Analysis of T1 weighted Spiral Projection Imaging

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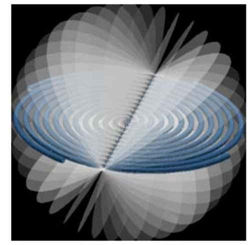


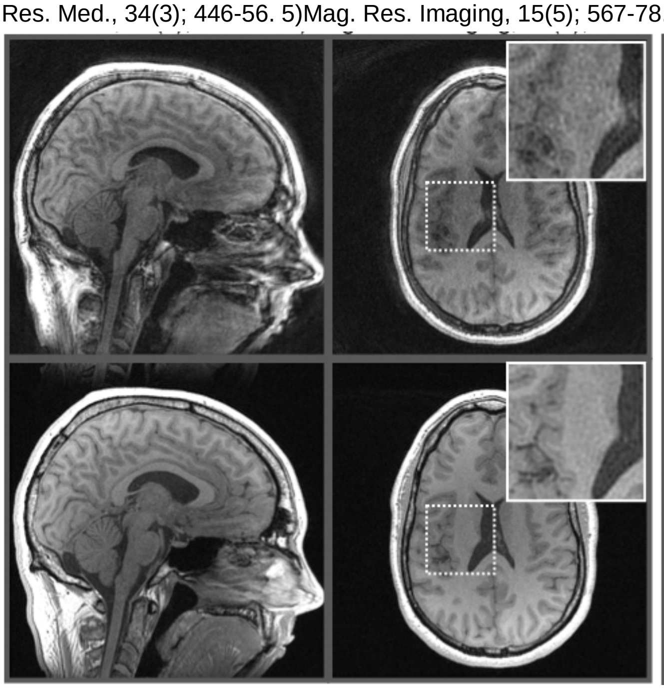
Fig. 1 Spiral planes are used to fill a sphere in k-space.

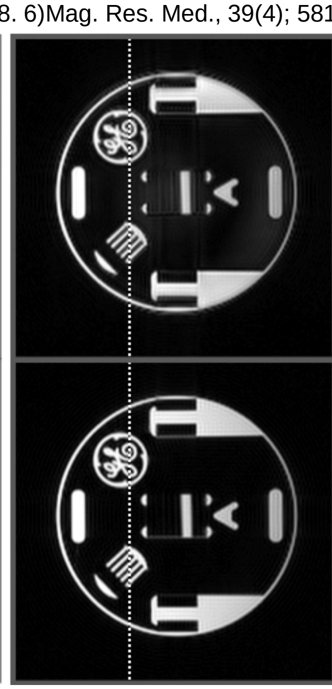
OBJECTIVE: Spiral Projection Imaging (SPI) is a versatile, fast 3D data acquisition. Data are sampled on 2D spiral planes that are rotated to fill a sphere in k-space (figure 1). The spiral basis of SPI provides flow insensitivity. Furthermore, it has been shown[1,2] that SPI allows for six degrees of motion correction similar to that used in PROPELLER[3]. SPI requires far fewer excitations than a line-by-line 3D Cartesian acquisition. This provides flexibility in the TR and thus a potential advantage in scan time, resolution, or SNR. However, the spiral and PR bases of SPI make it susceptible to off-resonance blurring and gradient inconsistencies. The goal of this study was to compare 3D spoiled gradient echo T1-weighted SPI images with similar Cartesian images to analyze the artifacts seen in SPI. While the focus here is on SPI, similar artifacts may be observed in other imaging trajectories.

METHODS: Data were acquired with the SPI trajectory on a GE 3T Signa Excite 3.0T (9.8ms TR, 20° flip, 410 planes, 90 interleaves, 6'10" scan time). A short ADC time (~2.4 ms) was used to minimize off-resonance blurring effects. Ultimately, SPI should use fewer interleaves, yielding improved resolution or reduced scan time but also introducing greater off-resonance blurring making off-resonance correction vital. Data were also obtained for a Cartesian acquisition (6.5ms TR, 16° flip, 240 frequency encode, 240x240 phase encodes, 6'13" scan time).

RESULTS: The figures show inferior image quality in SPI compared to the Cartesian scan. Severe distortions occur in some regions of the SPI images due to fat off-resonance that can be readily addressed with fat saturation. Subtle distortions seen within the brain tissue are more difficult to resolve. The measured SNR of the SPI data in figure 2 is 49% of the Cartesian data, but should theoretically be about 85% for the parameters specified above. This discrepancy may be explained in part by artifacts seen in the SPI images, as the measured SNR of the SPI phantom data is about 93% that of the Cartesian phantom data. Simulated SPI data demonstrate an imperceptible loss in image quality. However, when k-space coordinates derived from slightly delayed or misaligned gradient waveforms are used to reconstruct the simulated data, artifacts similar to those seen in the SPI phantom data are observed. Large improvements in SPI image quality were observed when a 4μs gradient group delay was measured and corrected. It is thus assumed that much of the remaining degradation seen in the acquired SPI data results from k-space coordinate inconsistencies due to gradient delays and other system imperfections. Methods exist for measuring actual k-space coordinates[4-7] and should be used to further characterize these effects.

REFERENCES: 1)Proc. ISMRM 2008, Abstract 1470. 2)Proc. ISMRM 2008, Abstract 1469. 3)Mag. Res. Med., 42(5); 963-9. 4)Mag. Res. Med., 34(3); 446-56. 5)Mag. Res. Imaging, 15(5); 567-78. 6)Mag. Res. Med., 39(4); 581-7. 7)Mag. Res. Med., 38(3); 492-6.





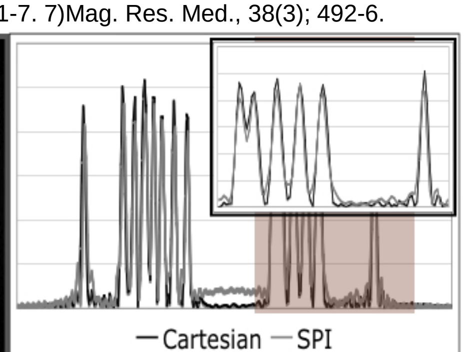


Fig. 3 Left: SPI (top) and Cartesian (bottom) phantom data. Right: Cross section of SPI and Cartesian data corresponding to the dashed white line in the images to the left. A zoomed version of the shaded region of the cross section is also shown to illustrate that the SPI data appears to have the same resolution as the Cartesian data.

Fig. 2 Sample images from 24x24x24 cm FOV, 1mm resolution SPI data (top) and Cartesian data (bottom).