

Assessment of motion and f_0 artifacts in 7T high resolution T_2^* -weighted imaging in Alzheimer's disease patients, and application of a navigator-based correction scheme

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Introduction. Many neurodegenerative diseases, such as Alzheimer's disease (AD) are accompanied by changes in local iron concentration (1), which generate magnetic field inhomogeneities. These can be visualized with MRI using, for example, T_2^* -weighted sequences. Very detailed high resolution T_2^* -weighted images at 7 T have been reported recently in healthy volunteers (2; 3) and post mortem in AD patients (4). However application of the same sequence in in-vivo AD patients showed a drastically reduced image quality. Possible reasons for the reduction in image quality are increased motion and/or other physiological fluctuations during acquisition. In this study the relative influence of motion and physiological resonance frequency (f_0) fluctuations was investigated. A navigator echo correction technique was introduced and evaluated.

Methods.

Source of image artifacts. The relative contributions from motion and f_0 variations to the image artifacts were investigated using phantom and in vivo experiments. Phantom experiments were performed in which the off-center position, angulation and f_0 of the imaging volume were changed for each acquired k-line during scanning to simulate the effects of movement. The particular motion parameters used were taken from an fMRI study in 4 AD patients at 3T and f_0 fluctuations were measured in two AD patients and two normal volunteers at 7T. The effects of translational motion in the anterior-posterior (AP-trans), right-left (RL-trans), rotations around all axes and f_0 fluctuations were quantified using the sum of squared differences between the motion corrupted image and the image without added motion. The motion, rotation and f_0 parameters were altered in amplitude by the following factors 0.25, 0.75, 1, 2 and 3.

Correction. A navigator echo correction technique was introduced to measure and correct for f_0 fluctuations (5). A high-resolution T_2^* -weighted sequence with the following parameters: TR/TE/flip angle = 796 ms/25 ms/45°, voxel size=0.24x0.24x1 mm³, FOV=240x180 mm² and 20 sections. Scan duration was 10 minutes. A navigator echo was acquired prior to the phase encoding gradient along the same direction as the read out gradient at time $TE_{nav} = 9.5$ ms. Images were reconstructed with and without navigator echo correction. All scans were performed on a Philips 7T Achieva system with a 16 channel Nova Medical coil. Four AD patients were measured.

Results. Figure 1 shows that the degree of image artifacts increases linearly with the amount of motion. The effect of f_0 fluctuations was found to be the major source of artifacts especially for AD patients. The f_0 fluctuations from a normal volunteer and an AD patient are shown in figure 2. Large jumps are visible in the f_0 pattern of an AD patient. The sinusoidal f_0 fluctuations were highly correlated with respiration. Figure 3 shows a typical example of a corrected and uncorrected image obtained in an 80 year old female AD patient. Significant improvements in image quality (reduced ghosting artifacts and increased homogeneity, see arrow) were present in all 4 subjects.

Discussion & Conclusion. We have shown that f_0 fluctuations are the major cause of artifacts in high-resolution T_2^* -weighted sequences at 7T. By incorporation of navigator echoes it was possible to correct for these f_0 fluctuations resulting in a substantial increase in image quality. The inclusion of a navigator echo resulted in a scan duration increase of 30 s, which is small compared to the total scan duration of approximately 10 minutes.

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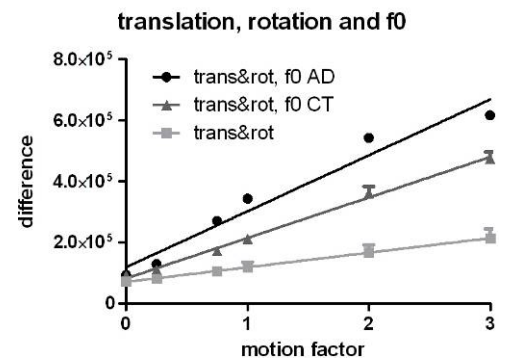


figure 1: motion and f_0 induced artifacts

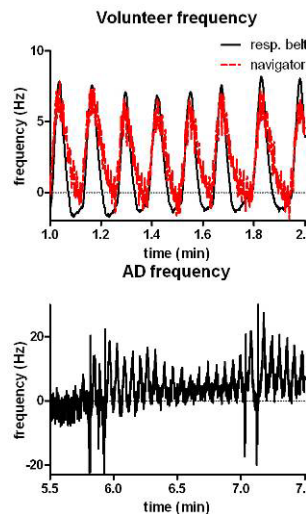


figure 2: f_0 pattern of normal volunteer (top graph) and AD patient (bottom graph).

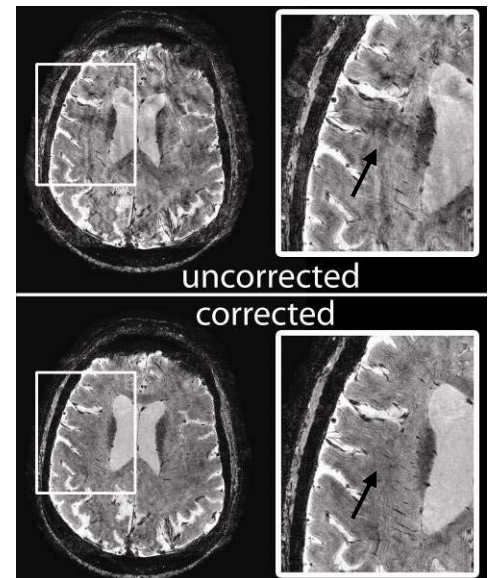


figure 3: slice from AD patient before and after correction