Whole brain 3D spiral imaging for multi-component T2 relaxometry of multiple sclerosis in 10 minutes: A feasibility study at 3 Tesla

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INTRODUCTION

Multi-component T2 relaxometry is a promising noninvasive method to quantify changes in myelin water content due to multiple sclerosis (1-3). In the conventional approach, multi-echo images are acquired using 2D fast spin echo (FSE), which may take 15-25 minutes per slice (4). Multi-slice spiral 2D acquisition (5) has been developed to overcome the long imaging time, yet a clinically feasible imaging sequence for full brain coverage is currently not available. The objective of this study was to develop a 3D T2prep spiral gradient echo sequence for whole brain coverage at 3 Tesla in 10 minutes.

MATERIALS AND METHODS

Fig.1 shows the schematics of the implemented T2 prepared 3D spiral spoiled gradient echo sequence. The sequence consists of T2prep with variable T_{PREP} to create T2 weighting, followed by segmented k-space stacks-of-spiral data acquisition with a k_z-centric view order and a variable time delay T_{VAR}, and completed by a saturation pulse (SAT) and a fixed time delay T_{FIX} to allow uniform magnetization recovery independent of T_{PREP}. 3D spiral imaging provides high SNR efficiency necessary for reducing scan time. Compared to FSE, gradient echo acquisition utilizes low flip angle and is therefore much less intensive with regards to specific absorption rate (SAR), making it particularly suitable for 3T field strength. In addition, T2prep imaging offers flexible control over scan time through the choice of the number of T2prep times. Five healthy volunteers (5 men) and five clinically definite MS patients (1 men, 4 women, 4 relapsing-remitting, 1 secondary progressing) underwent brain MRI at 3T (GE Excite HDxt). T2 relaxometry data were acquired with the following imaging parameters: axial FOV=30 cm; TR=2.5 sec; 21 T_{PREP} = 5, 10-90 ms (10 ms step), 110-310 ms (20 ms step); flip angle=10°; readout bandwidth=±125 kHz; matrix= 192x192; slice=5 mm; number of slices=28; spiral TR=5.6 ms; number of spiral leaves collected per segment=128; scan time=10 min, 8-channel receive coil). T2 spectra were obtained using regularized non-negative least squares fitting (2,4) for ROIs placed within the corpus callosum and the internal capsules. T2 spectra were also obtained for selective MS lesions. Myelin water fraction (MWF) was calculated as the ratio of the sum of spectral peaks under 50 ms and the sum of all peaks. SNR was measured in the splenium of corpus callosum.

Fig.1. Schematics of the 3D T2prep spiral gradient echo sequence for full brain coverage at 3T.

Table 1. Myelin water fraction of selected WM tissues.

Structure	Myelin water fraction (%)	
	Healthy (N=5)	MS (N=5)
Corpus callosum, genu	12.6 ± 1.9	10.8 ± 1.3
Corpus callosum, splenium	14.3 ± 2.2	12.1 ± 1.8
Internal capsules	13.4 ± 2.0	11.6 ± 2.1

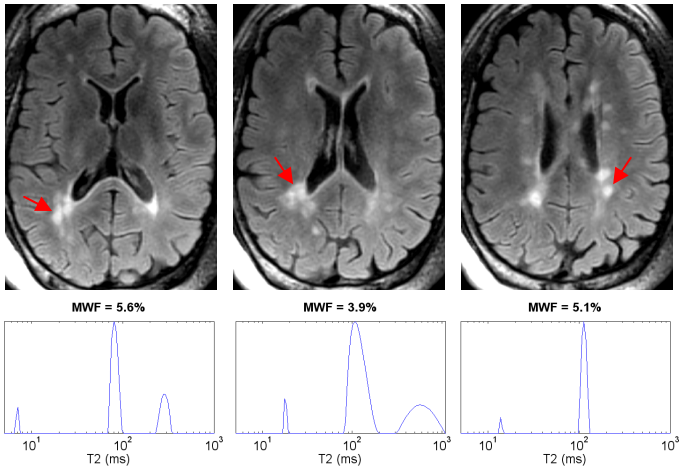

Fig.2. T2 FLAIR images and T2 spectra of MS lesions on 3 different slices obtained in one patient.

RESULTS

All scans completed successfully. Table 1 summarizes the MWFs obtained in selective WM locations in healthy subjects and patients. Fig.2 demonstrates the utility of the whole brain coverage of the 3D sequence for multi-slice T2 relaxometry analysis. SNR was 261±49 in healthy subjects (8-channel brain coil) and 251±49 in patients (8-channel neurovascular array).

DISCUSSION

Our initial results demonstrated that whole brain T2 relaxometry in clinically relevant scan time of 10 minutes is feasible and warrants evaluation in a larger patient population. The developed 3D spiral sequence may become part of a routine brain MRI protocol for multiple sclerosis patients.

REFERENCES 1. MacKay et al. MRM 1994;31:673. 2. Whittall et al. MRM 1997;37:34-43. 3. Laule et al. J Neurol 2004;251:284. 4. Kolind et al. MRM 2009;62:106. 5. Oh et al. MRI 2006;24:33.