Prospective Motion Correction for Single-Voxel ¹H MR Spectroscopy

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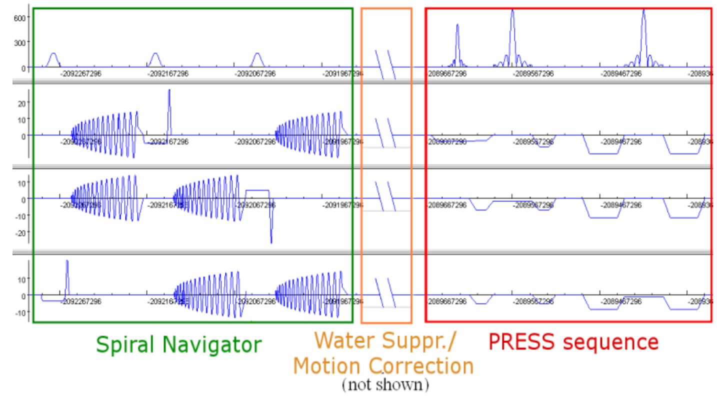
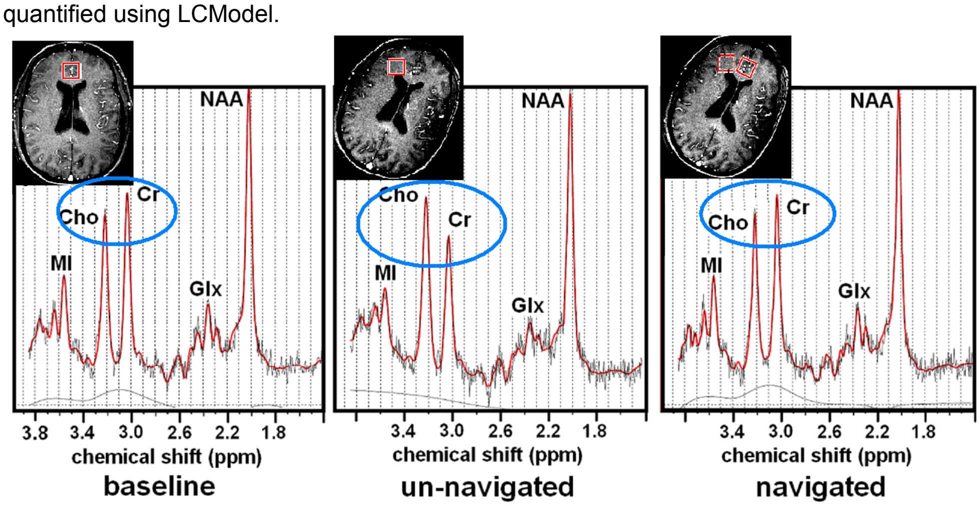
INTRODUCTION

Head motion during ¹H MR spectroscopy (MRS) acquisitions can compromise the quality and reliability of *in vivo* spectra. Such concerns are particularly acute with subjects who have difficulty holding still, for instance young children or adults who are in pain or confused. Therefore, we integrated a 3D image-based prospective motion correction module [1] into a single-voxel ¹H MRS sequence.

METHODS

Spiral navigators were incorporated into a point-resolved spectroscopy (PRESS) [2] sequence (TE/TR=30/3000ms) on a 3T Siemens Trio. Prior to the water suppression module, a series of 3 orthogonal, low flip-angle, low-resolution spiral navigator images are acquired. The rigid-body parameters (3 translations and 3 rotations) are estimated from the navigator images using a training data set and a Kalman filter [1,3]. The effects of non-rigid motion are minimized by masking out areas that can move non-rigidly with respect to the brain. Prior to each PRESS excitation, the slice gradients and RF frequencies are updated to maintain a constant voxel position relative to the (moving) brain. The complete pulse sequence is shown in the Figure to the right. Extensive testing was performed in 7 subjects using three motion modes: (1) *baseline* - no subject motion, (2) *non-navigated* with head rotation to the subject's left (20-25°) and (3) *navigated* with approximately the same motion as in (2). Coherent averaging of FIDs was achieved by performing shot-to-shot frequency and phase corrections based on a novel water suppression cycling scheme [4]. Metabolite levels were quantified using LCModel.





RESULTS

The figures on the left show medial frontal grey-matter spectra from one subject for the three modes of motion, as well as corresponding post-motion gradient echo images. The baseline spectrum (no motion, left) shows a lower choline than total creatine (Cr) peak, as is characteristic of grey matter [5]. In the un-navigated case, however, the voxel remains stationary as the head rotates, resulting in a Cho/Cr peak height ratio >1 (center), suggesting the voxel was predominantly in white matter (see also post-motion image inserted). Motion correction closely recovered the original grey-matter spectrum (right), demonstrating that the voxel remained in gray matter throughout the movement. Across subjects, the Cho/Cr concentration ratio of navigated acquisitions was very close to that of the baseline scan (-2.5%±9.4%, p=0.57). By contrast, the Cho/Cr ratio of the un-navigated spectra was markedly and significantly higher than the baseline value (+27%±21%, p=0.035).

DISCUSSION

Spectral changes induced by head motion may be difficult or impossible to detect during visual quality assurance. The resulting inaccuracies can be eliminated by the use of adaptive motion correction, which keeps the voxel stationary relative to the moving brain. Our approach can easily be extended to spectroscopic imaging acquisitions. The proposed MRS sequence with adaptive motion correction can improve spectral reliability even in the presence of large head movements.

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