EPI Navigator based prospective motion correction technique for 2D FLAIR imaging in the brain.

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TARGET AUDIENCE: Clinicians and researchers who are interested in using the FLAIR sequence.

PURPOSE: 2D T2 weighted turbo spin echo based fluid attenuated inversion recovery (T2 TSE FLAIR, henceforth called FLAIR) imaging is one of the most commonly used techniques in clinical neurological MRI [1]. High in-plane resolution FLAIR imaging is preferred, although due to conventional segmented k-space acquisition, motion sensitivity is increased [2, 3]. The goal of this work is to develop a novel prospective motion correction method for FLAIR imaging in the brain to maintain in-plane resolution and reduce motion sensitivity. The demonstrated technique is similar to the EPI navigator approach that has previously been shown for 3D-encoded MPRAGE/T2SPACE and 2D-encoded diffusion imaging in the brain [4, 5].

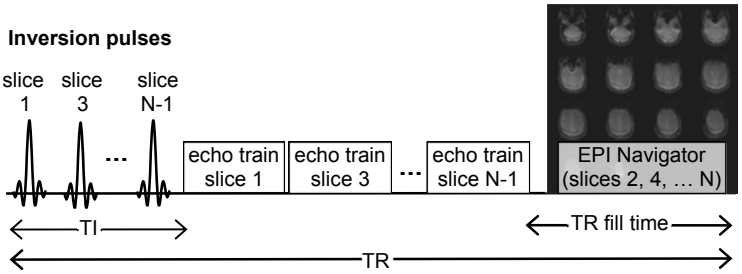

Fig 1: Schematic of the prospective motion corrected T2 TSE FLAIR sequence

METHODS: Rigid body motion navigation is achieved based on multi-slice 2D low spatial resolution single shot EPI images (EPI NAV) which are interleaved during the 2D FLAIR imaging sequence. The EPI navigators are inserted at the end of each TR during the fill time (Fig. 1). Since FLAIR requires a long TR to ensure no T1 contamination in image contrast, the EPI NAV acquisition does not increase scan time. Due to SAR constraints the FLAIR acquisition is done in two concatenations which are spatially interleaved. To minimize the time required for the EPI NAV acquisition, and to minimize interaction between the EPI NAV and FLAIR acquisitions, the following strategy was used: when FLAIR is acquiring the 1st concatenation (slices 1, 3, …N-1), the EPI NAV slices are acquired from the 2nd concatenation (slices 2, 4, …N), and correspondingly when FLAIR acquires the 2nd concatenation (slices 2, 4, …N), the EPI NAV slices are acquired from the 1st concatenation (slices 1, 3, …N-1). Sample EPI NAV images acquired with this approach are shown in Fig 1. During each TR a low spatial resolution volume is created from the EPI NAV slices and is used for prospective motion correction based on the 3DPACE method which uses a 3D rigid body motion model [6]. The first volume is used as the reference position by the 3DPACE algorithm. In the current implementation each concatenation of the EPI NAV acquisition has its own reference volume, which is acquired at the beginning of the scan. An additional 50 ms delay is introduced at the end of each TR to enable real-time slice position updates for the next TR, based on motion estimates given by the 3DPACE technique. Two healthy volunteers were scanned with the proposed motion corrected FLAIR technique, and with a standard non motion corrected FLAIR sequence. In addition, for comparison purposes a third FLAIR sequence based on the Propeller/BLADE technique [7, 8] was also acquired. To evaluate efficacy of motion correction, subjects were deliberately instructed to perform head motion during all scans. Imaging was performed on a 3T scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen). Parameters for the FLAIR scan were: spatial resolution 0.7 x 0.9mm^2, 36 slices with 3 mm thickness, acquisition time 4 mins 50 sec. Parameters for the BLADE FLAIR scan were: 14 BLADES with 28 lines per BLADE, acquisition time 4 mins 32 sec. Parameters for the EPI NAV scan were: FOV: 256x256 mm^2, matrix: 32x32, slices same as FLAIR, acquisition time/slice = 9.7 ms, total acquisition time /volume (consisting of 18 slices) = 175 ms.

RESULTS: Fig 2 shows the detected rotation and translation parameters and corresponding images with the three techniques. For subject 1 (top row), the scan without motion correction (Cartesian - no Moco) is corrupted by motion related blurring and ghosting artifacts. The scans with prospective motion correction (Cartesian - Moco) and BLADE both show very good image quality, free of any motion related artifacts. For subject 2 (bottom row), the scan without motion correction (Cartesian - no Moco) is highly corrupted by motion artifacts. The BLADE scan shows slightly improved results, however the scan with 3D prospective motion correction (Cartesian - Moco) shows the best image quality.

DISCUSSION AND CONCLUSION: We demonstrated an effective and robust EPI navigator based prospective motion correction technique for 2D FLAIR imaging in the brain. Compared with the traditional FLAIR sequence (without motion correction) the proposed method significantly improves image quality in the presence of substantial head motion. Imaging results are comparable to BLADE with the added advantage of enhanced through plane compensation. The relative failure of BLADE to compensate for motion in subject 2 can be attributed to significant through plane motion, for which BLADE does not compensate. In this case the subject was deliberately instructed to perform both through plane translation and rotation (see red arrows in motion trace). Based on these preliminary results, further investigation into clinical populations is warranted. This is the first demonstration of EPI Navigator based prospective motion correction for a routine clinical sequence. The proposed strategy can also be applied to other clinical sequences like T1 spin echo/TSE and T2 TSE. The ultimate goal of this work is to combine all of these sequences and perform an entire clinical neurological MRI exam with prospective motion correction.

REFERENCES: [1] Mikulis et al. JMRI 26:838-47 [2] Wintersperger et al. Inves Rad 41:586-92 [3] Nyberg et al. Am J Neurorad 33:77– 82. [4] Tisdall et. al. MRM 68:389-99. [5] Bhat et al. ISMRM 2012, #113. [6] Thesen et al. MRM 44:457-65. [7] Pipe MRM 42:963-69. [8] US Patent # US 7840049.

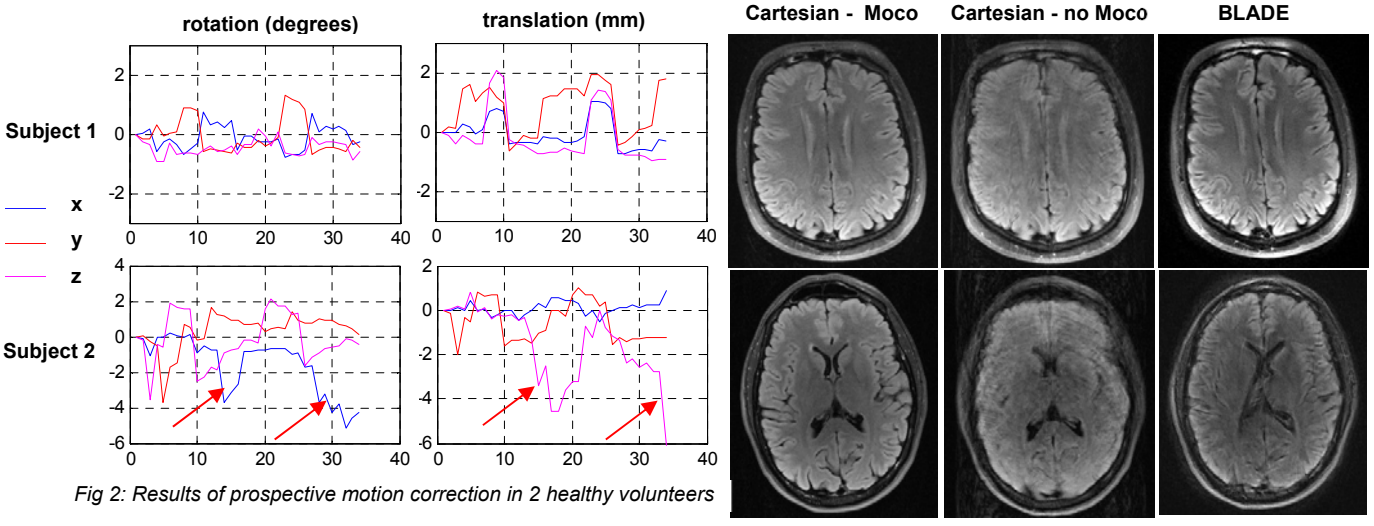

Fig 2: Results of prospective motion correction in 2 healthy volunteers