Spiral Chemical Shift Imaging in the Presence of Metal Artifacts

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Introduction: In this abstract, we propose the use of short readout, multi-interleaf spiral k-space trajectories acquired at a large number of echo times for imaging in the presence of metal. The raw data, acquired at varying echo times is Fourier transformed prior to gridding. The echo-time step size determines the spectral bandwidth that can be acquired and the difference between the longest and shortest echo times determines the spectral resolution. The pulse sequence is illustrated in Fig. 1. A hard pulse with the maximum RF amplitude is used for excitation to minimize the echo time and RF pulse duration, maximizing the spectral bandwidth excited.

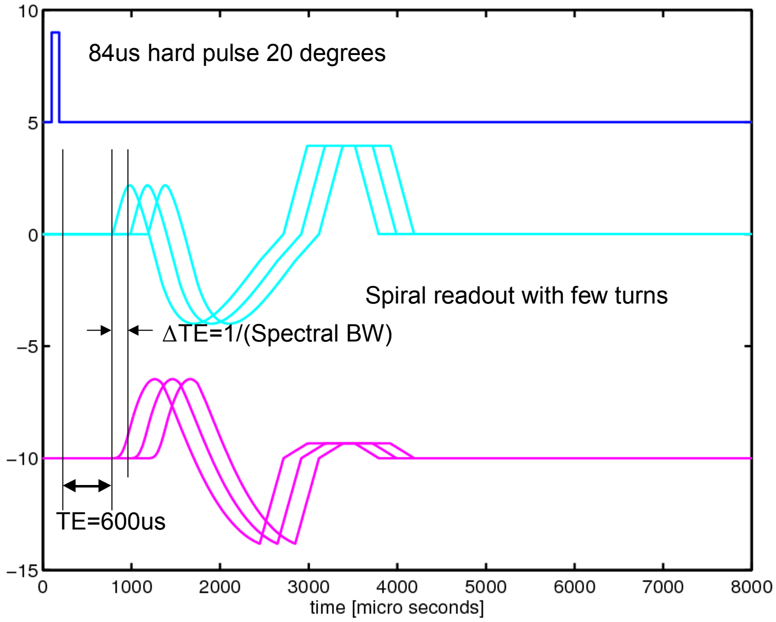

Figure 1: Pulse sequence. Spiral readout is short and multiple interleaves are used. The echo time is stepped from the minimum echo time to a prescribed maximum yielding a spectrum.

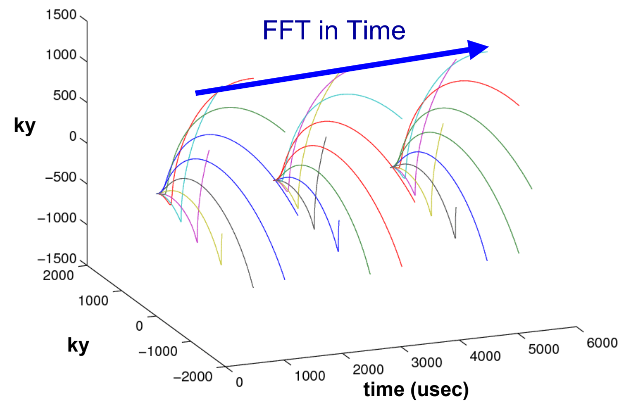

Figure 2: The resultant k-space trajectory resembles a stack of bowls in kx, ky, t space.

Materials and Methods: A small stainless steel Sweglock collar was placed in water in a Petri dish and imaged with the spiral sequence. Echo times were stepped by 500us resulting in a spectral bandwidth of 2000Hz. The readout time is 1.664msec and the pixel size in these images is 0.78mm.

Results and Discussion: Although the field perturbation around implanted metal can be as high at 10-15kHz, with short RF pulses, and small echo time step sizes, very high spectral resolution can be acquired. T2* blurring close to the metal will limit how close to the implant we can image. Due to long scan times, we do not propose this as a clinical method but rather as a way to map the field perturbations of implants in vitro.

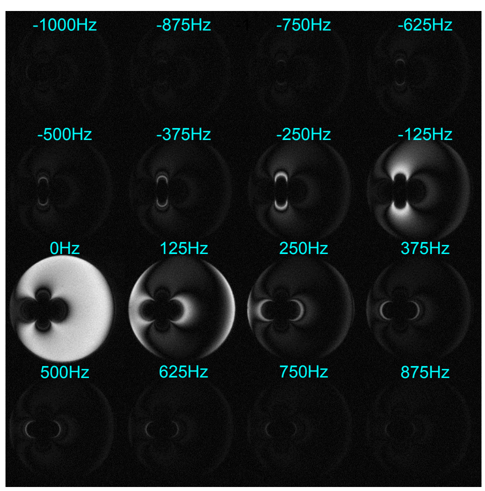

Figure 3: Images of each frequency bin are shown. The classic dipole field map is clearly visible. The vertical lobes have a negative frequency shift and the horizontal lobes have a positive frequency shift.

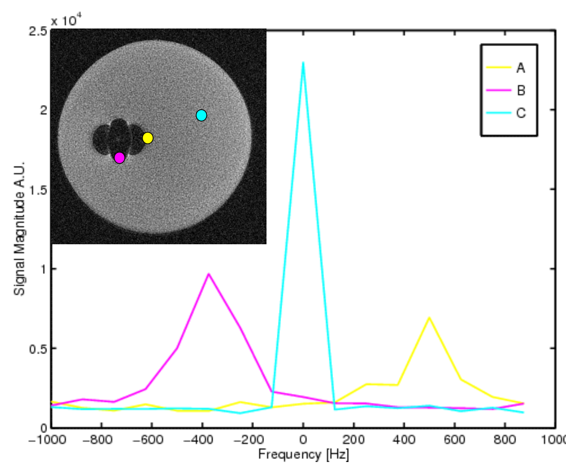

Figure 4: The same data is redisplayed as a magnitude spectrum. The cyan spectrum is from water far away from the stainless steel collar and the magenta and yellow spectra are from the lobes of the dipole field perturbation. Although the spectrum is coarse, the width of the spectra indicate the T2* within the indicated voxels. Signal loss in the images is due to unrecoverable T2* blurring.

References:
[1] D. Kim, E. Adalsteinsson, D. Spielman; Proceedings ISMRM, May 7-13, p. 722, 2005.
[2] D.Mayer, D-H.Kim, D.M.Spielman, R.Bammer; Magn.Reson.Med 59:891-897 (2008)