites, such as glutamate and GABA. In this work, we propose a motion correction method for *in vivo* 2D spectra. We also apply eddy current correction method (4) for 1D spectra to *in vivo* 2D spectra. We demonstrate improvements of F_2 distortion and F_1 noise on localized 2D CT-COSY spectra of the human brain.

Methods

The methods for eddy current and motion corrections for *in vivo* 2D spectra are as follows. First, eddy current correction is done by the water signal obtained with a localized sequence without water suppression. Only 1D signal along t_2 direction is acquired with a fixed t_1. The phase dependent on t_2, $\phi(t_2)$, is calculated from this data. By applying a localized 2D sequence, the data set on t_1-t_2 domain is acquired. Then, the phase of the data set is corrected by $\phi(t_2)$ along t_2 direction. As a result, the data set on t_1-t_2 domain without eddy current effects is obtained.

Since motion causes rotation of magnetization vector in the voxel due to the gradient pulses, zero-order phase is added on the F_2 spectrum at each t_1. Thus, motion correction is done as follows. First, the data set on t_1-t_2 domain after eddy current correction is Fourier transformed along t_2 direction and the data set on the t_1-F_2 domain is obtained. Second, the phase of the resonance for singlet of NAA at 2.01 ppm, $\phi_{NAA}(t_1)$, is calculated at each t_1. Next, zero-order phase correction is performed for each F_2 spectrum by using $\phi_{NAA}(t_1)$ in order to remove motion effects. Finally, the corrected data set is Fourier transformed along t_1 direction and 2D spectrum without motion effects can be obtained.

We applied the proposed methods to localized 2D CT-COSY spectra of the human brain at 4.7 T (3). After localized CT-COSY signals were acquired, Gaussian window functions for both t_1 and t_2 directions were performed and the resultant raw data were zero-filled. Next, two kinds of the human brain spectra were obtained. One was obtained via 2D FT. The other was obtained via 2D FT with the proposed post-processing methods.

Results & Discussion

Figure 1 shows the 2D CT-COSY spectra of the human brain without both of the corrections. The spectrum is displayed in a magnitude mode. The singlet peak at 2.01 ppm for NAA and the one at 3.03 ppm Cr are distorted along F_2 direction. After the eddy current correction, those distortions become less and those spectra are almost symmetrical with respect to the peaks along F_2 direction (Fig. 2).

On the spectrum without the motion correction, F_1 noises for diagonal peak of NAA and that of Cr arise (Fig. 1). After the motion correction, F_1 noises become less (Fig. 2). As a result, a cross peak between glutamate-3 at 2.1 ppm and glutamate-4 at 2.35 ppm can be clearly resolved.

Conclusions

The proposed correction methods for motion and eddy current are useful for *in vivo* 2D spectra. Eddy current correction gives us the spectrum without F_2 distortion. Motion correction allow us to obtain the spectrum with less F_1 noise. Therefore, these methods may allow us to improve quantitation and robustness of *in vivo* 2D spectroscopy.

References

1. Albert, M. T., Kenneth, Y., Binesh, N., Davanzo, P., Kumar, A., Siegel, B., Frye, M., Curran, J., Lufkin, R., Martin, P., Guze, B., *Magn. Reson. Med.*, 46, 58, 2001
2. Dreher, W., Leibfritz, D., Proc. Intl. Soc. *Mag. Reson. Med.*, 6, 357, 1998
3. Watanabe, H., Takaya, N., Mitsumori, F., Proc. Intl. Soc. *Mag. Reson. Med.*, 12, 113, 2004
4. Klose, U., *Magn. Reson. Med.*, 14, 26, 1990

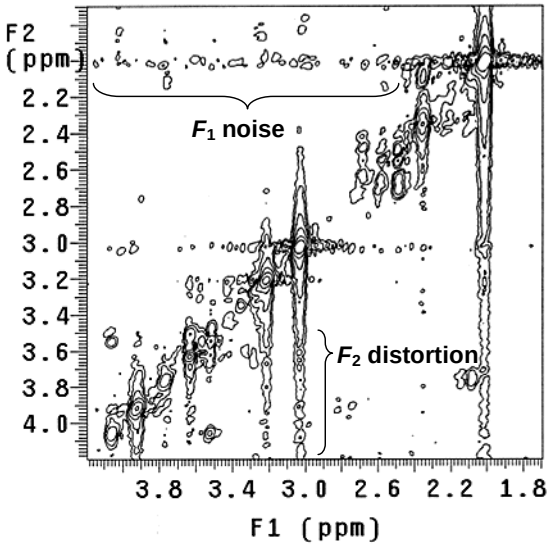

Fig. 1. A localized 2D CT-COSY spectrum of the human brain without eddy current and motion corrections.

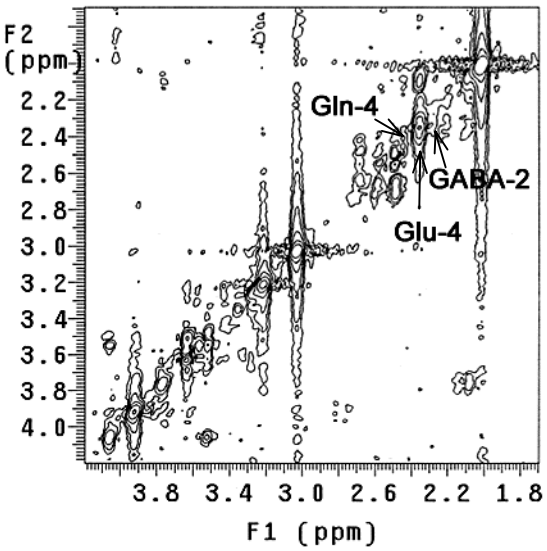

Fig. 2. The spectrum with eddy current and motion corrections.