Region and volume dependencies in spectral linewidth assessed by ^{1}H 2D chemical shift imaging in the monkey brain at 7T

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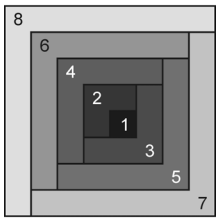
High magnetic fields increase the sensitivity and spectral dispersion in magnetic resonance spectroscopy (MRS). In contrast, spectral peaks are broadened *in vivo* at higher field strength due to stronger susceptibility-induced effects. Strategies to minimize the spectral linewidth are therefore of critical importance. In the present study, ^{1}H 2D chemical shift imaging (CSI) at short echo times was performed in the macaque monkey brain at 7 T. Large brain coverage was obtained at high spatial resolution with voxel sizes down to 50 µL being able to quantify up to nine metabolites *in vivo* with good reliability. Dependencies of the spectral linewidth on the CSI voxel size were determined by data reconstruction at different spatial resolution. An overall linewidth narrowing at increased spatial resolution and regional differences were found.

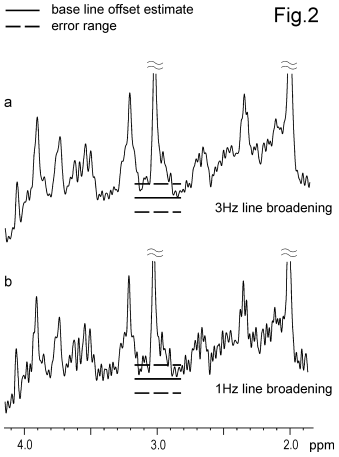
METHODS: Measurements were performed on a vertical 7T/60cm Bruker Biospec system with an 80mm surface coil in transmit/receive mode [1]. The setup, handling, and anaesthesia of the macaque monkey was described previously [2]. Shimming was done with FASTMAP; water suppression was achieved by a VAPOR module. For CSI, a STEAM sequence was used with a conventional 8x8 phase encoding scheme, leading to a nominal in-plane resolution of 3.5x3.5mm^2 (TE/TM/TR=10/10/4000ms, NA=35). The dependence of the spectral linewidth on the CSI voxel size was determined for water and the Cr/PCr peak at 3.03 ppm as representative brain metabolite. For data reconstruction at different spatial resolution, k-space segments were successively included into the analysis (see scheme of segments 1 to 8 in Fig. 1). Spectral linewidths were measured as FWHM (Fig. 2).

Fig.1



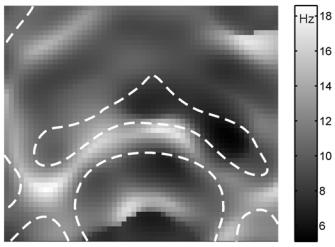
k-space segments

Fig.2



RESULTS: A map of water linewidths shows spectral linewidths to be tissue-specific exhibiting considerable regional variation (Fig. 3). At increased spatial resolution the mean linewidth of Cr/PCr decreased from 14.2 to 7.6 Hz (for decreasing voxel volumes of 3.14 mL to 50 µL) when the entire CSI slice was considered (Fig. 4). The linewidth distribution of the metabolites ranged from 5.5 to 10 Hz (7.6 ± 1.6 Hz, mean ± sd.) and was considerably smaller compared to that of water (10.6 ± 2.4 Hz). When the mean linewidths were calculated for two arbitrarily selected brain regions (region 1&2 in Fig. 5) for voxel sizes of 350 to 50 µL corresponding to k-space segment sizes of 3x3 to 8x8, a narrowing from 8.4 to 6.5 Hz was found for region 1, but no net gain in linewidth was observed for the region 2 (Fig. 6).

Fig.3



map of water linewidths (FWHM)

Fig.4

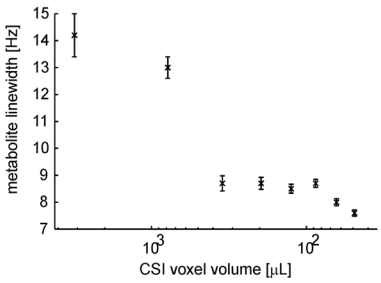


Fig.5

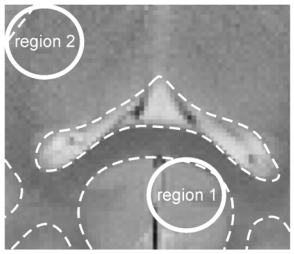
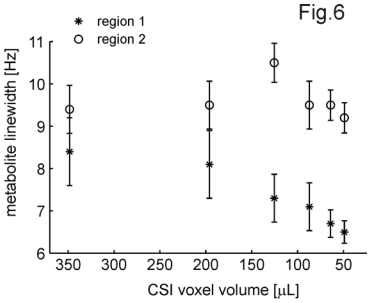


Fig.6



DISCUSSION: Our study demonstrated that even in well-shimmed areas assumed to have minimal macroscopic susceptibility variations, spectral linewidths exhibit considerable regional variation. Therefore, an overall improvement of a gross spectral linewidth - directly correlated with improved spectral quality and quantification - can only be achieved when voxel volumes are significantly reduced. The linewidth optimization afforded Cr/PCr linewidths down to 5.5 ± 0.8 Hz in the monkey at 7 T (300 MHz), which is up about 40% smaller than reported with single voxel MRS at 7T in the human brain [3].

[1] ISMRM 1877, 2089 (2003), [2] Nature Neurosci 2, 555 (1999), [3] Magn Reson Med 46, 451 (2001)

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