Development of Parallel Correlated Spectroscopic Imaging

Gaurav Verma[1,2]

[1]*Radiology, University of Pennsylvania, Philadelphia, PA, United States,* [2]*Radiological Sciences, University of California, Los Angeles, California, United States*

Introduction: Multi-Echo correlated spectroscopic imaging (ME-COSI) (1) facilitates the acquisition of spatially-encoded two-dimensional (2D) spectra, but with the tradeoff of slow acquisition resulting in crude spatial resolution. Parallel acquisition techniques, like Generalized autocalibrating partially parallel acquisitions (GRAPPA) (2) and Sensitivity Encoding (SENSE) (3), are well-established strategies for accelerating spatial encoding in MRI and MRSI. SENSE works by acquiring data intentionally undersampled in k-space and applying known sensitivity and phase information from a pre-scan with the phased array receive coil to "unfold" the resulting spatial aliasing. By applying SENSE to ME-COSI, thereby creating the first parallel COSI sequence, the acquired spatial resolution of ME-COSI can be effectively doubled without an increase in scan time.

Materials & Methods: The recently-introduced ME-COSI sequence was modified for SENSE acquisition by doubling the phase-encoding step in the conventionally-encoded dimension, corresponding to halving the nominal field of view (FOV). An 8x8 spatial array with a 144x72mm^2 FOV was acquired with a corresponding reconstructed 8x16 array with an FOV of 144x144mm^2. Other scan parameters were: TE/TR = 22/1500ms, 1 average, 256 complex points with 2000Hz bandwidth and 64 to 100 measurements with Δt_1 = 0.8ms, resulting in a scan time of 25-40 minutes. The slice thickness was 40mm, resulting in a voxel size of 18x9x40mm (6.48ml). An 18-second T_1-weighted pre-scan with an identical 144x144mm FOV was acquired with the phased array coil and body coil and the difference between these signals was used to generate the sensitivity matrix required for spatial unfolding. SENSE-based ME-COSI was tested with two scans each using phased-array 8-channel and 12-channel head coils. A MATLAB-based program was used to perform all post-processing, including SENSE reconstruction based on the algorithm described in the original SENSE paper (4).

Results & Discussion: Figure 1.1 shows the spatial profile of the cross peak of n-acetyl aspartate (NAA) at [F_1,F_2] = 2.5, 4.3 ppm (5) plotted against the T_1-weighted MRI of the brain phantom. The red and blue lines represent the acquired and reconstructed FOV, respectively. SENSE reconstruction and multi-echo acquisition were performed in the left-to-right and anterior-to-posterior dimensions, respectively. The figure demonstrates the doubling of spatial points from 8x8 within the red box to 8x16 in the blue box. Figures 1.2 show 2D ME-COSI spectra from central and peripheral voxels in the same study. Both spectra demonstrate several metabolite resonances including cross-peaks due to NAA, aspartate (Asp), glutamate/glutamine (Glx), myo-inositol (mI) and phosphoethanolamine (PE). The more central voxel shows higher signal intensity and this allows other cross peaks, such as those due to lactate (Lac) and phosphocholine (PCh) to also be resolvable there but not in the peripheral voxel.

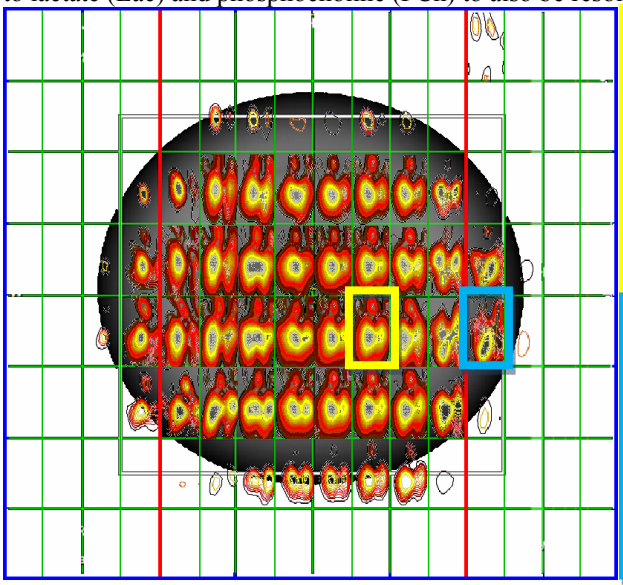

Figure 1.1 (Left): Spatial profile of NAA cross peak in a SENSE-based ME-COSI scan of brain phantom. Acquired 8x8 and reconstructed 8x16 spatial arrays are outlined in red and blue, respectively.

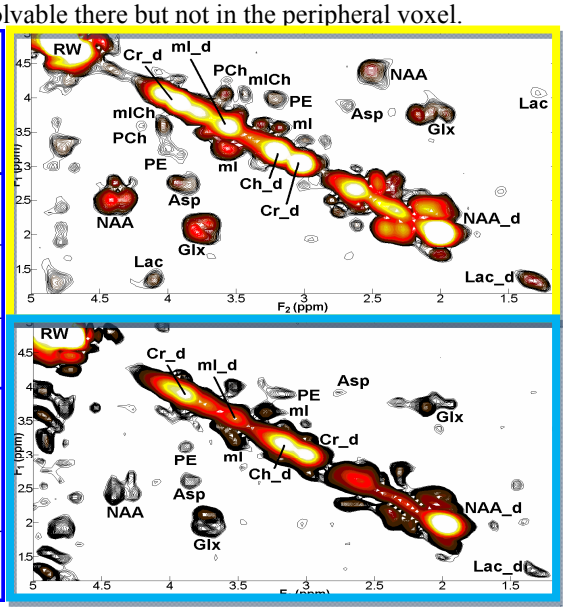

Figure 1.2 (Right): 2D spectra from central (top) and peripheral (bottom) voxels of SENSE-based ME-COSI scan of brain phantom. Higher signal intensity is evident in the central voxel.

Conclusion: This initial application of SENSE-based ME-COSI demonstrates the successful unfolding of spatially undersampled data with 2D spectra. A number of cross peaks were visible in reconstructed voxels outside of the originally acquired FOV, despite a decrease in signal intensity compared to central voxels that would be less affected by residual folding. While scan times were long in this initial implementation, the observed signal quality suggests a potential to apply SENSE along both spatial dimensions to reduce acquisition time. This would be facilitated by improvements in spatial sensitivity maps using improved noise thresholding and extrapolating sensitivity information beyond the region of the phantom.

References: 1. Verma G, et al. *JMRI*. 2011; 34:262-269 **2.** Griswold M, et al. *Magn Reson Med* 2002; 47:1202-1210 **3.** Dydak U, et al. *Magn Reson Med* 2001; 46:713-722 **4.** Pruessmann K, et al.. *Magn Reson Med* 1999; 42:952-962 **5.** Velan S, et al. *Magn Reson Med* 2007; 265:409