Magnetization transfer weighted double inversion recovery for an improved visualization of neocortical and juxtacortical signal abnormalities

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1. Introduction

Double inversion recovery (DIR) imaging is based on nulling the signal of cerebrospinal fluid (CSF) and white matter (WM) and is commonly applied for the detection of grey matter (GM) abnormalities such as neocortical and juxtacortical lesions in multiple sclerosis (MS) [1-2]. For whole brain coverage, 2D or 3D approaches are used, with the latter being more time consuming especially at higher field strength with longer T_1 relaxation times. Multi-slice approaches are usually more efficient [3], but it has been a matter of debate if and to what degree incidental magnetization transfer (MT) effects – as introduced by slice-selective refocusing pulses – may alter the image contrast [4]. MT is expected to shorten T_1 of brain tissue and to reduce its steady state magnetization [5]. In addition, it is speculated that MT may also improve the contrast between cortex and embedded lesions. In this study, we therefore investigated whether MT weighted DIR imaging may improve contrast and lesion conspicuity over conventional DIR imaging.

2. Subjects and Methods

Subjects: Nine MS patients (range 20-53yrs) with a relapsing-remitting course of the disease underwent MRI of the brain at 3T (TimTrio, Siemens Healthcare, Erlangen, Germany). Prior to scanning patients, three healthy controls were scanned to optimize the inversion times for an optimal suppression of white matter and CSF.

MT–DIR sequence: The 180° inversion pulses were implemented as slice selective adiabatic pulses, 20% thicker than the actual slice thickness. To generate additional MT contrast, Gaussian shaped saturation pulses (offset frequency =1.2 kHz, duration=10ms, FA=500°) were applied before each fast spin echo (FSE) readout train. An estimation of the inversion times TI_1/TI_2 was done graphically for producing maximum GM/WM contrast [3]. Other parameters of the DIR sequence were: TR=14600ms, TI_1/TI_2=3500ms/370ms, resolution= 0.9x0.9x3mm³, matrix=256x192, turbo-factor=10, BW=376Hz/pixel, 30 slices, slice distance factor=50%. Head coils with 32 and 12 receive channels were used with GRAPPA (R=2), resulting in an overall scan time of 4:55min. All images were reconstructed in magnitude mode. Contrast measurements in cortical GM and adjacent WM regions were done by region of interest analysis to assess the impact of MT weighting.

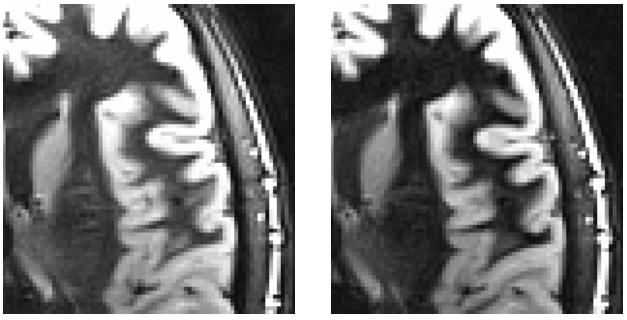

Figure 1: Conventional DIR (left) and MT-DIR (right) obtained with the 32-channel coil: Using identical windowing, MT-DIR provides higher GM/WM contrast and clearer delineation of GM.

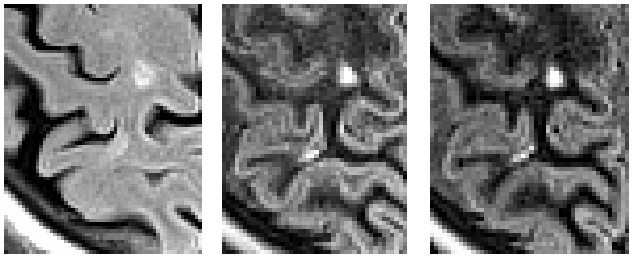

Figure 2: Lesion appearance in FLAIR (left), DIR (center) and MT-DIR (right). Note that the small focal cortical lesion is not visible on the corresponding FLAIR image**.**

3. Results

Comparison of a conventional and a MT weighted DIR scan are shown in figure 1 and illustrate increased suppression of WM and clearer delineation between cortical GM and WM. Furthermore, less WM contribution and reduced partial volume effects can reveal details in cortical regions. ROI measurements resulted in a normalized GM/WM contrast increase of 1.47 (SD=0.19) of the MT-DIR sequence compared with the conventional DIR sequence. The visual rating was in line with contrast measurements. Figure 2 shows the appearance of a small cortical lesion in a FLAIR, in the conventional DIR as well as in the MT weighted DIR image.

4. Discussion and Conclusion

We here demonstrate that utilization of MT saturation pulses in a DIR sequence provides increased GM/WM contrast and may result in a better delineation of cortical and subcortical structures. Due to MT saturation, WM contributions are suppressed more efficient than GM contributions which results in increased GM/WM contrast. The obtained results suggest that in particular juxtacortical WM and potentially also neocortical lesions in MS patients may be distinguishable better. However, the patients in the investigated cohort were rather in an early phase of MS and did not show a high incidence of cortical lesions. Therefore, further studies are needed with patients with a higher lesion load or a more advanced stage of the disease.

References:
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