Magnetization prepared 3D FLAIR imaging at 7.0 Tesla

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Introduction:

Multi slice FLAIR sequences are indispensable for the diagnosis of CNS pathologies. By introducing non-selective 3D acquisitions the problem of the inherent CSF-inflow artifacts and partial volume effects in FLAIR images have been reduced, this substantially improves the sensitivity and specificity of the technique. Successful implementations of 3D FLAIR sequences have been reported for 3T and below. At 7T, the implementation of FLAIR is less straightforward due to SAR constraints, high sensitivity to susceptibility and short T2* components and RF in-homogeneity. Moreover, the lengthening of T1 relaxation times [1] of grey and white matter (GM and WM) while the T1 of CSF is less field dependent, introduces more T1 weighting (Fig. 1) in FLAIR images that compromises the desired T2 contrast. The aim of the present study is to develop a 3D FLAIR sequence with high T2 contrast by using dedicated magnetization preparation pre-pulses for 7Tesla.

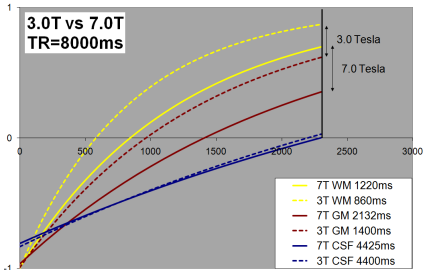

Figure 1: T1 influence standard vs T2prep

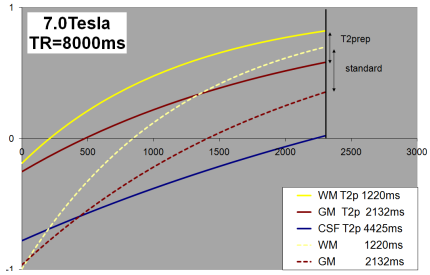

Figure 2: T1 influence standard vs T2prep

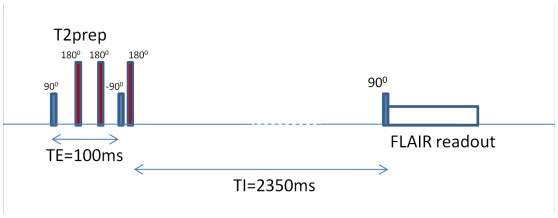

Figure 3: Magnetization prepared 3D-FLAIR

Methods:

Imaging was performed on a 7T scanner (Philips) using a 16 channel receive head coil with single channel transmit (Nova Medical). Figure 3 shows the schematic diagram of a sagittal non-selective 3D inversion recovery sequence covering the whole brain results in an isotropic voxel size of 0.8 x 0.8 x 0.8 mm, zero-interpolated to 0.5 x0.5 x 0.4 mm, FOV 250, 450 slices, TR/TI/TE 8100/2350/399, turbo train-length 130, 2D-SENSE factor 6, advanced refocus pulse angle sweep with nominal angle of 70^0. The non-selective adiabatic inversion pulse was optimized to meet the adiabatic conditions at 7T in the present of a relative in-homogenous B1 and B0 field. To saturate short T2 components prior to the inversion pulse an T2-prep (TE 100 ms) pulse was added consisting of two 90^0 block and two adiabatic inversion pulses, $90^0/180^0/180^0/-90^0$. Simulation of the evolution of Mz has been used to optimize the TI for CSF suppression for standard FLAIR and magnetizing prepared FLAIR. (fig. 1 and 2). Validation of the T2prep pulse is done using a 2D FLAIR sequence with short TE on a phantom with T1=1000, 1450 and 4500 ms mimicking the 3 main tissue characteristics of WM, GM and CSF. As a reference, oil is added to the phantom having a very short T1which is therefore not influenced by the inversion pulse at TI ~ 2s. In-vivo SNR and CNR comparison of WM/GW in the frontal lobe and CSF in the first ventricle is performed on 3 subjects with an identical sequence with and without the T2prep pulse.

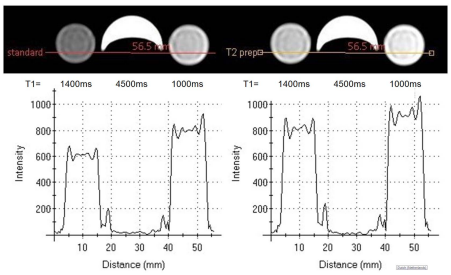

Figure 4: phantom result (left: standard / right: T2prep

Results:

The efficiency of the T2prep pulse has been shown by the phantom study where the T1 influence could be lowered by 20% for the phantom specific T1 relaxation times (fig.4). The quality of the high resolution in-vivo images (fig. 5) has increased substantially using the magnetization preparation. The experiments show a SNR improvement of 20-40% for WM and GM, respectively. CNR improves by 30% between GM and WM.

Conclusion:

High resolution 3D FLAIR has been implemented successfully at 7T. Magnetization preparation was used to improve SNR and CNR in 3D-FLAIR. The technique is also applicable for 2D single and multi slice FLAIR. To the best of knowledge, this is the first in vivo demonstration that high quality FLAIR imaging at 7T if feasible. As FLAIR imaging should be routinely included in many clinical studies, this finding will have a positive impact on the applicability of 7T MRI in clinical studies.

References:

[1] Rooney WD et al, Magnetic field and tissue dependencies of human brain longitudinal 1H2O relaxation in vivo. *MRM vol. 57*

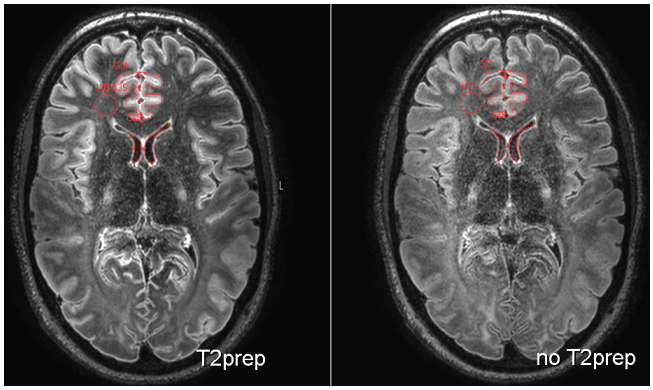

Figure 5: 3D FLAIR (MPR) left: T2prep, right: standard