7T rosette spectroscopic imaging in human brain

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Introduction: To make spectroscopic imaging clinically feasible, rapid and robust acquisitions with high SNR are necessary. 7T structural and functional imaging are now relatively more widely accepted however metabolic imaging has been slower to become fully realized. With transceiver arrays and high degree B0 shimming that have significantly improved the RF and susceptibility performance at 7T, we now report on implementation of a spin echo rosette k-space trajectory to achieve planar spectroscopic imaging acquisitions in under 2.5minutes.

Methods: A Siemens whole body 7T 8 channel multiple transmit system with body gradient coil, a very high order shim insert (VHOS, Resonance Research Inc.) and an 8x2 transceiver array for all acquisitions. The transceiver array was driven in coil pairs using 8 one-to-two splitters with independent reception from all 16 channels. B_1 shimming was performed targeting the large homogeneous volume of all intracranial tissue and a ring distribution targeting the superficial skin and skull. B_0 shimming was optimized over the slice using BOLERO (1) with the VHOS with 1^{st}-4^{th} degree shims and 2 5^{th} degree shims ZC4 and ZS4.

The planar rosette sequence used a 9mm slice selection and a semi-selective frequency refocusing pulse for water suppression supplemented with a narrow band adiabatic inversion pulse and delay. Spatially controlled lipid suppression was achieved using two adiabatic inversion pulses applied through the B_1 ring distribution (2). A moderate TE of 40ms was chosen to reduce macromolecular contributions to the baseline and reduce spectral overlap with amino acids. The spatial encoding was performed using the interleaved rosette (kx, ky) trajectories with Nshots=44, with each shot rotated by 2pi/Nshots, and each shot acquired in 400us (half 1/spectral bandwidth BW). To achieve a spectral BW=2500Hz, FOV = 216mm (readout time 320ms), two temporal interleaves were used. With a gradient slew rate of 40mT/m/ms and Gmax of 5.1mT/m, no additional eddy current corrections or trajectory corrections were needed.

Results: Fig. 1 shows results from a thalamic study. With the B_1 based ring lipid suppression, a TR =1.5s is permitted and enables detection of brain lipids with good SNR. The spectral BW=2500Hz shows good coverage extending to 0.6ppm without significant distortion.

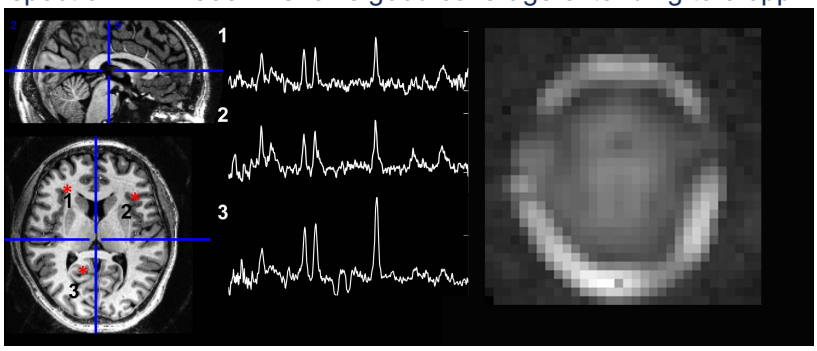

Fig. 1. (Left) MP2RAGE scouts showing the location of the thalamic slice. Asterisks indicate loci of shown spectra. (Right) Magnitude NAA image shows the consistency of the acquisition over the entire slice. Resolution, 9mm isotropic, 2.5min duration.

Discussion: Rosette trajectories utilize circular trajectories enabling data to be acquired over the entire signal decay window (3). At the same time, there are minimal gradient demands, minimal eddy currents and high flexibility with regards to the target spatial resolution and spectral bandwidth. At 7T where temporal interleaving is prudent, we see no problems with spectral quality (linewidth, baseline), consistent with the minimal eddy current performance with the rosette.

Conclusion: We have implemented the rosette trajectory with the spin echo spectroscopic imaging acquisition at 7T, achieving <3min high SNR images over the whole plane. The acquisition lends itself to a variety of optimizations, e.g., including a j-refocused acquisition and additional longitudinal spatial localization.

References: **(1)** Pan JW, Lo KM, Hetherington 2012 MRM 68(4):1007-17; (2) Hetherington HP, Avdievich NI, Kuznetsov A et al. MRM 2010 63(1):9-19; (3) Schirda C, Zhao T, Andronesi O et al 2016. MRM 76(2):380-90.
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