Correlated Spectroscopic Imaging Using Concentrically Circular Echo-Planar Trajectories in Human Calf

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Introduction – Localized correlation spectroscopy (L-COSY) can elucidate the complex spectra of *in vivo* metabolites by spreading frequency information over two orthogonal dimensions, thereby highlighting connections between J-coupled protons[1]. It can be incorporated into any standard chemical shift imaging (CSI) sequence, but with scan times proportional to the number of phase encoding steps and the number of t1 points (N_1), clinical application is impractical unless some acceleration techniques are used. EP-COSI combines L-COSY with a trapezoidal echo planar readout gradient, allowing simultaneous acquisition of a single line of k-space with spectral information from a pseudo free induction decay (FID) and reducing scan times to clinically feasible levels [2]. We propose an alternative method of k-space sampling in which a circle in k-space is acquired simultaneously with the spectral FID. This has the advantage of being more easily adaptable to higher field strengths, as higher spectral bandwidth is achievable using a sinusoidal echo-planar readout than with a traditional trapezoidal echo-planar readout due to gradient hardware limitations. In addition, fewer phase encoding steps are needed as all four quadrants of k-space are sampled symmetrically in a single TR.

Methods – Human calf scans were taken on a Siemens 3T Trio TIM scanner using a transmit/receive extremity coil. The following experimental parameters were used: TR/TE = 1500/30 ms, FOV = 16x16 cm^2, slice thickness = 2 cm, N_1 = 50, and 1 average. Sixty four points were collected for each k-space circle, and 512 points were collected for each spectral FID. Spectral bandwidth was 1250 Hz (~10 ppm) in both dimensions. Eight concentric circles were collected, and the polar data was gridded [3] to a 16x16 Cartesian plane, resulting in voxels measuring 1x1x2 cm^3. Total scan time was 10min 36s including prep scans and a non water suppressed scan for eddy current correction.

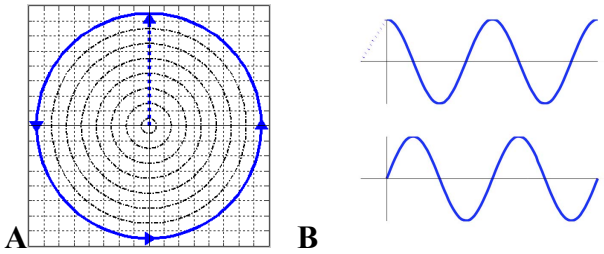

Figure 1. A) Circular k-space trajectory overlaid with the gridded Cartesian plane. Each circle is acquired repeatedly in a single TR. **B)** Readout gradients in the x- (top) and y- (bottom) directions illustrating the first two such acquisitions.

Results and Discussion – Figure 1 shows the acquired k-space trajectory along with the gridded plane and the readout gradients. Figure 2 shows localized 2D spectra taken from the soleus (Fig. 2B), tibialis anterior (Fig. 2C), and marrow (Fig. 2D). Note the splitting of the creatine 3.9 ppm diagonal peak in the tibialis anterior, the separation of IMCL and EMCL around 5.4 ppm in the soleus, and the lack of creatine and high lipid signal in the marrow. An EP-COSI sequence of similar spatial/spectral resolution would have taken 21min, and a CSI sequence would take over 5 hours.

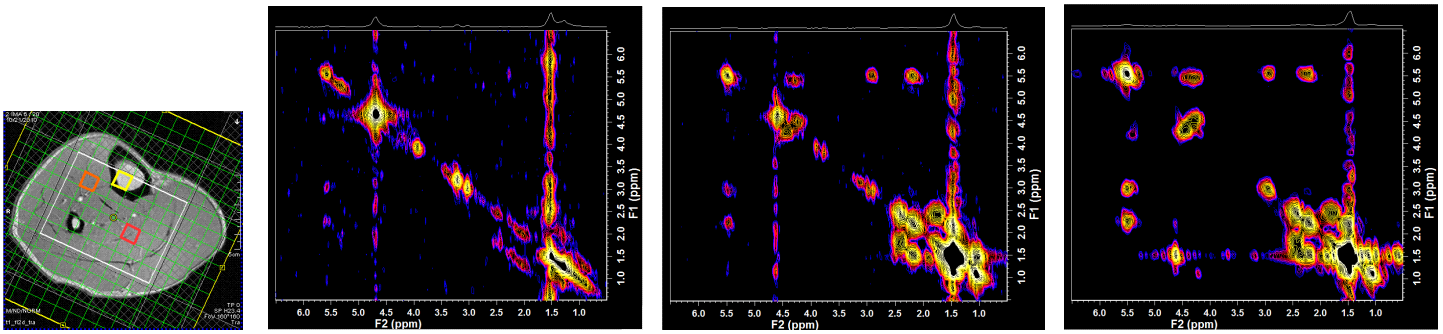

Figure 2. A) Localized calf volume along with select voxels in the soleus (red box), tibialis anterior (orange box), and marrow (yellow box). 2D spectra from the highlighted voxels are shown in **B)**, **C)**, and **D)**, respectively.

Conclusions – By sampling k-space using concentric circles and incrementing the evolution period t1, two dimensional spectra can be localized over an entire plane in clinically realizable scan times. This sequence can be easily adapted to record at the higher spectral bandwidths required at larger field strengths where hardware limitations threaten the applicability of trapezoidal echo planar techniques.

References

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