Validation of Automatic Voxel Positioning for MRS at 7T

Weiqiang Dou[1], Joern Kaufmann[2], Meng Li[3], Martin Walter[3], and Oliver Speck[1]

[1]*Biomedical Magnetic Resonance, Otto-von-Guericke University Magdeburg, Magdeburg, Saxony-Anhalt, Germany,* [2]*Department of Neurology, Otto-von-Guericke University Magdeburg, Magdeburg, Saxony-Anhalt, Germany,* [3]*Clinical Affective Neuroimaging Laboratory, Otto-von-Guericke University Magdeburg, Magdeburg, Saxony-Anhalt, Germany*

Introduction:

In clinical magnetic resonance spectroscopy (MRS), specially trained technicians or medical doctors usually use visual determinations to place spectroscopy voxels in the human brain. However, this manual voxel prescription is not only time-consuming, but also potentially influenced by a variety of factors, e.g., head position for patients at different scan sessions and the variability within and between operators [1]. Therefore, in this study, a vendor-provided automatic voxel positioning technique was for the first time applied to prescribe the spectroscopy voxel over multiple scan sessions in a longitudinal MRS study at high field 7T. Since image intensity variations at high field can potentially interfere with the automatic position detection, the accuracy and reproducibility of this technique was assessed systematically using *in vivo* experiments.

Materials and Methods:

Ten healthy subjects (30 ± 8 years old) were recruited after giving informed written consent and scanned at three different time points within two continuous days on a 7T MR scanner (Siemens MAGNETOM, Erlangen, Germany) using a 32 channel head array coil. MRS voxels were placed in pregenual anterior cingulate cortex (pgACC) and anterior mid-cingulate cortex (aMCC) regions (Fig. 1).

After applying the vendor-provided pre-scan sequence (Auto-Align Head) at the beginning of each scan session, all subsequent imaging volumes (i.e. 3D T1-weighted anatomical images and MRS voxels) manually defined in the first scan were automatically prescribed in the next two scans. A stimulated echo acquisition mode (STEAM) sequence with variable-rate selective excitation (VERSE) pulses (128 averages, TE/TM = 20ms/10ms, voxel size = 3ml (pgACC) and 3.75ml (aMCC), data size = 2048, bandwidth (BW) = 2800Hz) was employed for spectra acquisitions.

SPM 8 was used to co-register the respective T1-weighted anatomical images from the second and third scans into those from the first scan. The resulted transformation matrices were applied into the corresponding voxels from the last two scans. The overlap ratios of the voxels from the same regions between different scans were calculated, respectively. LCModel 6.1 was applied to analyze spectra for obtaining metabolite concentrations with respective Cramer-Rao Lower Bound (CRLB) values. The metabolite concentrations were expressed using institutional units (i.u.). SPSS 18 was used to statistically estimate the reproducibility of automatic voxel prescription using this technique.

Results and Discussion:

Accurate automatic voxel prescription was achieved with a mean voxel overlap ratio of 0.91 ± 0.06 across three scans and two regions over all subjects (Fig. 2). Paired-t tests were used to directly compare the voxel overlap ratios between the first and second and between the first and third scans for pgACC and aMCC regions, respectively. No significant difference was found either in pgACC ($p = 0.46$) or aMCC ($p = 0.31$). Additionally, Intraclass-correlation-coefficient (ICC) test [2] was applied to quantify the reproducibility of voxel prescriptions on different regions by using the averaged voxel overlap ratios over scans from pgACC and aMCC regions. A high ICC value of 0.88 was obtained. Repeated-measures analysis of variance (ANOVA) was applied to test the significance of two main effects (metabolite and scan time) on the metabolite concentrations of NAA, Cre and Glu+Gln (Glx) detected with high reliability (CRLBs < 4%) from three scan times for two regions (Table.1). No significant effect of scan time was revealed: $p = 0.94$ for pgACC region and $p = 0.50$ for aMCC region. Paired-t tests were applied subsequently to compare the metabolite concentrations between different scan times. Again, no significant difference was found.

Conclusion:

In this study, we demonstrated that the automatic voxel positioning (Auto-Align) technique can provide accurate and reproducible MRS voxel prescription for longitudinal studies at high field 7T despite the inhomogeneous image intensity of the pre-scan.

Acknowledgement:

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Reference:

[1] Itti L. et al. MRM 45:486-494 (2001); [2] Weir JP. J Strength Cond Res 19:231-240 (2005).

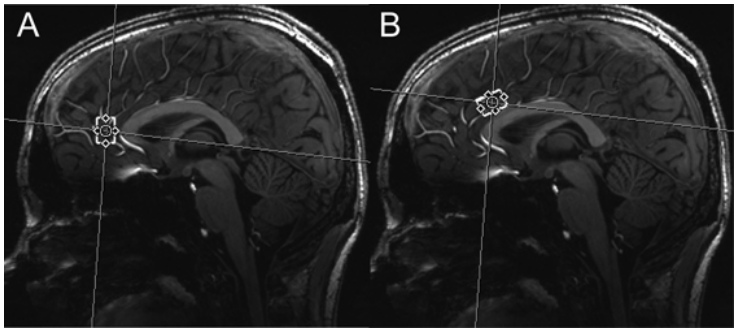

Figure 1 Representative voxel placement in pgACC (A) and aMCC (B) regions on 3D T1-Weighted anatomical images in sagittal plane.

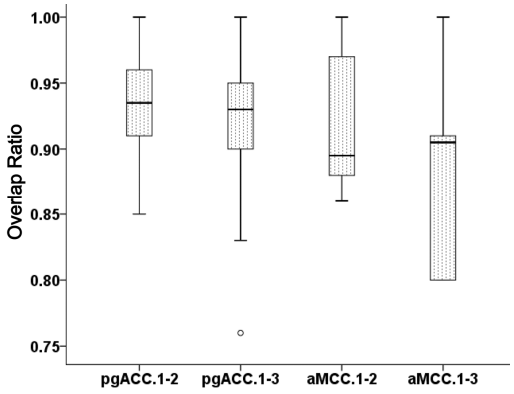

Figure 2 The overlap ratios of MRS voxels placed at the first to the second scans "1-2"and at the first to the third scans "1-3" for pgACC and aMCC regions for all subjects.

Table 1 Mean CRLB ± SD and absolute concentration ± SD (i.u.) of main metabolites NAA, Cre and Glu+Gln (Glx) in pgACC and aMCC regions from three-time scans over all subjects.

	CRLB (%)			Absolute Concentration (i.u.)		
	NAA	Cre	Glx	NAA	Cre	Glx
pgACC.1	3.1±2.1	1.7±0.5	3.6±0.5	8.3±1.3	9.3±0.6	7.3±1.0
pgACC.2	2.0±0.8	1.8±0.4	3.3±0.5	8.4±0.6	9.1±0.4	7.6±0.6
pgACC.3	1.7±0.5	1.6±0.5	3.4±0.5	8.8±0.6	8.8±0.3	7.5±1.0
aMCC.1	1.7±0.7	1.5±0.7	3.7±0.9	8.9±1.1	9.2±1.4	7.6±0.5
aMCC.2	1.7±0.5	1.3±0.5	3.8±0.6	9.1±0.8	9.4±0.6	7.3±0.5
aMCC.3	1.7±0.5	1.3±0.5	3.3±0.5	9.1±0.6	9.6±0.3	7.4±0.3