Atlas-Based Automated Positioning of Outer Volume Suppression Slices in Short-TE 3D MR Spectroscopic Imaging of the Human Brain

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INTRODUCTION

Outer volume suppression (OVS) using spatial pre-saturation [e.g. 1-2] is widely employed for short TE MRSI studies on clinical scanners. Inspired by the increasing use of statistical brain atlases for automatic positioning of MRI slices, we extend our previous work using an iterative optimization of the OVS placement in subject space [3] to an atlas-based approach, which optimally positions both the 3D MRSI slab and up to 16 OVS slices in an individual's head using affine transformation of MRSI slab and OVS slice positions that are optimally placed in the MNI space. We demonstrated on 3T clinical scanners the feasibility of 3D Proton-Echo-Planar-Spectroscopic-Imaging (PEPSI) in upper cerebrum with up to 16 automatically placed OVS slices.

METHODS

Theory The lipid-containing peripheral regions in a template head MNI_152_T1_1mm [4] are identified using the FSL tool BET [5]. A cost function is optimized to maximally cover this peripheral region while minimizing the intersection of OVS slices with lateral cortical brain areas and regions outside the head [3]. This step is carried out offline for a pre-defined MRSI slab position on the MNI template head. During the in vivo scan, high resolution structural MRI scans of the subject head are acquired and the FSL tool FAST is used to determine an affine transformation that registers the subject head to the template head. Then, optimal MRSI slab and OVS slices previously prescribed in the template space are mapped to the subject space using the inverse of this affine transformation. *Measurements* Eleven healthy subjects participated after giving institutionally reviewed informed consent. Data were collected on clinical 3T TIM Trio scanners (Siemens Medical Solutions, Inc). High resolution T_1-weighted MPRAGE scans were acquired with isotropic 1 mm voxel size. Manual (by a highly skilled operator) and automated placement of 8 OVS slices, and automated placement of 16 OVS slices was investigated. 3D PEPSI data were collected from a 40 mm thick slab in AC/PC orientation using: TR=2 s, TE=11 ms, FOV = 226x226x56mm, spatial matrix: 32x32x8 voxels, nominal voxel size: 0.34 cm^3, scan time 4:40 min. *Data Analysis* Data reconstruction was performed online in ICE. Spectral quantification was performed offline using phase and frequency shift correction based on a non-water suppressed reference scan and LCModel fitting [6] with an analytically modeled 19 component basis set.

RESULTS

Automatic positioning of 16 OVS slices and the MRSI slab based on the MPRAGE scan was perfromed in less than four minutes. In both atlas and subject space the peripheral lipid containing regions were 100 % covered by the automatically placed OVS slices in all subjects (Fig.1). Consistent spectral quality was obtained throughout the sensitive volume, enabling computation of good quality metabolite maps of Ino, Cr+PCr, Glu+Gln, NAA+NAAG, and macromolecular resonances at 0.9 and 2.0 ppm. Examples of metabolite maps obtained with automated OVS placement are shown in Fig.2. Slice-averaged metabolite concentration ratios with respect to Cr+PCr are shown in Table 1 for the 4 central slices located within the MRSI slab.

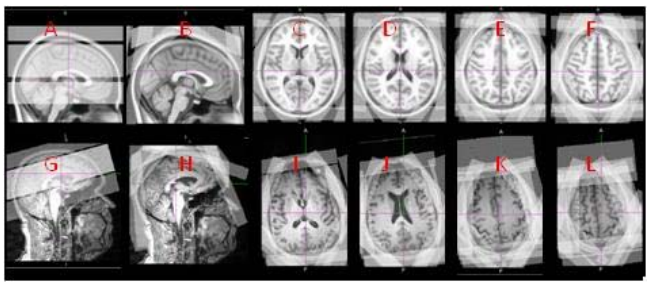

Fig.1: Automated placement of 16 OVS slices in template space (top) and subject space (bottom). A and G show the MRSI slab and the 2 co-planar OVS slices above and below the MRSI slab.

Slice	Placement	NAA/Cr	Cho/Cr	Glx/Cr
3	automatic	0.988	0.869	0.657
	manual	1.011	0.873	0.933
4	automatic	0.987	0.880	0.753
	manual	1.019	0.847	0.94
5	automatic	0.987	0.808	0.817
	manual	1.021	0.845	0.967
6	automatic	0.963	0.753	0.953
	manual	0.983	0.890	0.976

Table 1: Slice averaged metabolite concentration ratios

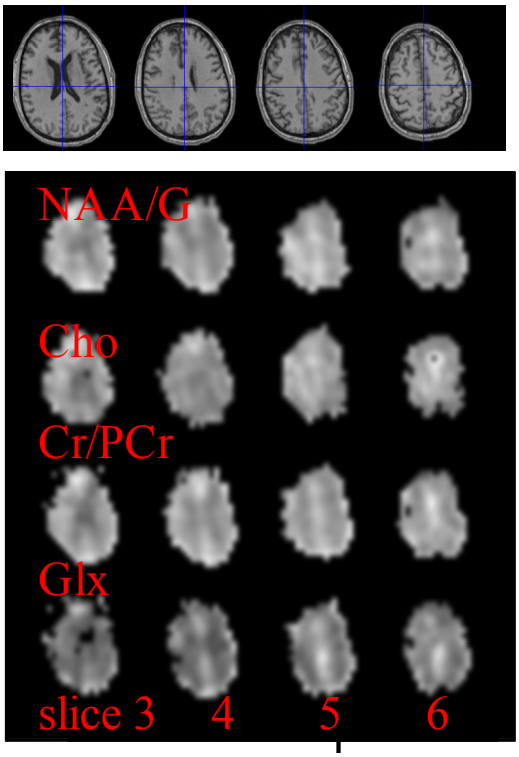

Fig.2: Metabolite maps for 8 automatically placed OVS slices. CRLB thresholds of 30% were used for NAA/G, Cr+PCr and Cho, and 50% for Glu+Gln.

DISCUSSION AND CONCLUSIONS

Automatic placement of the MRSI slab and OVS slices provides consistent VOI selection across subjects, which is desirable for clinical MRSI studies. The method reducing operator variability, improves consistency of data quality and speeds up clinical throughput.

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