# Clinical feasibility of 1H spectroscopic imaging of brain tumors and its fusion with 3D anatomical datasets.

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**Introduction:** Experimental studies have shown that robust two dimensional spectroscopic imaging (SI) protocols can improve delineation [1] of the gliomas and thus provide important unique information for the navigation of the neurosurgery [2], but a comparison of the performance of SI in different regions of human brain under clinical conditions has not been published yet. The main aim of this study was to evaluate the clinical two dimensional MRSI protocol on its feasibility and stability in different regions of human brain. Further more we tested the possibility to fuse the two dimensional metabolic maps with the three dimensional anatomic information by the means of software solutions included within spectrometer the operation system and thus improve the support of surgical neuronavigation system.

**Methods:** $^{1}$H MRSI and anatomical imaging was performed on a 3T clinical scanner (Tim Trio operating with syngoMR VB13, Siemens, Erlangen, Germany) in 25 patient with previously suspected glial tumors for additional information concerning tumor grading. Further we used this data for the integration into the intraoperative neuronavigation system to detect additional "SI-Hotspots" supplementary to already established studies (PET, fMRI). Conventional imaging protocol consisted of T2-weighted turbo spin echo (TSE) sequence along all three directions (4 mm slice thickness) and pre- and postgadolinium contrast enhanced axial T1-weighted gradient echo sequence (2mm slice thickness, 256x256 matrix).

MRSI measurements were performed parallel to axial T1- and T2-weighted slices. Routine automatic adjustments were applied prior to data acquisition. PRESS sequence was used for rectangular VOI selection excluding skull and subcutaneous tissue contamination. Size of the PRESS box varied according to the anatomical situation between 4 and 12 cm in both in plane dimensions. CHESS sequence was used for the water suppression. Sequence parameters included TR/TE 1700/135 ms, 16x16 eliptical weighted phase encoding steps across a 16x16 cm FOV, slice thickness of 1cm, 50% Hamming filter and 3 averages. The total acquisition time was less than 7 minutes. The processing and quantification of the spectra was performed off-line in the time domain using jMRUI [3] software package. Remaining water signal was removed using HLSVD filter [4]. Amplitude, standard deviation of the amplitude and the line width of choline (Cho), creatine (Cr) and total-N-acetyl-aspartate (tNAA) signals were calculated with appropriate prior knowledge using AMARES [5]. Spectral quality was assessed by relative SD and the line width of the Cr signal. Relative SD of Cr amplitude higher than 50% was considered as a threshold between good and poor quality of the spectra. Means of relative SDs, line-widths and percentage of poor quality spectra ± respective SD from 16-70 evaluated voxels per patient are given in the results section.

To enable and guide subsequent integration of SI data separate T2w TSE with FOV identical to that of MRSI and fifteen 2mm-thick slices was obtained. This data set provided the basis for the metabolic map projection and geometrical information for the integration. In detail, metabolic map used here were produced using Spectroscopy application within the spectrometer operating system (syngoMR VB13) After zero filling, phasing, Hamming filtering of the data polynomial baseline correction was applied and line fit in the frequency domain was used to obtain Cho, Cr and tNAA amplitudes. An artificial dataset consisting of five 2mm thick slices containing metabolic information pasted between two five-slices-thick blocks without any signal containing only geometric information was constructed with the help of T2w data set. Consequently, "fifteen slices" T2w dataset was co registered to T1w contrast enhanced data covering whole brain (in addition to fused PET, fMRI and CT data) using semi-automated rigid registration algorithm within the imaging-guided surgical workstation (Stealth Station; Medtronic, USA). Resulting registration matrix was applied to artificial metabolic data set, resulting in co registration of metabolic and three dimensional anatomic data.

**Results:** In general, SI measurements yielded reliable data in the FOV positions above (n= 9) and in the height (n= 9) of lateral ventricles (Fig.1. left), with data quality enabling the calculation of reliable metabolic maps. Poor shim, big susceptibility changes and resulting problems with water signal suppression compromised data quality (Fig.1. middle) from the regions below lateral ventricles (n= 7; temporal, occipital). Only two of these seven measurements (both occipital, Fig.1. right) provided data suitable for reliable metabolic maps. Summary of evaluated spectral parameters is given in the Tab. 1. MRSI data integration into neurosurgical system was successful whenever valid metabolic maps have been produced.

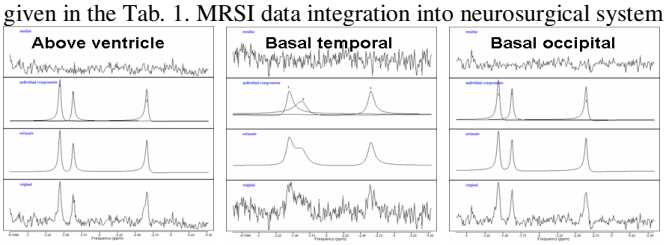


Fig.1. Spectral regions containing Cho, Cr and NAA resonance (from left to right) obtained from the tumor lesions in different brain regions. Acquired spectra, estimates, individual lines and residua are shown (from bottom to up)

| FOV position | n | rel SD [%] | LW [Hz] | % of poor qual. spectra |
|---|---|---|---|---|
| above ventricles | 9 | 16 ± 7 | 6 ± 1 | 12 ± 5 |
| lateral ventricle | 9 | 26 ± 7 | 8 ± 2 | 17 ± 7 |
| basal occipital | 2 | 16 ± 1 | 8 ± 1 | 16 ± 9 |
| basal temporal | 5 | 66 ± 34 | 23 ± 15 | 56 ± 16 |

Tab.1. Relative SD, line width of Cr signal (3.05 ppm) and percentage of poor quality spectra.

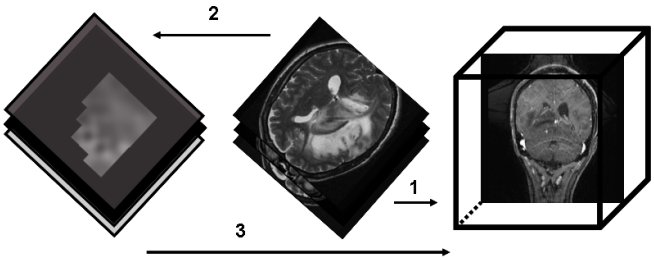


Fig 2. Scheme of the SI data integration. T2w dataset (middle) is co registered to 3D T1w data (right) (1). Metabolic map is projected onto T2w data covering SI region and pasted between blank slices containing geometric information from T2w dataset (left, 2). T2w-to-T1w registration matrix is applied for SI-to-T1w registration (3).

**Conclusion:** Routine SI measurement protocol provides good quality data for the primary and secondary intracerebral tumors. These data can be used for the integration into neurosurgical neuronavigation system by three step co registration into three-dimensional anatomic data. Additional shimming procedure and/or special selection of spectroscopic VOI has to be considered for the SI measurements of the meningial tumors and/or lesions near the skull (base).

**References**: 1. Stadlbauer et al. NeuroImage 23: 454-461, 2004 2. Stadlbauer et al. J Neurosurgery 101: 287-294, 2006 3. Naressi et al. MAGMA, 2001 4. Pijnappel et al. J. Magn. Reson. 97: 122-134, 1992 5. Vanhamme et al. J. Magn. Reson. 129: 35-43, 199