Brain 3D MRSI using Dualband Spectral-Spatial Excitation and k-Space Corrected Spiral Readout

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Introduction

Brain magnetic resonance spectroscopic imaging (MRSI) has demonstrated its usefulness in diagnosing and monitoring brain illness. To obtain high fidelity metabolite spectra, it is critical to suppress water and lipids. Instead of having complete water suppression, partial water signal can provide valuable phase and frequency reference for subsequent signal processing. In order to utilize full capacity of the gradient system and reduce imaging time, spiral k-space trajectory is generally applied. However, gradient imperfection caused by eddy currents would result in distortion or drift in k-space. To address these issues, in this paper, we present an MRSI sequence based on PRESS [1] technique at 1.5T with additional VSS suppression of lipids, dualband spectral-spatial excitation and k-space corrected spiral readout.

Method

Three spectral-spatial RF pulses were incorporated into a PRESS sequence to form a spin echo [2]. The 90 degree pulse is designed to fully excite both water and metabolites. To retain partial water signal, dualband spectral-spatial 180 degree pulses were designed and implemented. At 1.5T, the spectral profile is designed to excite metabolites that resonant from 3.2ppm (Choline) to NAA(2.02ppm) with 15Hz margin on both sides. A partial passband of about 70 Hz that has amplitude of 0.08 was centered on water resonance. The spectral-spatial pulses also suppress lipids below 1.4ppm as opposed to the non-selective inversion recovery technique that normally leads to 30% metabolite signal loss [3]. A minimum-phase spectral profile was chosen to retain a sharp transition band. Before excitation, VSS pulses were prescribed for outer volume lipid suppression. During readout, spirals with 4 interleaves were played out for spatial and spectral encoding. Actual k-space trajectories were calculated by measuring the different phase accrued between signals with gradients on and off before they were used in reconstruction [4]. The final imaging sequence has the following characteristics: outer volume suppression, dualband spectral-spatial PRESS RF pulse for metabolite excitation, partial water suppression and further lipid suppression, TR/TE=1500/144ms, 4 spatial interleave spiral readout gradients, 256 spirals per readout, 500 Hz spectral bandwidth, 32/32/16 matrix size, 1cc voxel, 8 NEX with phase cycling and 13 minute acquisition time.

Results

The dualband RF, gradient waveforms and its spectral profile are shown in Figure 1. The ripple magnitude in the pass and stop bands are 1% and the transition bandwidth on the lipid side is about 30 Hz. Figure 2 shows one interleaf of an ideal spiral trajectory and its difference from 256 measured ones in one TR. Spectra from voxels in one of 16 slices from an in vivo study, after rephasing with water signal, are shown in Figure 3. The enlarged spectra from 4 representative voxels clearly show well phased spectra. The reconstructed data were reordered to generate DICOM compatible data and put back to the scanner database to be viewed using standard GE spectroscopic tools (Functool).

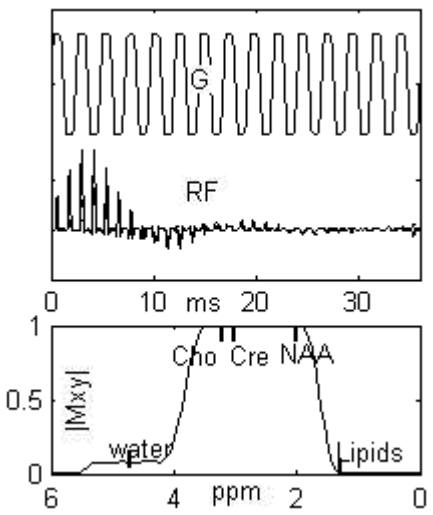

Fig 1.Dualband spatial-spectral 180 RF pulse and gradient and its spectral profile.

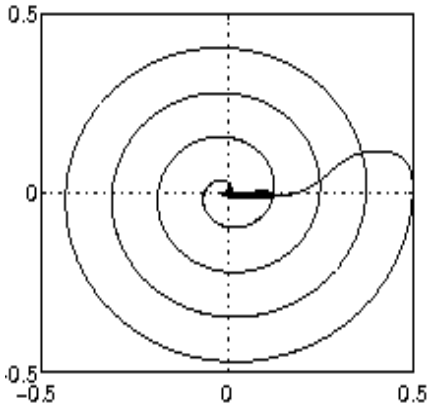

Fig 2. One interleave of ideal spiral trajectory and its difference from the measured ones for for one TR. The dense dots near the origin represent differences between the ideal spiral and 256 measured ones.

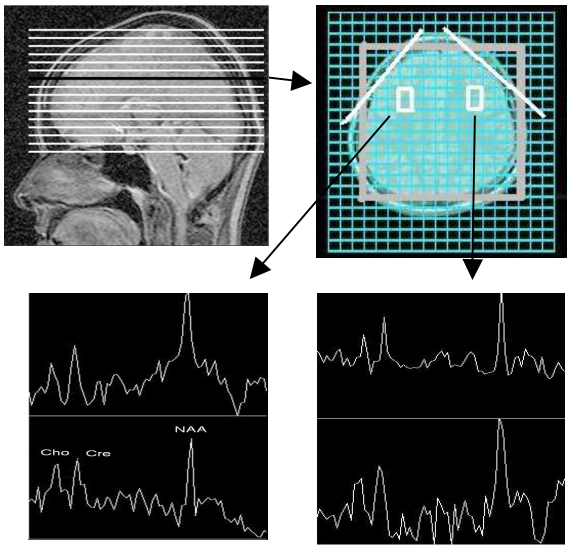

Fig 3. Metabolite spectra from a volumetric ^{1}H MRSI in vivo brain study. The white bars on the grid represent the VSS region and the gray box represents the PRESS box. Spectra from 4 representative voxels are displayed.

Conclusion

A 3D MRSI sequence based on PRESS localization with outer-volume lipid suppression, dualband excitation and k-space corrected spiral readout has been implemented at 1.5T for brain imaging. Its capability of obtaining high quality metabolite spectra with water reference has been demonstrated from an in vivo study. Ongoing studies are being performed to evaluate if the lipid suppression provided by the spectral-spatial pulse is sufficient to eliminate the need for the VSS pulses and the PRESS box.

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