Assessment of motion and f0 artifacts in 7T high resolution T2*-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, T2*-weighted sequences. Very detailed high resolution T2*-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 (f0) fluctuations was investigated. A navigator echo correction technique was introduced and evaluated.

Methods.

Source of image artifacts. The relative contributions from motion and f0 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 f0 of the imaging volume were changed for each acquired k-line during scanning to simulate the effects of motion. The particular motion parameters used were taken from an fMRI study in 4 AD patients at 3T and f0 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 f0 fluctuations were quantified using the sum of squared differences between the motion corrupted image and the image without added motion. The motion, rotation and f0 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 f0 fluctuations (5). A high-resolution T2*-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 TFnav = 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 f0 fluctuations was found to be the major source of artifacts especially for AD patients. The f0 fluctuations from a normal volunteer and an AD patient are shown in figure 2. Large jumps are visible in the f0 pattern of an AD patient. The sinusoidal f0 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) were present in all 4 subjects.

Discussion & Conclusion. We have shown that f0 fluctuations are the major cause of artifacts in high-resolution T2*-weighted sequences at 7T. By incorporation of navigator echoes it was possible to correct for these f0 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.


This research was performed within the framework of CTMM, the Center for Translational Molecular Medicine (www.ctmm.nl), project LeARN (grant 02N-101).