T1 contrast in the human brain at 7 Tesla

M. Wyss1, D. O. Brunner1, A. Morel2, and K. P. Pruessmann1

1Institute for Biomedical Engineering, University and ETH Zürich, Zurich, Switzerland, 2Laboratory for Functional Neurosurgery, University Hospital Zurich, Zurich, Switzerland

Introduction:

MRI in humans at ultra-high field offers not only high baseline sensitivity but also interesting contrast behavior. Compared to lower field strength T1 relaxation times generally increase but seem to remain highly diverse, promising strong T1 contrast especially in brain imaging. Exploring this potential is mainly hampered by the non-uniformity of the transmit RF fields generated by available RF resonators (Fig.1, top row). In the present work we report sequence considerations for robust T1-weighted brain imaging at 7T and discuss the anatomic contrast thus obtained.

Methods:

To achieve reliable and strong T1 contrast despite RF field inhomogeneity an inversion recovery (IR) approach with an adiabatic inversion pulse was chosen. To use the inherently high power deposition of such pulses efficiently, the adiabatic full-passage pulse of 45 ms was followed by approximately 100 low flip-angle excitations in a transient gradient-echo 3D imaging scheme taking a total of 2 min. The B1 integral of the inversion pulse was optimized between the competing goals of robustness against B1 inhomogeneity, bandwidth and specific absorption rate. Using relatively low inversion times of 400-600 ms deep brain regions such as the thalamus were considered especially, comparing the 7T in-vivo data with a histological image and an MR scan of a formaldehyde-preserved ex-vivo sample. The latter was imaged at 3T, averaging a proton-density-weighted CPMG sequence over 5 hours. All in-vivo imaging was performed on a Philips 7T Achieva system, using a volume transmit resonator and a 16-channel receive array.

Results:

As Fig.1 shows, the described sequence yields stable T1 contrast across the whole brain despite considerable transmit RF inhomogeneity especially in the temporal lobes and deep brain regions. Close inspection of the thalamic region (Fig.2) revealed higher contrast than known from lower field strengths, permitting the differentiation of several thalamic nuclei, pallidothalamic, cerebellothalamic and other fibertracts (mtt, ft, frf, fct).

Discussion:

This work demonstrates that robust acquisition of T1-weighted images is feasible at 7T, requiring moderate scan time for full brain coverage. It was found that the high field yielded not only high SNR and resolution but also surprisingly strong contrast throughout the brain. It permitted the distinction of anatomical structures which have been hard to recognize at lower field strengths. Such enhanced contrast may be particularly useful for MR-guided interventions. The higher-than-expected contrast may be related not only to changes in relaxation time but also to saturation transfer effects due to the long adiabatic prepulse.