Development of the layered dumbbell shape phantom for MRS Quality Assurance

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INTRODUCTION

For the performance evaluation of an MR system, one-dimensional peak intensity of magnetic resonance spectroscopy (MRS) is more sensitive than image contrast and the resolution of MRI. Thus, proton MRS data generated is more reliable than MRI data concerning quality assurance (QA), and MRS can be employed for QA and quality control (QC) of an MR system. However, the use of QA methods with MRS has rarely been studied [1]. Therefore, the purpose of this study was to develop a standard MRS phantom, to establish a QA protocol with principal factors and to perform QA of an MR system.

MATERIALS AND METHODS

For the QA of MRS, seven principal factors (SNR, chemical shift, water suppression percent, line width, symmetry, VOI localization accuracy, VOI quantification and accuracy) were selected and measured. A layered dumbbell shape phantom was symmetrically designed to evaluate VOI localization accuracy and VOI quantification accuracy. (Fig. 1) Both end sides were designed open to remove air bubbles and to reduce susceptibility artifacts. The form of the phantom was made of acrylic resin and the layered dumbbell shape vial was filled with various metabolite materials (such as NAA, Cr and Cho) [2]. All experiments were performed on two 3T MRI/MRS systems (Philips: University of California, Irvine-UCI, Kyung-Hee University of Korea-KHU) with the following parameters: STEAM, TR/TE/TM = 2000/30/12 (ms), Avg. = 128, data-points = 1024, voxel size = 1 × 1 × 1, 1.5 × 1.5 × 1.5, 2 × 2 × 2 (cm). In addition, a follow-up study with a voxel size of 2 × 2 × 2 (cm) was performed during 3 months (June-September, 2007) at KHU. The SNR, chemical shift, water suppression percent, line width and symmetry were estimated analyzing the reference water peaks in "Voxel IV" as shown in Figure 2 (C) and all data was processed using jMRUI-TM -Gaussian fitting, apodization (4 Hz), and AMARES analysis methods.

RESULTS

All MRS QA factors of each MRI/MRS system were calibrated (Table 1). The relationship between metabolite signal intensity and metabolite amount using the layered dumbbell shape phantom was established. (Fig. 2) The follow-up study showed that the QA factor values in September 2007 were superior to those obtained in June 2007. (Table 1 and Fig. 3) The peaks of myo-inositol and phosphorus creatine were easily analyzed in September 2007, while they were not possible to obtain in June 2007.

Fig.1 The layered dumbbell shape phantom

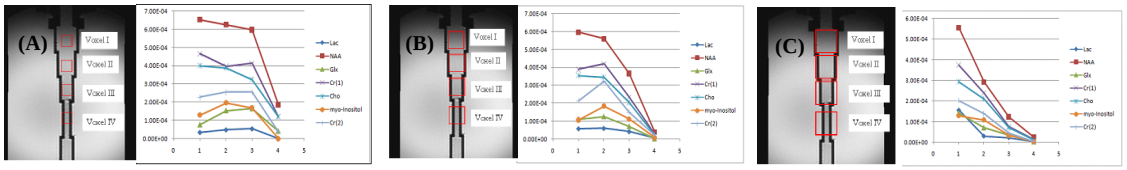

Fig.2 Voxel localization and the change of each metabolite intensity. (A) 1 × 1 × 1 cm; (B) 1.5 × 1.5 × 1.5 cm; (C) 2 × 2× 2 (cm).

DISCUSSION AND CONCLUSIONS

We propose that the principal seven MRS QA factors can be used to evaluate MR spectra as well as measure the stability of an MR system as with an MRI QA protocol [3]. The linearity between metabolite signal intensity and metabolite amount represents the relationship between VOI localization and quantification accuracy. Thus, the evaluation of VOI localization and VOI quantification accuracy as determined by MRS can be easily performed due to the layered structure of the layered dumbbell shape phantom. In addition, the phantom can be used to investigate the relationship between the signal intensity and the voxel size. (Fig. 2) The present follow-up study revealed that the MRI/MRS system or the skill of the operator was improved after 3 months. If the database of QA protocols with 7 factors is fully established, this database can be used as a guideline for QA/QC of MRI/MRS systems [4].

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Table 1. Results of measured MRS QA factors

	Univ. of California, Irvine	Kyung-Hee Univ. of Korea	
		Jun.2007	Sep. 2007
SNR	48570	42500	43400
Chemical shift	~0.10 (ppm)	~0.10 (ppm)	~0.15 (ppm)
Water suppression percent	99.76(%)	99.63(%)	99.92(%)
Line width of water peak	5.1 (Hz)	6.39 (Hz)	4.09 (Hz)
Symmetry (Fluctuation)	little	little	little

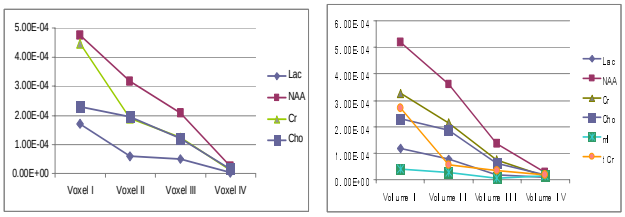

Fig. 3 The change of each metabolite intensity during 3 months (A)June, (B) September. 2007