Fluid attenuated inversion recovery (FLAIR) with readout-segmented (rs)-EPI

Samantha J Holdsworth[1], Stefan Skare[2], Kristen Yeom[3], and Michael E Moseley[1]

[1]*Lucas Center for Imaging, Department of Radiology, Stanford University, Palo Alto, CA, United States,* [2]*Clinical Neuroscience, Karolinksa Institute, Stockholm, Sweden,* [3]*Lucile Packard Children's Hospital, Department of Radiology, Stanford University, Palo Alto, CA, United States*

Target Audience: Researchers and clinicians who are interested in a fast FLAIR sequence. **Introduction:** The fluid attenuating inversion recovery (FLAIR) MRI method[1] is an important technique for the differentiation of brain lesions. Conventional FLAIR uses the Fast-Spin-Echo (FSE) method for image acquisition. However, the combination of long inversion recovery (TI) times and the inefficient sampling of the echo times (TEs) result in prolonged scan times, posing a challenge for motion-prone patients. More rapid FLAIR imaging of the brain can be achieved using the half-Fourier acquisition single-shot turbo-spin (HASTE)-FLAIR and Echo-Planar imaging (EPI)-FLAIR sequences[2]. However these sequences have relatively poor image quality and reduced ability to show smaller lesions compared with FLAIR-FSE[2]. Here, we show preliminary data using a readout-segmented (rs)-EPI[3,4] FLAIR implementation. Rs-EPI has reduced susceptibility-related artifacts compared with EPI, is faster than FSE sequences, and is relatively robust to motion[5].

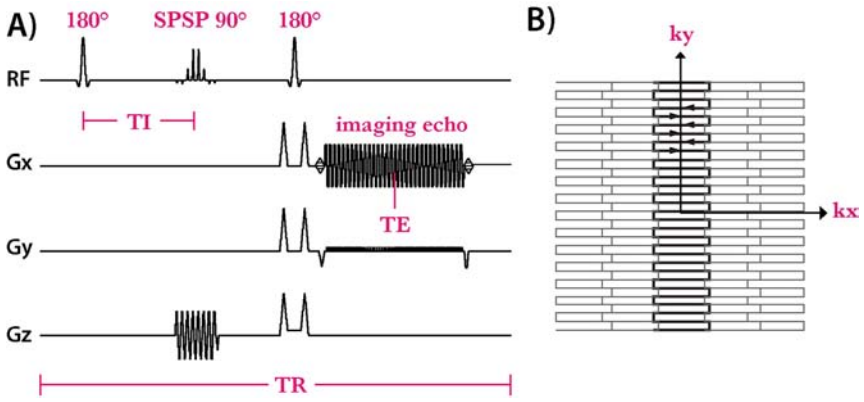

Figure 1: (A) Pulse sequence timing diagram for the rs-EPI-FLAIR sequence. The RF pulses are shown in this order: inversion 180°, spectral-spatial 90°, 180° spin echo, and refocusing180°. (B) Resulting segmented k-space. The central segment (bold black) is used for the parallel imaging calibration.

Materials & Methods: All scans were performed on a 3T GE system (*Milwaukee, WI, USA; G of 40 mT/m, slew rate of 150 mT/m/s*) using an 8-channel head coil. FLAIR datasets were acquired on a 6-year old pediatric patient after written formal consent was obtained from the patient's parents. The rs-EPI-FLAIR pulse sequence and k-space trajectory is shown in Fig. 1. The rs-EPI-FLAIR sequence imaging parameters were: matrix size = 192^2, segment width = 64, TE = 48ms, acceleration factor = 2, signal averages = 2, 32 slices, scan time = 1:45min. Parallel imaging and Nyquist-ghost correction was performed on the center segment, with resulting calibration parameters applied to each segment[5]. rs-EPI segments were then stitched together using gridding. For reference, a conventional FLAIR-FSE was acquired (matrix size = 353 x 224, TE_{eff} = 146 ms, 29 slices, scan time = 2:45min) and an EPI-FLAIR (matrix size = 192^2, acceleration factor = 2, signal averages = 2, TE = 80ms, 32 slices, scan time = 21sec). All sequences used TR/TI = 10s/2.2s, FOV = 22cm, and slthck = 4mm.

Results: Fig. 2 compares FLAIR-FSE, EPI-FLAIR, and rs-EPI-FLAIR images. FLAIR-FSE shows superior contrast with regards to white matter signal abnormality than EPI and rs-EPI. rs-EPI shows reduced blurring compared to EPI.

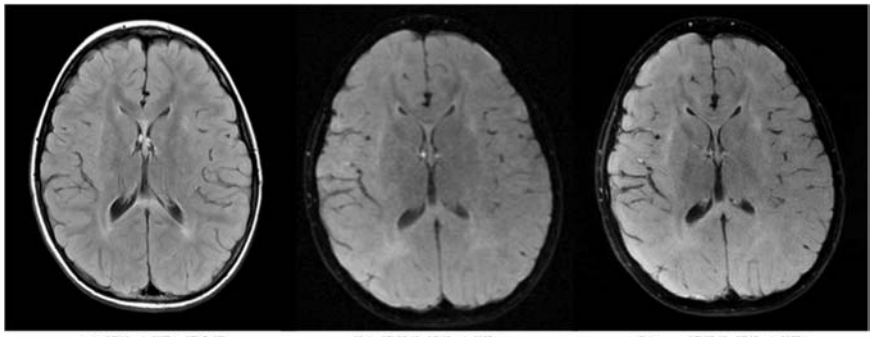

Figure 2: Comparing the FLAIR FSE, EPI-FLAIR, and rs-EPI-FLAIR images acquired on a 6-year old patient. Note the right-edge artifact on the rs-EPI is an unexplained issue with the reconstruction.

Discussion: This abstract shows that rs-EPI-FLAIR produces images with improved effective resolution and reduced blurring compared with EPI-FLAIR. Compared with FLAIR-FSE, the white matter contrast of rs-EPI (and EPI) was limited, likely due to the shorter TE selected. The scan time came at a 5-fold increase compared with FLAIR-EPI and a ~1.5-fold decrease compared with FLAIR-FSE. However, a further ~2-fold reduction in scan time for EPI and rs-EPI sequences can be achieved by using only one signal average. Next we will deploy rs-EPI-FLAIR together with a navigator echo and test its motion-correction capability on a larger cohort of patients.

Conclusion: Here preliminary data are presented on the clinical application of FLAIR-rs-EPI. While the contrast within the white matter of this implementation of FLAIR-rs-EPI needs improvement relative to the FLAIR-FSE, it has reduced susceptibility artifacts compared with EPI-FLAIR. With a better selection of imaging parameters (such as TE), rs-EPI-FLAIR may be a useful rapid and motion-correctable alternative to conventional FLAIR and EPI-FLAIR in the clinics.

References: [1] De Coene B, et al. AJNR 1;13(6):1555–64 (1992). [2] Filippi M, et al. A. AJR. 20(10):1931–8 (1999). [3] Holdsworth SJ, et al. EJR 65(1):36-46 (2008). [4] Porter DA, Heidemann RM. MRM 62(2):468–75 (2009). [5] Holdsworth SJ, et al. MRM 62:1629–40 (2009).