3D Magnetization Prepared Double Inversion Recovery (3D MP-DIR) at 7 Tesla

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Introduction:
Double Inversion Recovery (DIR) [1] is a valuable tool for the diagnosis of cortical and/or sub cortical lesions [2]. By introducing non-selective 3D acquisitions the problem of inherent CSF-inflow artifacts and partial volume effects in DIR images have been reduced, substantially improving the sensitivity and specificity of detecting sub-millimeter lesions . Successful implementations of 3D DIR sequences have been reported for 3T and lower field strengths [3]. At 7T, the implementation of 3D DIR is less straightforward [4] due to SAR constraints, high sensitivity to susceptibility , short T2 components and RF in-homogeneity. Moreover, whereas the T1 of CSF is relatively constant, lengthening of T1 relaxation times [5] of grey and white matter (GM and WM) at 7T, introduces more T1 weighting (Fig. 1) compromising the desired T2 contrast. The aim of the present study is to develop a 3D DIR sequence with high T2 contrast and high SNR by using dedicated Magnetization Preparation pre-pulses (MP) for 7Tesla.

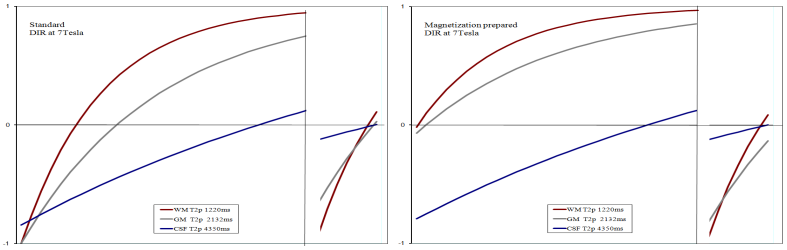

Figure 1, left standard DIR, right MP-DIR

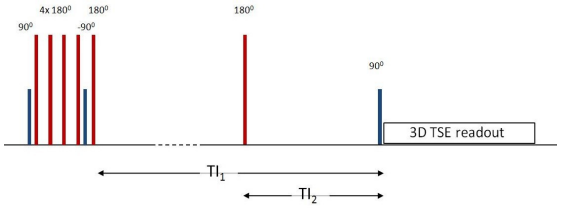

Figure 2 , schematic diagram MP-DIR sequence

Methods:
Imaging was performed on a 7T scanner (Philips) using a 16 channel receive head coil with single channel transmit coil (Nova Medical). Figure 2 shows the schematic diagram of a sagittal non-selective 3D double inversion recovery sequence covering the whole brain. Isotropic voxel size of 1x1x1 mm, zero-interpolated to 0.5x0.5x0.5 mm, FOV 250, 380 slices, TR/TI_1/TI_2/TE 8500/3075/465/299, turbo train-length 130, 2D-SENSE factor 6, low refocusing pulse angle sweep with nominal angle of 70^0. To saturate short T2 components prior to signal inversion a Magnetization Preparation (MP) pulse was added consisting of two 90^0 block and four adiabatic inversion pulses, 90^0/4x180^0/-90^0 (TE 200 ms). All non-selective adiabatic inversion pulses were optimized to meet the adiabatic conditions at 7T in the presence of a relative in-homogenous B1 and B0 field. Simulation of the evolution of Mz has been used to optimize the TI for CSF and WM suppression for standard DIR and MP- DIR (fig. 2). For the standard DIR, TI_1 had to be lengthened to 3350ms compared to MP-DIR, all other parameters were kept the same. Total scan time is 9:58 minutes. In-vivo SNR and CNR comparison of WM/GW in the frontal, temporal, occipital lobe and CSF in the first ventricle is performed on 3 healthy subjects with an identical sequence with and without the MP pulse. Four patients were scanned with known cortical and sub-cortical Multiple Sclerosis (MS) lesions for initial validation of lesion sensitivity.

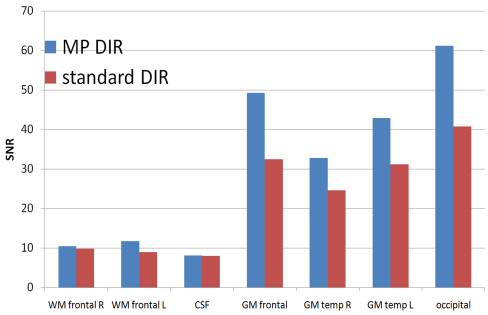

Figure 3, SNR of WM / CSF / GM

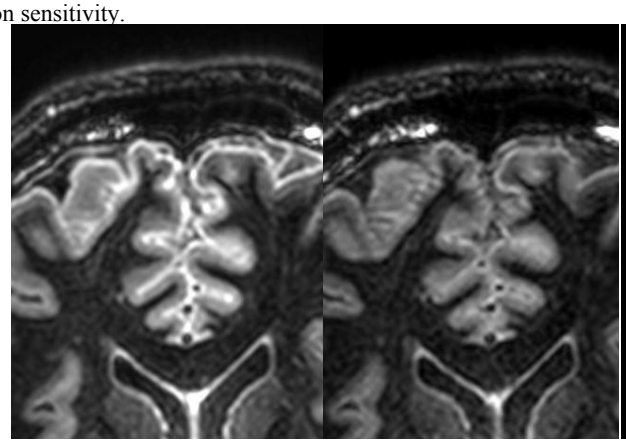

Figure 4, left MP-DIR right standard DIR

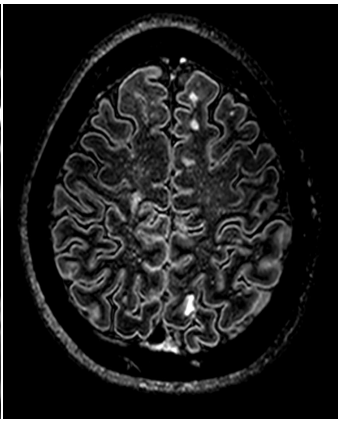

Figure 5, MP-DIR patient with MS

Results:
The efficiency of the MP pulse is clearly demonstrated (fig.3).The experiments show a SNR improvement of 40% for GM where WM and CSF are not affected . CNR improves by 25% between GM and WM as complete WM suppression was not achieved in the MP DIR. The quality of the high resolution in-vivo images (fig. 4 and 5) has increased substantially using the magnetization preparation. The initial results on patients show a high sensitivity for cortical and/or sub cortical lesions.

Conclusion:
High resolution 3D-DIR has been implemented successfully at 7T. Magnetization preparation was used to improve SNR and CNR in 3D-DIR. The technique is also applicable for 2D single and multi slice imaging. This technique provides a new diagnostic window for the detection of sub-millimeter cortical and/or sub cortical lesions in future clinical studies.

References:
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