Proton MR Spectroscopic Imaging of the Human Cervical Spine at 3 Tesla

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Introduction

There is increasing interest in non-invasive imaging methods that can provide measures of axonal integrity and/or myelination in the spinal cord. Proton magnetic resonance (MR) spectroscopy has the potential to provide such information. This abstract describes the development of a proton MR spectroscopic imaging (MRSI) protocol for evaluation of the cervical spine on a 3.0 Tesla system.

Materials and Methods

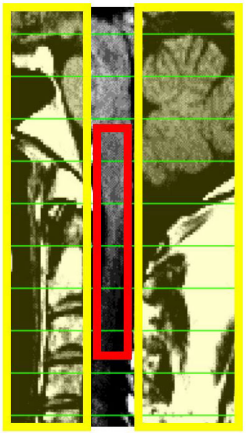

Figure 1. T1 MRI indicating location of PRESS excitation voxel (red), OVS pulses (yellow) and 1D MRSI voxels (green).

All scans were performed on a Philips Intera 3.0 Tesla system using a 6-element CTL receiver coil array. RF pulses were transmitted using the body coil. A PRESS excitation sequence was used to excite a 1.3x1.3x8cm column along the cervical spine, with the top of the PRESS box at the pontine-medullary junction (red box, Figure 1). A one-dimensional, 16-step phase-encoding scheme (with a variable number of averages per step, up to a maximum of either 32 or 64) was applied in the superior-inferior direction, parallel to the axis of the spine. Water and lipid suppression was applied using frequency selective "BOOZE" pulses [1], and 4 outer-volume saturation (OVS) pulses were applied (left, right, anterior, posterior). Scan parameters were TR 2 sec, TE either 35 or 144 msec, 24cm field of view and 16 phase-encoding steps (giving a nominal voxel size of 2.5 cm^3), scan time 9 or 18 minutes (for 32 or 64 averages, respectively). Prior to MRSI field homogeneity was optimized using high order shimming. A second MRSI data set was recorded without water suppression (2 averages, scan time 1 minute); this scan provides information about relative synergy coil sensitivity profiles and phase errors, B_0 field homogeneity, and also could be used as a water reference for quantitation [2]. After MRSI, additional rapid gradient echo MRI scans were recorded to provide maps of the B_0 and B_1 field strengths. Multi-channel MRSI data were reconstructed using 2DFFT and processed as described previously [3]. The protocol was tested in 4 normal adult subjects (age 33 ± 8 years, 3 males).

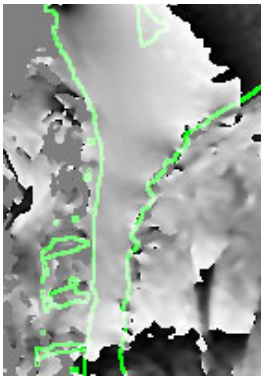

Figure 3. B_0 field map corresponding to Figure 1. The full gray scale range corresponds to ±100 Hz

Results

Figure 2 shows 1D-spectra from the voxel locations indicated in figure 1. Signals from choline (Cho), creatine (Cr) and N-acetyl aspartate (NAA) are apparent. In all 4 subjects, average ratios of NAA/Cho, NAA/Cr and Cho/Cr were 3.31 ± 1.96, 4.28 ± 2.61 and 1.36 ± 0.40 respectively. B_0 field maps also showed some fine structure in the spine, with periodic perturbations of about 20-25 Hz corresponding to the vertebral arcs, as described previously [4] (Figure 3). Spectra at short echo time (35 msec) showed improved SNR compared to those at TE 144 msec, however they also generally exhibited worse lipid contamination.

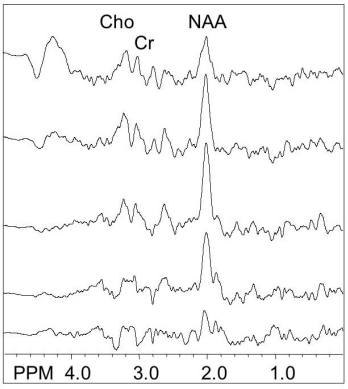

Figure 2. 1D MRSI spectra from the PRESS voxel indicated in Figure 1.

Discussion

Previous single-voxel MRS studies at 2.0T have demonstrated the feasibility of proton spectroscopy of the cervical spine [4]. This study extends these methods to one-dimensional spectroscopic imaging to potentially map out regional metabolite variations along the spinal cord. Use of a 3T magnet may improve signal-to-noise ratio compared to lower field, although magnetic susceptibility effects will also be increased. In the current study, sensitivity could be enhanced by the optimal combination of multi-coil MRSI data [3]. MRSI of the spine is challenging due to its small size, magnetic susceptibility effects from surrounding vertebrae (which may ultimately limit available spectral resolution), and the need to suppress large water and lipid signals from surrounding tissues. It is anticipated that improved outer-volume suppression schemes and coil technology will enhance spectral quality.

References

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