3D Fast Spin Echo Double Inversion Recovery with PROspective MOtion Correction (PROMO)

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Introduction: Double inversion recovery (DIR) fast spin echo (FSE) sequences are used to null the signal from the CSF and white matter and have been shown to improve cortical lesion detection in patients with multiple sclerosis[1-3]. Initial results have also been shown that DIR may have uses in pediatric populations for the detection of cortical malformations[4]. Results from both 2D and 3D versions of DIR have been reported[5] and all suffer from one common issue – the scan times are long (6-15 minutes) because of the long TR that is necessary to allow sufficient T1 recovery. In a clinical setting, acquisition techniques with long scan times are often more susceptible to motion artifacts due to patient non-compliance. Within-scan motion is problematic for most 2D and 3D-based DIR sequences because multiple slices (or sections) are played out during each TR to minimize scan time.

A number of prospective motion correction techniques have been reported that can be applied to 3D sequences to address motion-induced artifacts[6-8]. Previously reported work showed promising results using an image-based prospective motion correction technique (PROMO) in a 3D FSE sequence[9]. The purpose of this work was to investigate the feasibility of incorporating PROMO with a 3D FSE DIR[10] (Cube DIR) sequence.

Methods: The Cube DIR sequence was modified to include the acquisition of a set of 3-plane spiral navigators at the beginning of each TR. The data for these navigators was sent to an online process where it was reconstructed and 6 degrees-of-freedom motion estimates were computed and sent back to the pulse sequence in real-time. The gradients were modified in real-time to adjust the imaging volume to the currently detected position of the subject. The spiral navigators were positioned to be played out before the first adiabatic inversion RF pulse in order to insure maximum navigator SNR. Additional rescanning of those imaging segments most severely corrupted by motion was appended to the scan.

Informed consent was obtained and volunteers were scanned under an IRB-approved protocol on a 3T MRI scanner (MR750, GE Healthcare, Waukesha, WI). Cube DIR images were acquired with prospective motion correction enabled (PROMO-on) and for comparison purposes a second scan was performed with the correction disabled (PROMO-off). The subjects were instructed to perform predetermined motion and that motion was repeated, as closely as possible, for the second uncorrected scan. Imaging parameters were: ±62.5 kHz bandwidth, TR/TE 5000/12.9 ms, 256x256 matrix, 0.5 NEX, echo train length 72, 26x23.4 cm FOV, 150 sections, 1.2mm thick, self-calibrated 2x2 accelerated parallel imaging, with a baseline scan time of 6:21 minutes.

Results: Figure 1 shows an example Cube DIR scan reformatted as an axial plane and the originally acquired sagittal plane with PROMO-on (a&b) and PROMO-off (c&d). A plot depicting the corresponding motion estimates for the PROMO-on scan is shown in Figure 1e, which were similar to those experienced for the PROMO-off scan (not shown). For this scan 21 of 76 segments were rescanned due to severe motion corruption, extending the scan time 1:45 minutes.

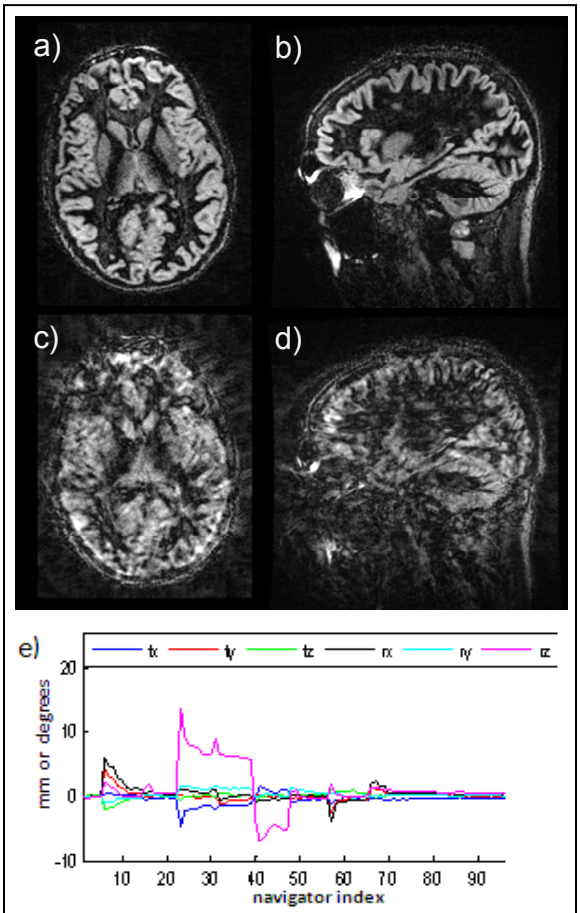

Figure 1: Example 3D FSE DIR axial reformat and sagittal images acquired with PROMO-on (a,b) and PROMO-off (c,d). Corresponding estimated motion plot for the PROMO on scan shown in (e).

Discussion: The results presented indicate that prospective motion correction can significantly improve Cube DIR image quality when there is patient motion. Further study of 3D FSE DIR with prospective motion correction in a clinical setting is warranted.

References: [1] Geurts et al *Radiology* 2005;236:1:254-260 [2] Calabrese et al *Arch Neurol* 2007;64:1416-1422 [3] Simon et al *Eur Radiol* 2010;20:1675-1683 [4] Kotsenas et al *Proc ISMRM* p2018 [5] Geurts et al *Neurology* 2011;76(5):418-424 [6] Welch et al 2002;47:32–41 [7] van der Kouwe et al *Magn Reson Med* 2006;56:1019–1032 [8] Zaitsev et al *Neuroimage* 2006;31:1038–1050 [9] Busse et al Proc ISMRM 2008 p1347 [10] White et al *Magn Reson Med* 2010;63(1):91-105