7 Tesla 3D-FLAIR and 3D-DIR: high sensitivity in cortical regions in Multiple Sclerosis

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Introduction In Multiple Sclerosis (MS) increasing attention is given to demyelinating aspects in the cortical region of the brain [1]. At 1.5T, cortical lesions are best visualized with Fluid Attenuated Inversion Recovery (FLAIR) and Double Inversion Recovery (DIR) sequences [2]. At higher field, the gain in SNR can be used to increase spatial resolution, which may enhance the sensitivity of these sequences [3]. In this study at 7T the sensitivity of 3D-DIR and 3D-MP-FLAIR [4] is compared with PD/T2 and 3D-T1 weighted imaging. Data are compared with 3D-FLAIR, PD/T2, and T1 images of the same subjects scanned at 3T.

Material and methods 5 MS patients and 5 healthy volunteers were examined at 3T (GE HDxt - 8-channel phased array head coil) and 7T (Philips, Achieva - 16-channel phased array head coil). Time interval between examinations at the two field strengths was < 2 weeks. At 7T parameters were: PD/T2 (TSE (factor: 8), TR/TE1/TE2: 4969/21/80 ms, Acq. Res: 0.7x0.7x2mm, Reconstr. Res.: 0.45x0.45x2mm), 3D-T1 with magnetization preparation (TFE (factor: 312), TR/TI/TE: 7.0/1129/2.9 ms, Acq. Res: 0.8x0.8x0.8mm, Reconstr. Res.: 0.5x0.5x0.4mm), 3D-MP-FLAIR (TSE (factor: 125), TR/TI/TE: 8107/2425/303 ms, Acq. Res: 0.8x0.8x0.8mm, Reconstr. Res.: 0.49x0.49x0.4mm) and 3D-DIR (TSE (factor: 125), TR/TI1/TI2/TE: 8000/3150/550/294 ms, Acq. Res: 0.99x1x0.8mm, Reconstr. Res.: 0.5x0.5x0.4mm). At 3T parameters were PD/T2 (TSE (factor: 24), TR/TE1/TE2: 7340/22/113 ms, NEX: 2, Acq. Res: 0.6x0.65x3mm , Reconstr. Res.: 0.5x0.5x3mm), T1 (SE, TR/TE: 400/7.5 ms, NEX : 2, Acq. Res: 1x1.3x3mm , Reconstr. Res.: 1x1x3.0mm) and 3D-FLAIR (FSE (factor: 230), TR/TI/TE: 8000/2334/132 ms, Acq. Res: 1.1x1.1x1.2mm , Reconstr. Res.: 1x1x1.2mm). At 3T no 3D-DIR was available yet. Total acquisition time is about 35 min. on both field strengths. No adverse reactions or complaints of subjects have been observed. Images were evaluated for quality and artefacts. Lesions were scored and classified per location in consensus between a biomedical engineer and a radiologist: peri-ventricular (PV), deep white matter (DWM), juxta-cortical (JC), mixed grey/white matter (type I) and grey matter lesions (type II). Other lesion types were infrequently found but were not used for this comparison.

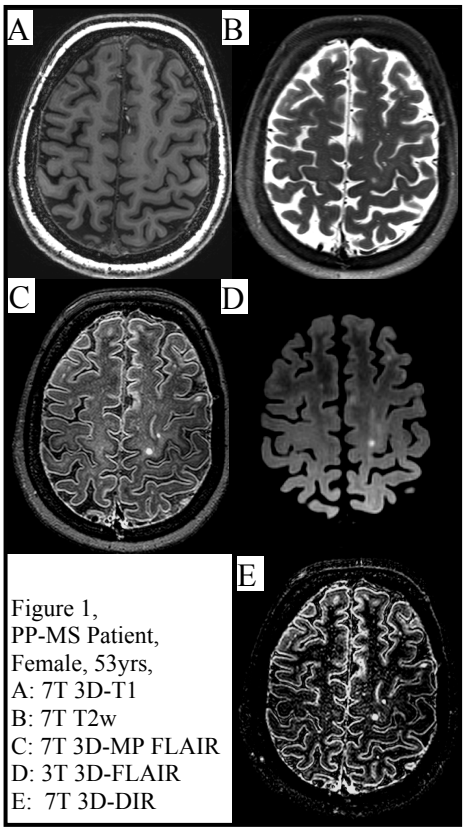

Figure 1,
PP-MS Patient,
Female, 53yrs,
A: 7T 3D-T1
B: 7T T2w
C: 7T 3D-MP FLAIR
D: 3T 3D-FLAIR
E: 7T 3D-DIR

Results Figure 1 shows examples of images of an MS patient at 7T (A, B, C and E) and 3T (D). The images at 7T with higher spatial resolution show high contrast between cerebral structures. At 7T FLAIR, the outer cortical layers appear hyper-intense [4], which cannot be seen at 3T. DIR images at 7T show a similar phenomenon, which can influence classification of lesions around the motor cortex. Furthermore, DIR images at 7T have poorly attenuated peri-vascular spaces (PVS) in white matter which can be mistaken for lesions. However, the differentiation between inflammatory white matter lesions and pure PVS can be made by following them over several slices. In the healthy controls in total only two atypical lesions were found, which were visible on all sequences and at both field strengths. Lesion numbers in patients are listed in the table. Provisional analysis shows a higher sensitivity for lesion detection for all 7T sequences. Especially around the cortex, lesion detection is substantially improved as compared with 3T. Despite the lack in grey/white contrast on some image types, FLAIR, and DIR and T1 at ultra-high field increase accuracy and reliability in lesion classification.

Discussion and Conclusions

Overall, higher lesion numbers were observed at 7T than at 3T, which may result from high resolution as well as signal and contrast to noise. Additionally, 7T reveals different contrasts as compared with 1.5 and 3.0T. These changes ask for a reassessment of ultra high field image interpretation in MS patients. This the first demonstration in patients that non contrast enhanced 3D (isotropic) FLAIR, DIR and T1 imaging at ultra high field can increase accuracy and reliability in white and grey matter lesion classification. The higher sensitivity at 7T is particularly seen for cortical lesions, which are smaller than WM lesions. The performed examinations were obtained in clinically feasible scan times.

Table 1, no. of lesions observed at 7T / 3T in 5 MS patients, per sequence and location.

	White matter involved			Cortex involved		Total
	PV	DWM	JC	Type I	Type II	7T / 3T
PD/T2	46 / 20	47 / 21	42 / 16	31 / 0	3 / 0	169 / 57
T1	41 / 27	21 / 12	14 / 3	20 / 8	4 / 0	100 / 50
3D-FLAIR	39 / 25	57 / 18	58 / 18	39 / 7	5 / 0	198 / 68
3D-DIR	53 / NA	44 / NA	45 / NA	39 / NA	7 / NA	188 / NA

Ref. [1] Geurts JJ, et al., J Neurol. 2009 [2] Moraal B, et al., Eur. Radiology, 2008 [3] Wattjes et al., Neuroradiol. 2009 [4]Visser F, et al., ISMRM Conf. proc. 2009