Intermolecular Double-Quantum Coherence MR Microimaging of Pig Tail with Unique Image Contrast

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1.Introduction

Recently, great research efforts have been focused on the phenomena of intermolecular multiple-quantum coherences (iMQCs) [1], and also in its applications to MR imaging [2,3,4]. The novel image contrast of iMCQs provides improved detection of tumors, for example, without the need for contrast agent injection.

2.Methods

The spin-echo (SE) CRAZED-like imaging sequence, as shown in Fig. 1, was used to obtain intermolecular double-quantum coherence (iDQC) [3,4] images and performed using a 7.05 T Varian Unity Inova spectrometer with microimaging capabilities. Crusher gradients $G'\delta'$ were placed along the *y*-axis on either side of the soft π pulse to dephase signals other than that from the selected slice. A four-step phase cycling scheme, (x, -x, y, -y) for the first π/2 RF pulse along with (x, x, -x, -x) for the receiver phase, were adopted to remove residual conventional SQC signals.

The images were obtained at room temperature and pig tail samples were cut into sections of about 4 cm long. The typical imaging parameters were utilized: a gradiant strength G of 21.4 G/cm, G' of 24.4 G/cm, FOV of 3.5 cm × 3.5 cm, slice thickness of 3 mm, and matrix size of 256 × 128.

3.Results and Discussions

A transverse image of the pig tail obtained by conventional SE MRI with TR of 4 s and TE of 35 ms is shown in Fig. 2(a). The fat and subcutaneous tissues(I in Fig. 3(a)) , the muscles(II in Fig. 3(a)), and the marrow in the central spinal bone(III in Fig. 3(a)) all appear bright. As expected, a signal minimum was observed when the gradients are at the magic angle (θ=54.74°,Fig. 2(c)), and the signal is approximately half when the gradients are along the direction perpendicular to B_0 (Fig. 2(d)), in comparison to the image with iDQC gradients along B_0 (Fig. 2(b)). iDQC images obtained with and without the phase cycling scheme are shown in Fig. 2(b) and Fig. 2(e), respectively.

Fig. 3(a) and (b) are iDQC images of the pig tail with varied areas of the iDQC-encode gradient or the crusher gradient, while keeping their gradient strengths, G and G′ constant at 42.8 G/cm. It is obvious that iDQC images with variation of the iDQC-encode gradient area demonstrate a greater contrast change than those of the iDQC images with variation of the crusher gradient area.

4.Conclusions

The effects of iDQC-encode gradient on image contrast were demonstrated. When suitable imaging parameters are selected, images with unique contrast can be achieved. Diffusion weighting imposed by the iDQC-encode gradient certainly contribute to the contrast, however, the contribution of correlation distance cannot be ruled out.

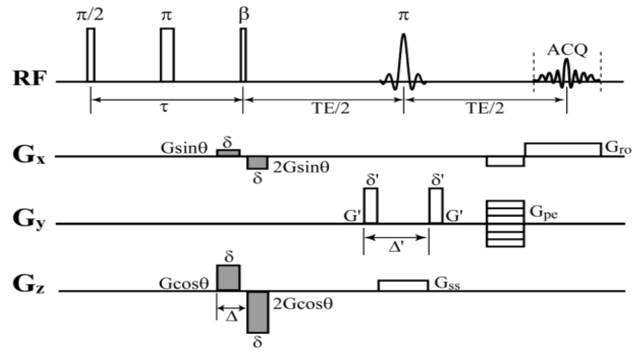

Fig. 1 iDQC SE imaging sequence with $\beta=\pi/3$

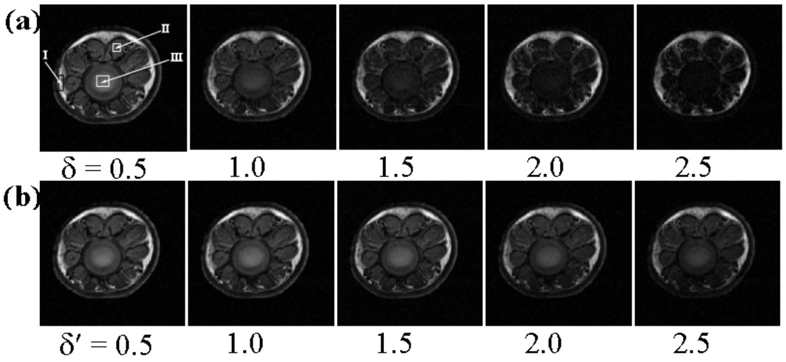

Fig. 3 Diffusion-weighting images of a pig tail. (a) iDQC image with different iDQC-encode gradient duration δ ms, (b) iDQC images with different crusher gradient a duration δ′ ms.

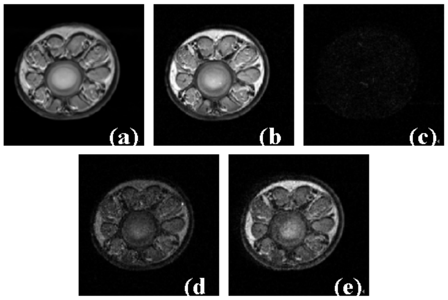

Fig. 2 Images of a pig tail under different experimental schemes. 1ms and 0.5ms are taken for δ and δ′ respectively. (a)Conventional SE image; (b) iDQC images with four-step phase cycling when the iDQC-encode gradients are along the direction of the static magnetic field B_0, (c) along the direction of the magic angle, (d) and along the direction perpendicular to B_0; (e) iDQC image with the same imaging parameters as in (b) but without phase cycling.

References---

[1] Warren WS, Ahn SD, Mescher M, Garwood M, Ugurbil K, Richter W, Rizi RR, Hopkins J, Leigh JS. MR imaging contrast enhancement based on intermolecular zero-quantum coherences. Science 1998;281:247-251.

[2] Mori S, Hurd RE, van Zijl PCM. Imaging of shifted simulated echoes and multiple spin echoes. Magn Reson Med 1997;37:336-340.

[3] Zhong J, Chen Z, Kwok E. In vivo intermolecular double-quantum imaging on a clinical 1.5 T MR scanner. Magn Reson Med 2000;43:335-341.

[4] Zhong J, Chen Z, Kwok E, Kennedy S. Enhanced sensitivity to molecular diffusion with intermolecular double-quantum coherences: implications and potential applications. Magn Reson Imag 2001;19:33-39.