Blipped Phase-Encoding in MR Spectroscopic Imaging Revisited: comparison to SENSE-MRSI

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Introduction

Various techniques have been proposed to accelerate proton magnetic spectroscopic imaging (MRSI), including parallel imaging methodologies and echo planar spectroscopic imaging (EPSI). The method of blipped phase-encoding (BPE) has previously been proposed to accelerate EPSI (1,2), but to our knowledge has not been used for conventional MRSI. In this abstract, BPE-MRSI is implemented and compared to conventional MRSI and SENSE-MRSI (3).

Material and Methods

In BPE, alternative positive and negative blipped phase-encode gradients are applied between success time domain points of the FID, thereby providing phase-encoding information in the time-domain readout. The sampling rate (receiver bandwidth) is double compared to that of a conventional MRSI acquisition, while the total experimental time (governed by the number of (non-blipped) phase encoding steps) can be halved.

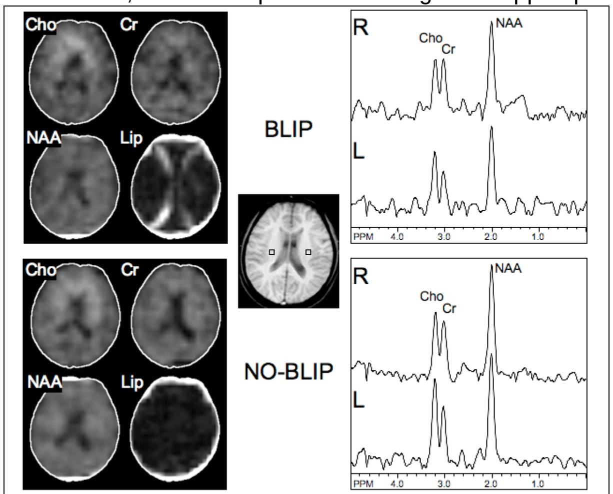

Figure 1. Blipped (top) and conventional (bottom) metabolic images and selected spectra from a normal volunteer at 1.5T.

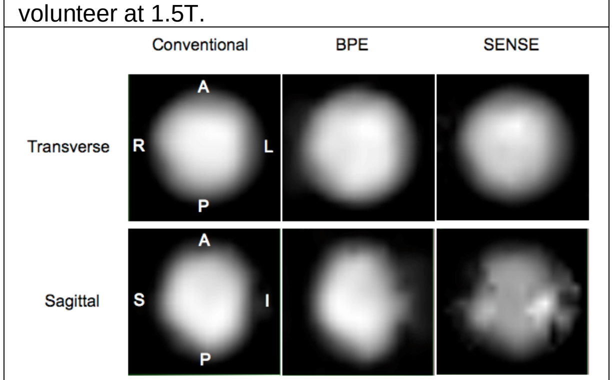

Figure 2. Conventional, blipped and SENSE-MRSI in a spherical phantom at 3T. While all 3 methods produced similar images in the axial plane, the SENSE-MRSI scan shows artifacts in the sagittal orientation due to unfavorable coil geometry.

Experiments were performed at 1.5 and 3.0T with gradient systems of 30 and 40 mT/m respectively (slew rate 150 T/m/s). Experimental demonstration of BPE-MRSI was performed on a healthy normal volunteer (male, age 29 years) at 1.5T using a slice-selective, spin-echo multi-slice MRSI experiment with 'WET' water suppression (4) and outer-volume saturation (OVS) for lipid suppression (5). Conventional MRSI consisted of 3 slices, thickness = 15 mm, FOV = 220×165 mm, TE = 280 ms, TR = 1500 ms, receiver bandwidth BW = 500 Hz, matrix size = 32×24×128 (x, y, δ), nominal voxel size = 0.7 cm^3, total scan time 19 minutes with one signal average. BPE-MRSI was identical except that receiver bandwidth was 1000 Hz and during data acquisition, 0.1 ms positive and negative blip triangular BPE pulses were applied, giving a 9.5 minute scan time.

For comparison to SENSE-MRSI, phantom experiments were performed at 3T using an 8-channel head coil. SENSE-MRSI and BPE-MRSI experiments were performed in the axial and sagittal planes.

Results

Figure 1 shows BPE-MRSI and conventional MRSI in the normal volunteer. Quality of spectra and metabolic images was very similar between the 2 scans, with the average SNR in the conventional MRSI experiment being 18.9 ± 5.7 (mean ± standard deviation) and 13.6 ± 5.5 in the BPE-MRSI, which is approximately 72% of the conventional experiment. This is in close accordance with the expected value of 70.7% (1/√2), based on the two-fold reduction in scan time. Figure 2 shows the phantom comparison between BPE- and SENSE-MRSI. It can be seen that both methods work well in the axial plane, but that SENSE-MRSI demonstrates artifacts in the sagittal plane due to unfavorable coil geometry ('g'-factor) for phase-encoding in the superior-inferior (S-I) direction.

Discussion

It is a historical curiosity that, as far as we are aware, BPE appears not to have been previously implemented for scan time reduction in non-EPSI MRSI studies. The current study shows that BPE-MRSI is feasible and can produce high quality data, the SNR reduction being in strict accordance with that expected from reduced scan time only. BPE offers comparable acceleration factors as are available from SENSE, but does not require a favorable coil 'g' factor, and hence can be applied in any direction with any coil system (including single channel coils). The main limitation of BPE is the limited spectral width that can be attained (due to the length of the blip gradient), particularly on high field systems, and/or if acceleration greater than a factor of two is required.

References

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