Towards a 10 minute clinical Alzheimer MR imaging protocol

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Introduction: The purpose of this work is to explore the feasibility of employing recent advances in MRI technology to substantially reduce scan times in clinical MR protocols. Particularly in a clinical setting, such protocol optimization is desirable, because (a) motion artifacts are reduced, (b) patient comfort is improved and (c) patient throughput can be managed more efficiently. In this work we leveraged the synergistic attributes of the excellent SNR properties of a dedicated 32-channel receive head coil operating at 3T in combination with parallel imaging technology to reduce the acquisition time for a standard clinical Alzheimer disease (AD) protocol [1]. Data sets with 2, 3, 4, or 5-fold acceleration were analyzed and compared against the Alzheimer's Disease Neuroimaging Initiative (ADNI) protocol. Images were qualitatively interpreted by a blinded experienced observer and also quantitatively analyzed with the automated evaluation pipeline of ADNI, which includes calculations of the boundary shift integral [2].

Methods: All measurements were performed on a standard clinical 3T Siemens Tim Trio (VB13 software) equipped with a pre-production 32-channel receive-only head coil (based on [3]). Two healthy subjects were imaged using the ADNI protocol [1]. In the first measurement standard 3D MPRAGE protocol parameters were used. In the four subsequent repetitions, parallel imaging (GRAPPA) with 2, 3, 4, or 5-fold acceleration was applied. The entire protocols ranged between 25 min (standard) and 8 min (5-fold acceleration) and accordingly for one MPRAGE series between 9:15 and 2:50 min (incl. ref-scans). For quantitative analysis and comparison with the standard protocol, all data ran through the various corrections of the ADNI pipeline (3D distortion, B1-receive field correction, and N3 to compensate for central brightening), were graded by an experienced, blinded observer participating in the ADNI trial, and finally volumetric measurements were performed.

Results: In Fig. 1 typical MPRAGE images from one subject without (left) and with 5-fold acceleration (right) are shown. According to the coil geometry [3] and physics, the expected SNR drop in the accelerated images is primarily evident in the center of the brain. Figure 2 shows the quantitative analysis of the boundary shift integral (BSI). In theory, differences in the BSI between pairs of images express volumetric differences between the scans. Deviation from zero may represent data noise, systematic hardware or software effects. Evidently, data for the whole brain BSI exhibits a slight trend toward negative changes with increasing acceleration factors.

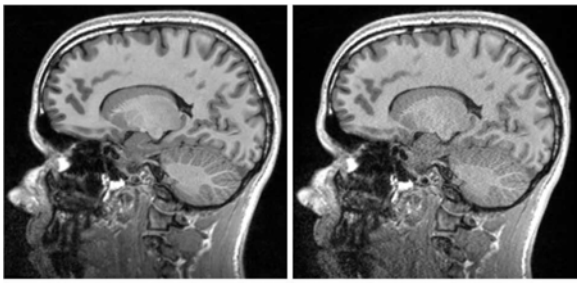

Figure 1: MPRAGE images without (left) and 5-fold (right) acceleration.

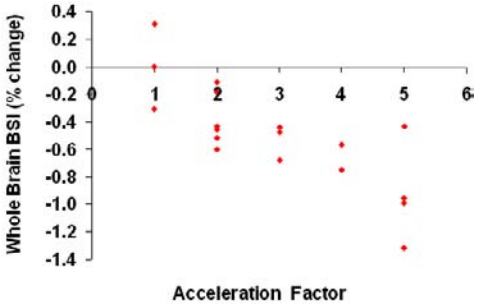

Figure 2: The BSI measures for all acquisitions.

Discussion: With the combined use of a dedicated RF-coil and massive parallel imaging the clinical ADNI protocol was reduced from 25 min down to 8 min. Experienced interpreters considered even the 5-fold accelerated images as useful for qualitative image interpretation, as Radiologists typically can read through artifacts and inhomogeneous noise distributions. Noteworthy, with shorter scan times motion artifacts will be reduced substantially, which may compensate for the reduced SNR obtained with parallel imaging. For quantitative, automated methods like those used in ADNI, the results suggest a more detailed investigation of the observed drift in the BSI. Even though another measure for the inter-scan compatibility ("Composite Width") is well within limits for all data with acceleration factors up to 4, the expected variation for BSI of approximately +/-0.6% is exceeded for high accelerations. Since data tend to exhibit a systematic trend, further work will investigate effects from (a) SNR changes between protocols and (b) hardware. We speculate that these effects could vanish in intra-subject comparisons and in longitudinal studies, as long as the same protocol and acceleration factor was chosen.

Conclusion: We show that recent advances in MRI technology can be applied successfully to shorten scan times of clinical protocols by at least a factor of ~3. This is particularly desirable because motion sensitivity is reduced, patient comfort improved and throughput more efficient. For quantitative, automated methods closer investigation is recommended. Nevertheless, a maximal BSI change of 1.4% in the 5-fold accelerated data represents a very promising perspective.

References: 1. http://www.loni.ucla.edu/ADNI/Research/Cores/ADNI_Siemens_3T_TrioTimVB13.pdf 2. P.A. Freeborough et al, IEEE Transactions on Medical Imaging 16:623-629 (1997) 3. G.C. Wiggins et al., MRM 56:216 (2006)