Fast 3D Pediatric Brain MRSI

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Introduction

Pediatric neuro spectroscopy provides unique information regarding the metabolic variations during normal and abnormal brain development. Spectroscopic imaging can add to this feature by providing topologic information. While most clinical 3D MRSI methods require scan times on the order of ~15 minutes, the ability to perform fast 3D MRSI in pediatric studies would be highly recommended due to issues of risks associated with prolonged sedation and/or susceptibility to motion induced artifacts.

We have developed a fast 3D MRSI clinical protocol to study pediatric subjects (6:24 minute). The long term clinical goal of this project is to understand the metabolic differences in subjects with motor dysfunction by analyzing spectroscopic imaging data throughout the corticospinal tract (CST). In this preliminary study, we initally focused on the feasibility of obtaining fast spectroscopic data from infants/children with normal motor function using this protocol.

Methods

A 3D MRSI sequence was developed using PRESS excitation in combination with a spiral based readout gradient for use at 3T [1]. Spiral readout gradients can greatly reduce the overall scan time needed compared to conventional sampling schemes. A dualband spectral spatial spin echo pulse for 3T neuro applications, designed to excite only 1% of the water signal and suppress lipids while passing the NAA, Cr, and Cho resonances was used [2]. Data collection using a 8 channel receiver coil provided increased signal to noise ratio (SNR). Overall, the following MRSI parameters were used for data collection; 3T, TR/TE = 1500/130 ms, body coil excitation, 980 Hz spectral bandwidth, 32x32x8 matrix over a 32x32x8 cm FOV (1cc spatial resolution), 6:24 minute scan time. Each coil data set was individually reconstructed by performing gridding and FFT, which was followed by a zero and first phasing algorithm [3]. The spectra was then combined by weighting according to the water signal amplitude from the dualband excitation to optimize for SNR.

Quantification was perfomed by retrieving voxels corresponding to the CST and incoporating this into the LCModel fitting procedure. Voxel shifting was performed prior to fitting to cover the CST region when necessary. Four subjects who had normal motor functions were imaged using this protocol to date. All scans were performed under the guidelines of the institutional review board.

Results

Fig. 1 shows typical spectral quality obtained from these subjects. The average SNR of the NAA metabolite from the gray matter was approximately 22, which was overall higher than adult brain scans (~20) persumably due to lower noise contribution from the smaller head sizes. The average remaining water signal due to the dualband RF pulse was approximately 10:1 compared to NAA levels.

Quantitative analysis via LCModel fitting resulted in standard deviation of the major metabolites to be less than 10%. The range of the PRESS excitation box normally started covergage beginning at the precentral gyrus lateral to the centrum semiovale and ending at the cerebral peduncle region as seen in the Figure. Fig. 2 shows NAA/Cho ratios from the whole CST obtained as a function of age along with a linear fit to the plotted points. This data shows a linear trend in the change of metabolite ratios for the CST given this age range. Further data collection is needed to confirm this trend. Regardless, the ability to analyze spectra from the whole CST pathway (and other pathways) is unique using spectroscopic imaging.

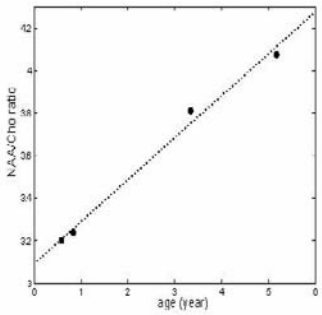

Fig. 2 NAA/Cho ratio from the CST

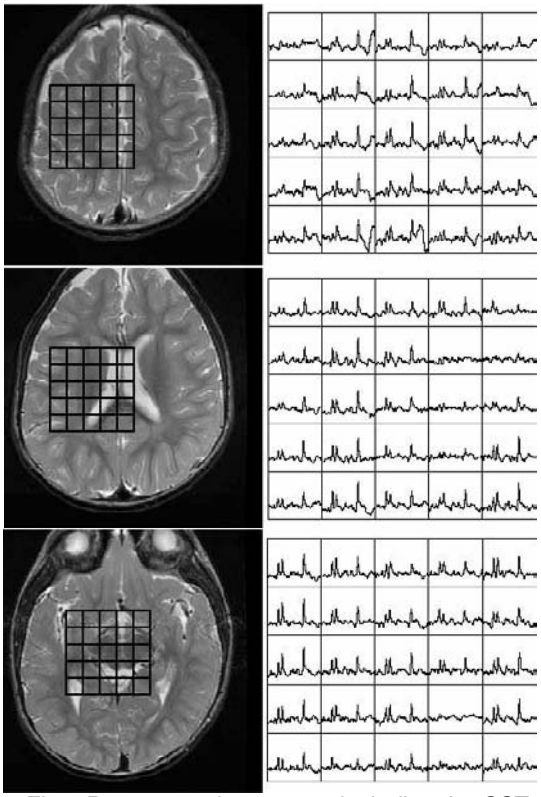

Fig.1 Representative spectra including the CST.

Conclusion

We have developed a robust fast 3D MRSI technique for pediatric neuroimaging. Preliminary results from the CST demonstrate linearly increasing NAA levels as a function of age in those with normal motor function. Using this sequence, we are currently conducting a study to correlate those with reduced NAA in the CST to those with motor dysfunction and presumably damaged CST.

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References: [1] Adalsteinsson E, et.al. MRM 1998;39:889-898. [2] Cunningham C, et.al. MRM 2005;53:1033-1039. [3] Gu M, et.al. 13th ISMRM p2763.