The quantitative comparison of doing eddy current correction before and after combination for 1H MRS using phased array coils with LCModel

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Introduction

As the increasing usage of phased array coils for MR spectroscopy, a series studies regarding the determination of absolute metabolite concentrations have been proposed [1]. In the meanwhile, the reliability and accuracy of the quantification as well as combination methods with phased array coils need to be validated due to the various acquisition scheme from quadrature coil. Each element of phased array coils may be subjected to different degree of eddy currents and thus needs to be corrected individually. The purpose of this study is to demonstrate the importance of doing eddy current correction for each coil element before combination for phased array MRS data, and validate the reliability and accuracy in terms of SNR and absolute concentrations of MRS in vivo.

Material and Methods

All studies were conducted at 1.5T system (General Electric, Milwaukee, WI). Four healthy subjects (all males, age: 23 y/o) were included in this study. Localized single voxel MRS measurements were performed at temporal lobe using a PRESS sequence (TR/TE = 1600/35 ms, Ave =128, voxel size= 20x20x20mm^3) with quadrature head coil and an 8-channel receive-only phased array head coil respectively. Routine 3D T1 protocol was performed for voxel localization of MRS to ensure the identical voxel positioning for different coils (Fig.1(a)). With phased array coil, both the raw data combined by phased array coil manufactory and the raw data of each individual channel were acquired by two different modes: Spectro-Mode and Array-Mode respectively.

Spectra acquired from quadrature coil were analyzed by LCModel [2] with predefined factor of calibration for absolute concentrations. In the meanwhile, the spectra of each coil element acquired by phased array coils were underwent eddy current correction (ECC) according to [3] before being combined with weighting factors. Those weighting factors were determined by $W_i = A_{nws,i} / \sum_{i=1}^{8} A_{nws,i}$, where $A_{nws,i}$ refers to the maximum absolute value of time-domain signal without water suppression. The corrected, combined spectra were then analyzed by LCModel for water scaling procedure. On the other hand, those uncorrected, uncombined spectra were analyzed using water scaling with eddy current correction provided by LCModel. The accuracy of absolute concentrations was evaluated by $\textbf{\textit{Error = \{[M]-[M]}_{fcal}\textbf{\textit{\} / [M]}}_{fcal}\textbf{\textit{ x 100\%}}$, where $[M]_{fcal}$ is the absolute concentration quantitated by factor of calibration. SNR provided by LCModel, which is defined as the ratio of the maximum in the spectrum-minus-baseline over the analysis window to twice the RMS residuals, was used as an index of the quality for fitting as well as quantification.

Results and Discussion

Figure 1 shows the T1 MRI with voxel localization (Fig. 1(a)) and the analyzed result of the spectra acquired by quadrature coil (Fig. 1(b)), phased array coils with Spectro-Mode (Fig. 1(c)), as well as with Array-Mode, being quantitated by LCMgui (Fig.1(d)) and by Klose et al.'s eddy current correction scheme (Fig. 1(e)). Table 1 summarizes the quantitative result of 1H proton MRS acquired by quadrature coil and phased array coils, followed by quantification of calibration method and water scaling respectively. SNR is the fitting estimation provided by LCModel. The absolute concentrations in the unit of "mM" are shown in the format of "mean ± standard deviation", followed with Errors in %.

There is no difference in terms of SNR for the spectra doing eddy current correction before and after combination. However, while comparing to the absolute concentrations using quadrature coil with factor of calibration, doing eddy current correction individually for each channel results in more reliable absolute concentrations as shown in table 1. Our result shows that for those data acquired by phased array coils, eddy current correction needs to be included for each coil element individually since the MRS data of each coil element may have different phase and eddy current distortion. Moreover, doing eddy current correction before combination of each channel data will improve the accuracy of absolute concentrations and benefit the multi-center comparison in clinical applications.

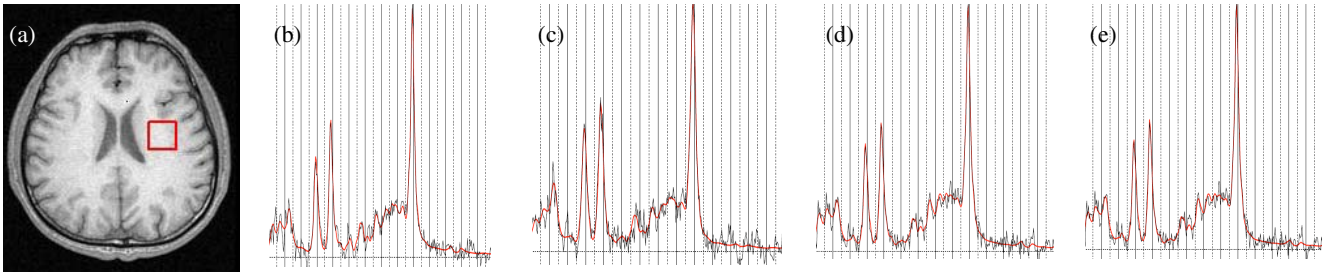

Figure 1. (a) The T1 MRI with voxel localization. The analyzed result of the spectra: (b) acquired by quadrature coil quantified by calibration method; acquired by phased array coils with: (c) Spectro-Mode, Array-Mode and (d) doing ECC after combination by LCMgui as well as (e) doing ECC for each element coil before combination.

Table 1. The quantitative results of 1H proton MRS acquired by quadrature coil and phased array coils, followed by quantification of calibration method and water scaling respectively.

	Calibration	Water Scaling		
		phased Array		
	Quadrature Coil	Spectro-Mode	Array-Mode	
			ECC after combination by LCMgui	ECC before combination
SNR	13.75 ± 1.89	11.75 ± 0.50	13.75 ± 1.71	13.75 ± 1.71
NAA+NAAG	10.71 ± 0.87	9.35 ± 0.35 (12%)	9.05 ± 0.55 (15%)	9.93 ± 0.58 (7%)
Creatine	5.65 ± 0.96	5.00 ± 0.66 (11%)	4.80 ± 0.70 (15%)	5.31 ± 0.73 (6%)
Choline	1.45 ± 0.14	1.23 ± 0.17 (16%)	1.19 ± 0.11 (18%)	1.33 ± 0.13 (9%)
Myo-Ins	3.59 ± 0.89	3.13 ± 0.35 (16%)	3.67 ± 0.84 (17%)	4.00 ± 0.87 (18%)

References

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