Experimental and Numerical Studies on Signal Behaviors of iMQC MR imaging Depending on Relaxation Times at 14 T

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Introduction

As a new method for contrast enhancement in MRI, the intermolecular multiple quantum coherences (iMQCs) MR imaging has recently attracted considerable attention mostly because of the intrinsic sensitivity of the iMQCs to changes the magnetization and susceptibility structures.[1-3] Relaxation times (T_1 and T_2) play an important role in creating and determining susceptibility structures of the matters for MRI detection. In this study, we have experimentally and numerically investigated the relaxation time dependence on the intensity profiles and/or contrasts of the intermolecular double quantum coherences (iDQCs) MR images by fixing and varying T_1 and T_2, respectively and vice versa.

Materials & Methods

For this study, we have made 6 samples having different relaxation times using the well-known contrast agents for MRI - Omniscan, and Feridex. The samples could be separated into two-types, T_1-fixed and T_2-fixed. The T_1 and T_2 values and the concentrations of contrast agents for the samples are shown in Table 1. All experiments were performed at 14.1 T micro-MR imaging system at KBSI. We have analyzed the contrast behaviors of iDQCs MR images with echo-time (TE) variation, and compared them with various conventional MR images (echo planar imaging, T_1-weighted spin echo imaging, T_2-weighted spin echo imaging and T_2*-weighted gradient echo imaging). The experimental results were also compared with those of the numerical simulation using the modified Bloch equations with the distant dipolar field, radiation damping field.[4-5] The pulse sequence used for the iMQC MR imaging and the numerical simulations is depicted in Fig. 1.

Table. 1. Relaxation time (T_1, T_2) for water proton signals in contrast agent solutions.

Omniscan w/ Saline

Concentration[mM]	0.450	0.100	0.020
T_1 [msec]	506.3	1366.1	2127.7
T_2 [msec]	52.2	51.9	52.6

Feridex w/o Saline

Concentration[mM]	0.10	0.050	0.005
T_1 [msec]	2688.1	3076.9	3105.8
T_2 [msec]	21.8	28.7	38.2

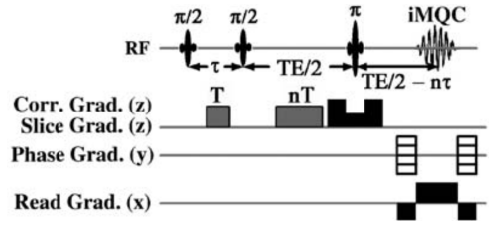

Fig. 1. Pulse sequence for acquiring iMQCs images.

Results & Discussion

As shown in the previous experimental studies and theoretical expectations (and this study, see Figs. 2 and 3), the intensity profiles of the iMQCs with the echo time (TE) should be quite different from those of conventional MR images which are simply decaying.[6]

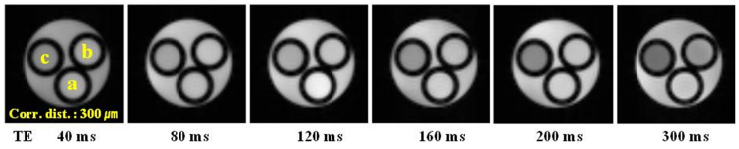

Figure. 2. The iDQCs images for the three parts having different concentrations of Omniscan aqueous solution (a: 0.02 mM, b: 0.10 mM, and c: 0.45 mM Omniscan aqueous solution) with TE variation.

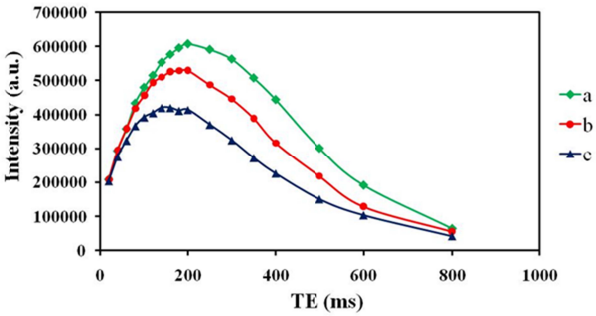

Figure. 3. The iDQCs images intensity profiles of the TE variation.

The experimental T_1- and the T_2-dependence on the intensity profile seemed to be somewhat different each other since T_1 and T_2 affect longitudinal (M_z) and transverse (M_y) magnetizations, respectively. Especially, the image contrasts were quite depending on differences in relaxation times and TE. And, the numerical simulations were able to confirm the same trend for the signal behaviors as seen in the experiments. These systematic studies showed that the iMQC MR imaging have unique signal behaviors which are more effective in image contrast enhancement than those in conventional MR techniques. Additionally, these behaviors could be controlled by relaxation times and be expected by the numerical simulation.

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