Techniques of highly resolved in vivo 1H CSI in mouse brain tumors at 7 Tesla

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INTRODUCTION: Chemical shift imaging (CSI) allows a spatially resolved analysis of the metabolite pattern which is of relevance when the most significant spectral changes are not uniformly distributed over tissue of interest. To achieve reasonable results on small rodents, highly efficient water suppression strategies, proper shimming methods and also powerful hardware are necessary [1]. Since mouse spectroscopy needs several times higher shim power than, for example, rat spectroscopy [2], to our knowledge no mouse CSI study has been published up to now.

PURPOSE: To demonstrate the technical feasibility of CSI acquisition on controls and pathology afflicted mice models of human disease with a novel development of integrated shim and gradient coils in combination with a PRESS localization in the acquisition weighted CSI method.

METHODS: Different strains of mice, including tumor bearing ones (intracranial injection of tumor glioma cells), underwent magnetic resonance imaging (MRI). The MRI experiments were performed in a 7T 16 cm *PharmaScan*® (Bruker BioSpin MRI GmbH, Ettlingen, Germany) with a 23 mm birdcage resonator and a 7T 30 cm *BioSpec*® (Bruker BioSpin MRI GmbH, Ettlingen, Germany) with a quadrature receive surface coil actively decoupled from a linear mini imaging resonator with 72 mm inner diameter The MR scanners were equipped with gradient coils B-GA9S and a B-GA20S, respectively. These are two of a new generation of actively shielded gradient coils with integrated shims and efficient water cooling to deal with high duty cycles, which were designed for high fields. For this, mice were anesthetized with isoflurane. Tumors were first localized with a T2-weighted RARE, TR/TE: 4200/41 ms, 8 echoes. For CSI, linear and second order shims were automatically adjusted with FASTMAP in a (4.5 mm)3 voxel. CSI was performed with a PRESS localization method and weighted acquisition [3]. The weighted acquisition was performed to improve the shape of the point spread function. The number of acquired averages was determined by the Hanning function. To obtain the same spatial resolution as in a standard experiment the total matrix size may be increased. Data was zero filled before reconstruction. A CSI-PRESS VOI (4.5x4.5x2.0) mm3 was positioned inside the FASTMAP voxel in order to include both tumor and healthy tissue, in the cases of pathology afflicted mice. Water suppression was performed with a VAPOR sequence [4]. Acquisition parameters were TR=1500 ms and TE=25 ms.

RESULTS: FASTMAP shimming leads to waterline width of 14-16 Hz inside the CSI voxel with both gradient/shim coils. Figure 1 represents the spectroscopic quality that can be consistently obtained in both cases in this preliminary study. Extracted spectra of the CSI data leads to a comparable spectral pattern as single voxel spectroscopy with PRESS with narrower line widths of the metabolite peaks, even with the B-GA20S which is intended for use with larger animals e.g. guinea pigs, rabbits. Even during acquisition times of more than one hour no effect of unwanted B0 field drift due to thermal effects, caused by extreme high shim currents, were observed like in other published studies [2]. Therefore, no frequency correction was necessary. This was achieved by efficient water cooling circuits inside the gradient/shim coil.

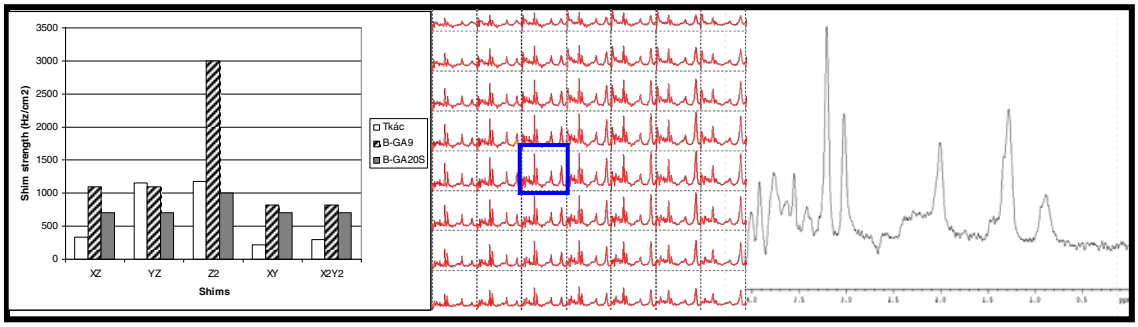

Fig. 1: Left: Comparison of available shim strength in B-GA20S and B-GA9S with specifications needed for mouse spectroscopy applications described by Tkác et. al [2]. Middle: (4.5x4.5x2.0) mm3 CSI matrix measured *in vivo* in a mouse brain tumor. Right: Extracted spectrum (blue square) of CSI data.

CONCLUSIONS: The new generation of hard- and software opens new possibilities for spectroscopic applications in mouse models, eg, tumor heterogeneity can be studied from the spectral pattern point of view with sub voxels of (0.6x0.6x2) mm3, 0.8µl, each [5]. The described CSI study with mice harboring brain tumors was made possible by a novel development of integrated shim and gradient coils, with efficient water cooling circuits, in combination with PRESS localization in the CSI method.

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