Short Acquisition Time 3D High Resolution (1cc) In Vivo Brain 1H MRSI using LASER-RSI

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Introduction: To achieve high resolution (1cc) ^{1}H MRSI (Magnetic Resonance Spectroscopic Imaging) data *in vivo* human brain we combine Rosette Spectroscopic Imaging (RSI), which is a fast, high sensitivity acquisition technique [1], with LASER [2], a high performance excitation scheme, and use a 32-channel phased array coil at high field (3T).

Materials and Methods: Data for the phantom and human volunteers were acquired on a 3T Magnetom Tim Trio (Siemens, Erlangen), using a 32-channel head phased array coil (manufactured by Siemens). The prescribed volume was FOVxyz=16x16x8cm^3, volume-of-interest VOI=10x10x4cm^3 for the phantom and 10x8x4cm for the subjects. The z-direction readout encoding for the prescribed slab was classical (Cartesian); 8 partitions were used. The x-y-freq readout encoding was done using the rosette trajectories which were optimized for a spectral bandwidth of SW=1200Hz, and 16x16 matrix for an in-plane-resolution IPR=1x1cm^2 , as described in [1]. For the phantom, readout trajectories were designed for the shortest scan time allowed by the scanner hardware capabilities; for the desired spectral bandwidth and spatial resolution, the limiting factor was the gradient slew rate. The maximum gradient and slew rate were Gmax=12.5mT/m and Smax=150mT/m/s^2. The echo/repetition time wereTE/TR=45/1000ms, readout time Tread=300ms for a spectral resolution df= 1/Tread=3.3Hz. The number of rosette shots needed for proper coverage was calculated using the formula provided in [1], Nsh=16, for a total acquisition time of 8x16sh x1s=128 sec (no averages used). Considering the 4 equilibrium (dda) acquisitions, the scan time for the phantom was 2:12min:sec. For the humans, more conservative parameters were used, since some subjects can experience peripheral nerve stimulation when strong gradients are applied (as is also the case with EPI-based acquisitions used for DTI, fMRI, etc). The maximum gradient strength was constrained to 10mT/m. This was now the limiting factor in how fast the data could be collected; the max gradient and slew rate were now 10mT/m and 102 mT/m/s^2. The optimal number of shots for each partition was calculated to be 18. In addition, a TR of 1750ms was used. In addition to providing for better relaxation of the metabolites, the SAR level decreases. The acquisition time for the humans was 8x18sh *1.75s=252 sec. With the 4 equilibrium excitations, sequence scan time was 4:19min:sec. The reconstruction was done off-line. A 5Hz line broadening time-domain filter was used. The data points were gridded, for Fast Fourier Transform (FFT) reconstruction. To ameliorate ringing artifacts, the spatial dimensions were zero-padded to 64x64x32 or to128x128x32 before FFT was done; no spatial filters were used.

Results: The NAA map for one slice, for the BRAINO phantom, is shown in Fig. 1. LASER produces a very homogeneous excitation profile. The NAA maps for a few slices for the human brain are displayed in Fig. 2. The ventricles can clearly be seen (appear darker because of lack of NAA in the CSF that fills the ventricles). One spectrum is shown for a typical periventricular voxel. The NAA resonance (pointed at by the arrow), as well as other metabolites –e.g. the Cre and Cho peaks (to the left of the NAA peak) - can easily be identified.

Discussion and Conclusions: Using very conservative settings in gradient strength, slew rate and repetition time, we demonstrate that high quality, 3D high resolution *in vivo brain* 1H spectra can be obtain in approx. 4 minutes.

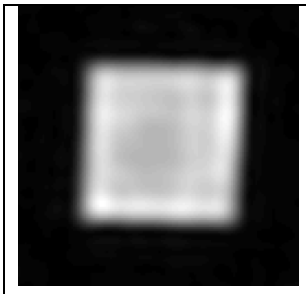
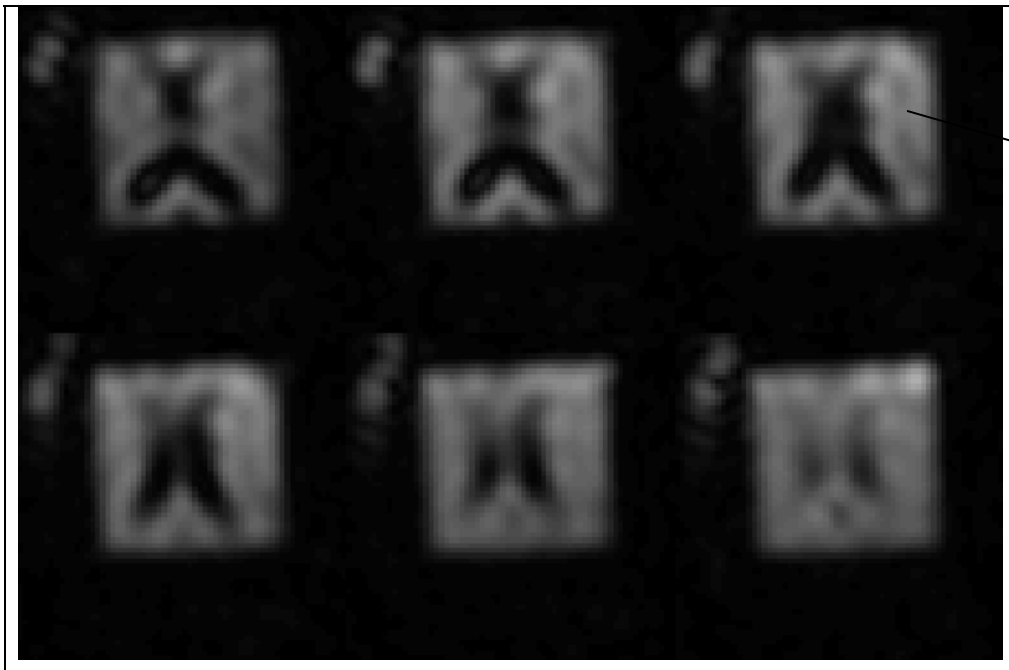


Fig 1: *NAA metabolite map for the BRAINO phantom*



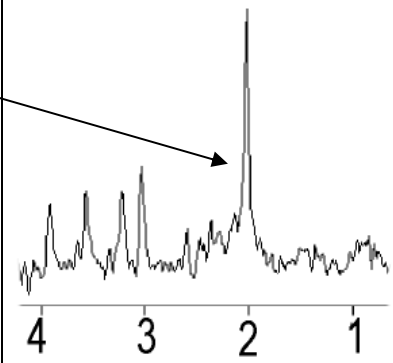


Fig 2: LASER-RSI Acquisition: *NAA metabolite map (left) for a few slices. The effective in-plane resolution is 1cm x 1cm; both the x and y resolution were digittally enhanced(through zero-padding, before FT) by a factor of 4.The spectrum for a periventricular location(indicated by the arrow) is shown above.*

References: [1] Schirda et al, JMRI **29 (6):** p1375, 2009 [2] Andronesi et al, JMR **203**: p283, 2010