Comparison of SLIM Localization and Voxel Averaging in 3D MRSI

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Introduction

High resolution 3D MR spectroscopic imaging (MRSI) has been highly successful in mapping regional distributions of metabolite concentrations in the brain, with important clinical and research applications, e.g. differentiating brain tumor types [1]. However, 3D MRSI sequences require very long scan times (~20 min) which limits their practicality. To significantly reduce scan times, the phase encoding in two dimensions in the echo planar spectroscopic imaging (EPSI) sequence could be reduced while taking advantage of non-Fourier reconstruction to overcome the resolution deficit. We have implemented a 3D version of Spectral Localization by Imaging (SLIM), which promises accurate reconstruction of spectra of distinct anatomical compartments with potentially fewer k-space acquisitions [2,3]. In this work, we compare the results of SLIM and region of interest voxel averaging for high resolution EPSI data. Our aim is to improve the utility of 3D MRSI by reducing the scan time and improving quantitative and anatomical accuracy over Fourier reconstruction and post-processing.

Methods

Six healthy subjects (35±10 years of age) were consented according to institutional review board approved protocols. MR measurements were performed on a 3 T scanner (Skyra, Siemens) using a 20-channel head/neck array coil. Three-dimensional T1-weighted images were acquired using a magnetization-prepared rapid acquisition gradient echo (MPRAGE) sequence (matrix = 176×256×256, resolution 1×1×1 mm^3). ^{1}H MRSI 3D data were acquired using the volumetric echo planar sequence (TE/TR1/TR2=17/1551/511, matrix = 50×50×18, FOV = 280×280×180 mm^3) [4]. Anatomical parcellations were obtained using FreeSurfer. Processing was done in Matlab and MIDAS software [5]. Spectra were quantified using LCModel.

Results

SLIM reconstructions were performed with *x*,*y* phase encoding sizes cropped to 50, 40, 20, and 16, and the axial (*z*) direction spatially cropped to 8 voxels. Voxel averaging was done by MIDAS at full resolution (50x50x18) on the same region of interest masks. Metabolite ratios were compared to avoid differences of internal water scaling. The metabolite ratios of N-acetyl aspartate, creatine and choline resonances were consistent between MIDAS and SLIM with varying k-space sizes. Averaged ratios of SLIM and MIDAS tCho/Cre in the left thalamus were 1.02±0.1, 1.02±0.0, 0.99±0.0 and 1.0±0.1 for 50, 40, 20 and 16 sizes, respectively, and 0.93±0.1, 0.93±0.1, 0.95±0.1 and 0.98±0.1 respectively for right thalamus. Similarly, the ratios in all Cadual Cingulate gray matter and white matter were between 0.79 and 1.20 for tCho/Cre and for tNAA/Cre. In a 25×50×8 undersampled test, the SLIM to MIDAS ratios for thalamus tCho/Cre were 0.94 and 0.99 for left and right thalamus, respectively.

Discussion

The SLIM non-Fourier reconstruction takes advantage of co-aligned high resolution MRI to localize metabolite spectra of distinct anatomical compartments rather than voxels. While SLIM solves the intra-voxel contamination problem associated with the large point spread function of MRSI, the results show that SLIM is also compatible with 3D MRSI to undersample individual phase encoding dimensions for acceleration. The thalamus can be difficult to target with MRS due to its heterogeneous bordering anatomy. We found agreement among major metabolite ratios with k-space sizes as small as 16x16x8, including 1/2× reduced phase encoding in one dimension. On the other hand, healthy regional distributions of metabolites are relatively uniform, and the presence of heterogeneous conditions such as tumor could provide stronger cases for SLIM. Due to the large matrix size, implementation benefited from large memory (48 GB), although the reconstruction was fairly fast (<2 min per subject).

Conclusion

The 3D SLIM algorithm showed strong agreement with voxel averaging of high resolution EPSI data with variously reduced k-space dimensions. Agreement of metabolite ratios was also found with undersampled *x* phase encoding, compatible with truncating the EPSI phase encoding time. Non-Fourier reconstruction could thus prove beneficial for accurate, efficient 3D volumetric MRSI.

References

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