The Reduction of Flow Artifacts in T1W Spiral Spin-Echo Imaging: A Preliminary Study in Children

Zhiqiang Li[1], Houchun H Hu[2], Dinghui Wang[1], Jeffrey H Miller[2], John P Karis[3], and James G Pipe[1]

[1]*Imaging Research, Barrow Neurological Institute, Phoenix, AZ, United States,* [2]*Radiology, Phoenix Children's Hospital, Phoenix, AZ, United States,* [3]*Neuroradiology, Barrow Neurological Institute, Phoenix, AZ, United States*

Introduction: Contrast-enhanced T1-weighted imaging is an important tool for the diagnosis of neural abnormalities. Spin-echo (SE) and turbo spin-echo (TSE) sequences are widely used in routine clinical procedures. It is well known clinically that post-Gd-contrast SE/TSE Cartesian-based imaging is sensitive to flow-related artifacts. In axial slices, artifacts that arise from superior sagittal and transverse sinuses are readily noticeable. Recently, an alternative spiral-based SE technique was proposed as a means to reduce these flow artifacts[1], which is achieved by the use of larger crushers (labeled in green in Fig.1). The spiral SE acquisition was also shown to provide faster scan speeds. In this preliminary study, we compare and evaluate the performance of the spiral water-fat separated (e.g. mDIXON[2,3]) T1-weighted SE pulse sequence in pediatric patients, focusing on flow artifact reduction and diagnostic image quality with respect to its Cartesian TSE counterpart.

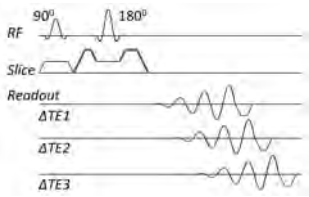

Fig. 1 Diagram of the spiral SE sequence.

Methods: The prospective study was approved by the local ethics committee. To date, thirteen pediatric patients were examined on a 3T Philips Ingenia scanner (10 males, 3 females, age range: 1-13 years, 5.5±4.1 years). Each patient underwent a standardized brain MRI exam per institution protocol, which included an axial Cartesian-based 2D T1-weighed TSE sequence. After the injection of Gd contrast agent, the 2D Cartesian TSE was scanned, followed by the proposed spiral SE.

Typical acquisition parameters for the Cartesian-based TSE mDIXON sequence was: FOV 220x220 mm^2, in-plane resolution = 1.0x0.8 mm^2, slice thickness = 3 mm, slice gap = 0.3 mm, number of slices = 15, ETL = 3, TE = 9 ms, TR = ~674 ms, 2-pt mDixon (with echo shift of 0 and 1 ms off the SE), inferior saturation band and in-plane flow compensation, scan time = 2 min 30 s.

The mDIXON spiral SE was acquired with the same TR, FOV, slice thickness, slice gap, and number of slices. In-plane resolution = 0.85x0.85 mm^2, number of spiral interleaves = 36, TE = 10 ms, 3-pt mDixon (echo shift = -0.2, 0.57, and 1.34 ms), no saturation band or flow compensation, scan time = 1 min 18 s, representing an approximate two-fold acceleration with respect to the Cartesian variant.

The reconstructed water images from Cartesian TSE mDixon and spiral SE were blindly and independently reviewed by two experienced radiologists to assess (a) the flow artifact, and (b) the overall diagnostic image quality. For each patient, the paired Cartesian- and spiral-based images were randomly illustrated in a left and right columns format. The radiologists used a 5-point rating scale: the left image is significantly better than the right, the left image is moderately better than the right, the left image is equivalent to the right, the left image is moderately worse than the right, and the left image is significantly worse than the right.

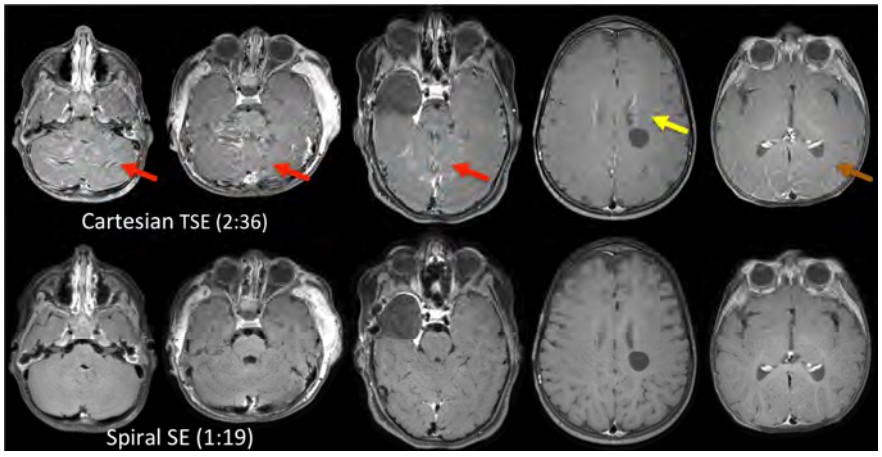

Fig. 2 Representative images from Cartesian TSE mDixon (top) and spiral SE (bottom) in 5 patients. In the Cartesian-based images, red arrows point to "ringing" flow-related artifacts, yellow arrow points to a motion artifact, and brown arrow points to hyperintense vascular signal. These artifacts and characteristics are absent in the spiral images (bottom).

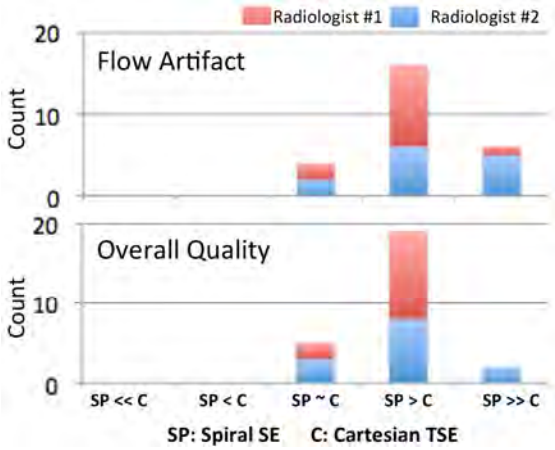

Fig. 3 Qualitative scores on flow artifacts (top) and overall quality (bottom) between Cartesian TSE mDixon and spiral SE.

Results and Discussion: Fig. 2 shows images obtained with TSE mDixon (top) and spiral SE (bottom) from different patients. Artifacts that are noticeably present in the Cartesian TSE mDixon results are minimized in the spiral SE data. Histograms of the qualitative evaluations from the radiologists are shown in Fig. 3. Both radiologists noted improved performance in flow artifact reduction with spiral SE than the Cartesian TSE mDixon variant. The radiologists also preferred spiral SE in terms of overall diagnostic quality. No radiologist found spiral SE to be worse than Cartesian TSE. The *p* values of the test on flow artifact and overall quality are 0.17 and 0.42, respectively, indicating that the scores from the radiologists were not statistically different from each other. Qualitatively, both radiologists also expressed that the spiral data exhibited adequate SNR despite its reduced scan time. Another potential advantage of spiral SE is the absence of bright vascular signals (due to the larger crusher), which are present with TSE mDixon and may obscure true pathological enhancement.

Conclusion: The spiral SE technique significantly reduces flow-related artifacts commonly observed in post-contrast T1-weighted Cartesian-based SE/TSE imaging, yields comparable diagnostic image quality, and is therefore a viable alternative in the clinical setting.

References: 1) Li Z et al. ISMRM-ESMRMB 2014;4246. 2) Berglund J, et al. MRM 2010;63:1659. 3) Eggers H, et al. MRM 2011;65:96.

Acknowledgement: This work was funded by Philips Healthcare.