A Spiral Spin-Echo Sequence for Fast T2-Weighted Imaging with Improved Contrast

Zhiqiang Li[1], Dinghui Wang[1], John P Karis[2], and James G Pipe[1]

[1]*Imaging Research, Barrow Neurological Institute, Phoenix, AZ, United States,* [2]*Neuroradiology, Barrow Neurological Institute, Phoenix, AZ, United States*

Introduction: T2-weighted Turbo Spin-Echo (TSE)[1] is commonly used as a routine scan in neuroimaging. TSE generates a T2-weighted contrast that is slightly different from a SE sequence, primarily due to the long train of RF pulses[2]. By incorporating techniques such as IDEAL[3] or mDixon[4,5], TSE is also capable of providing the water and fat images, but at the expense of scan speed. In this study, we propose to use a SE sequence for its improved T2 contrast, with a spiral readout to reduce the scan time. The spiral acquisition also provides inherent insensitivity to motion.

Methods: A standard SE sequence was modified to collect the data with a spiral-in/out readout, which has also been proposed for fast abdominal imaging[6]. To produce the water and fat images, the SE data were acquired at two ΔTEs. The water/fat separation and deblurring were performed using a B0 field map acquired in a separate scan.

Volunteer data were acquired on a 3T Philips Ingenia scanner with a 32-ch dS head coil. The parameters of the reference Cartesian TSE were: FOV = 230x200x144 mm^3, resolution = 0.8x0.8 mm^2, slice thickness = 4 mm with 0 gap, inferior saturation band, ETL = 16, flip angle = 120°, TE = 80 ms, ΔTE = 0 and 1 ms for mDixon, TR = 4 s, scan time = 4:18. The spiral scans used a similar protocol except that FOV = 230x230x144 mm^3, no inferior saturation band, 25 spiral interleaves, ADC = 32 ms, 2 ΔTEs (0 and 1.15 ms), scan time = 3:16. Pure noise images were also acquired for the evaluation of SNR performance[7].

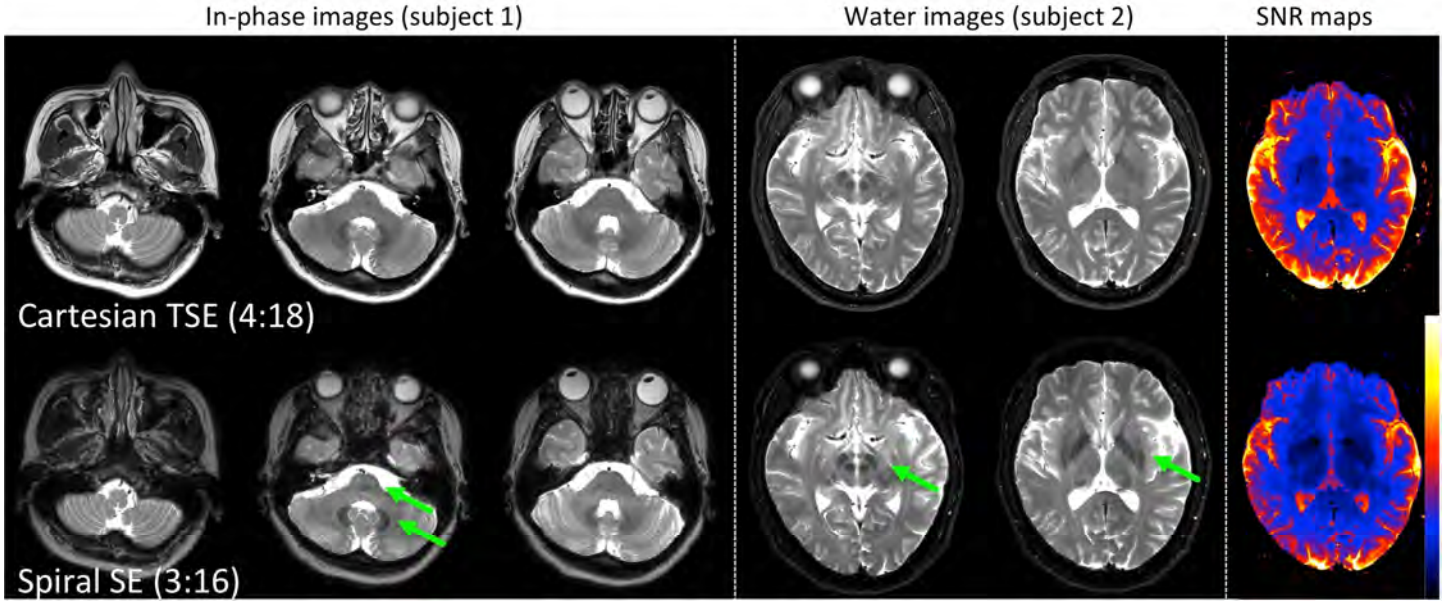

Fig. 1 Representative results from Cartesian TSE mDixon (top) and spiral SE (bottom). The left panel shows in-phase images and the middle one shows water images. The green arrows point to enhanced contrast in the spiral SE results. The right panel shows the calculated SNR maps.

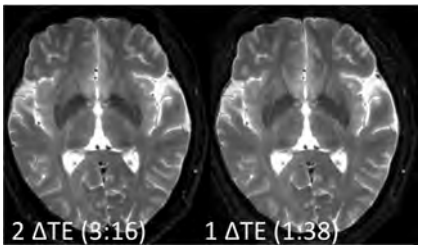

Fig. 2 Water images reconstructed from spiral SE data acquired with 2 ΔTEs (left) and 1 ΔTE (right).

Results and Discussion: Fig. 1 shows the in-phase images (left panel) and the water images (right panel) obtained with Cartesian TSE mDixon (top) and the proposed spiral SE (bottom). It is observed that the spiral SE produces increased T2 contrast, especially in tissues such as the dentate nuclei, the red nuclei, globus pallidus, putamen, etc., as pointed to by the green arrows in Fig. 1. The main cause of this difference is the reduction of susceptibility weighting by the RF train in the TSE sequence, as discussed in Ref. 2. The SE sequence is more sensitive to T2* effect and thus produces increased contrast in blood or tissues with increased ion deposition. The fat signal in the spiral SE data is less bright than that in the TSE data because of the loss of the J-coupling effect in TSE. The right panel of Fig. 1 shows the SNR maps from Cartesian TSE and spiral SE. Even though the total scan time is shorter with spiral SE (3:16 vs 4:18), the SNR from spiral SE is very close to that from Cartesian TSE, in part because the total ADC time is comparable (1.53 s vs 1.64 s). This demonstrates that the spiral acquisition is more efficient. Other impacting factors include the T2 decay induced smoothing in TSE, and the refocusing RF flip angle, which is typically lower than 180° in TSE. The scan time with spiral SE can be further reduced by acquiring data at only a single ΔTE and utilizing the unbalanced spiral-in and spiral-out parts to jointly separate fat and water and deblur the images[8], as shown by the preliminary results in Fig. 2. However, future work is required to reliably extract and deblur the fat image[8].

Conclusion: The spiral SE technique with the spiral-in/out readout provides fast speed, improved T2 contrast and high SNR efficiency, thus provides a promising tool for T2 weighted neuroimaging.

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