Lesion Recognition in Multiple Sclerosis: A Sequence Comparison and Quantification Study at 3T

T. Kober[1,2], C. Granziera[3,4], D. Ribes[1,2], P. Browaeys[5], M. Schluep[6], K. Wohlfarth[7], R. Meuli[5], and G. Krueger[2]

[1]Laboratory for functional and metabolic imaging, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [2]Advanced Clinical Imaging Technology, Siemens Suisse SA - CIBM, Lausanne, Switzerland, [3]Department of Neurology, Hôpitaux Universitaires de Genève, Lausanne, Switzerland, [4]Brain and Mind Institute, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [5]Department of Radiology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland, [6]Department of Neurology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland, [7]H IM MR PLM AW Neurology, Siemens AG, Erlangen, Germany

Introduction

Lesion detection in multiple sclerosis (MS) is an essential part of its clinical diagnosis. In addition, radiological characterisation of MS lesions is an important research field that aims at distinguishing different MS types, monitoring drug response and prognosis. To date, various MR protocols have been proposed to obtain optimal lesion contrast for early and comprehensive diagnosis of the MS disease.

In this study, we compare the sensitivity of five different MR contrasts for lesion detection: (i) the DIR sequence (Double Inversion Recovery, [4]), (ii) the Dark-fluid SPACE acquisition schemes, a 3D variant of a 2D FLAIR sequence [1], (iii) the MP2RAGE [2], an MP-RAGE variant that provides homogeneous T1 contrast and quantitative T1-values, and the sequences currently used for clinical MS diagnosis (2D FLAIR, MP-RAGE). Furthermore, we investigate the T1 relaxation times of cortical and sub-cortical regions in the brain hemispheres and the cerebellum at 3T.

Methods

10 early-stage female MS patients (age: 31.6±4.7y; disease duration: 3.8±1.9y; disability score, EDSS: 1.8±0.4) and 10 healthy controls (age and gender-matched: 31.2±5.8y) were included in the study after obtaining informed written consent according to the local ethic protocol. All experiments were performed at 3T (Magnetom Trio a Tim System, Siemens, Germany) using a 32-channel head coil [5]. The imaging protocol included the following sequences, (all except for axial FLAIR 2D with 1x1x1.2 mm^3 voxel and 256x256x160 matrix): DIR (TI1/TI2/TR XX/3652/10000 ms, iPAT=2, TA 12:02 min), MP-RAGE (TI/TR 900/2300 ms, iPAT=3, TA 3:47 min); MP2RAGE (TI1/TI2/TR 700/2500/5000 ms, iPAT=3, TA 8:22 min, cf. [2]); 3D FLAIR SPACE (only for patient 4-6, TI/TR 1800/5000 ms, iPAT=2, TA=5;52 min, cf. [1]); Axial FLAIR (0.9x0.9x2.5 mm^3, 256x256x44 matrix, TI/TR 2500/9000 ms, iPAT=2, TA 4:05 min). Lesions were identified by two experienced neurologist and radiologist, manually contoured and assigned to regional locations (s. table 1). Regional lesion masks (RLM) from each contrast were compared for number and volumes of lesions. In addition, RLM were merged in a single "master" mask, which represented the sum of the lesions of all contrasts. T1 values were derived for each location from this mask for patients 5-10 (3D FLAIR contrast was missing for patient 1-4).

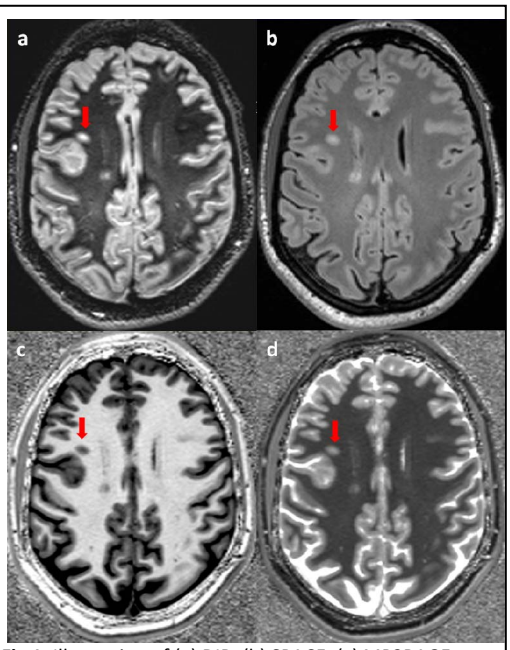

Fig 1: Illustration of (a) DIR, (b) SPACE, (c) MP2RAGE and (d) T1 map of the same slice from a patient before registration. Red arrows mark a sub-cortical lesion visible in all contrasts.

Results & Discussion

The DIR sequence appears the most sensitive for total lesions count, followed by the MP2RAGE (table 1). The 3D FLAIR SPACE sequence turns out to be more sensitive than the 2D FLAIR, presumably due to reduced partial volume effects. Looking for sub-cortical hemispheric lesions, the DIR contrast appears to be equally sensitive to the MP2RAGE and SPACE, but most sensitive for cerebellar MS plaques. The DIR sequence is also the one that reveals cortical hemispheric lesions best.

	total	DIR	FLAIR	MP2RAGE	MP-RAGE	SPACE
GM hem	4	4	0	0	0	1
WM hem	294	254	159	252	242	219
GM/WM hem	20	19	12	19	16	20
WM cer	15	14	8	12	10	13
GM cer	4	4	0	0	0	0
GM/WM cer	6	5	1	3	3	3
Σ	**343**	**300**	**180**	**286**	**271**	**256**

Table 1: Number of lesions recognised in the different MR contrasts.

T1 relaxation times at 3T in the WM and GM of the hemispheres and the cerebellum, as obtained with the MP2RAGE sequence, are shown in table 2. Extending previous studies, we confirm overall longer T1-values in lesion tissue and higher standard deviations compared to the non-lesion tissue and control tissue in healthy controls. We hypothesize a biological (different degree of axonal loss and demyelination) rather than technical origin.

	T1 (ms) of lesions (patients)	T1 (ms) of non-lesion tissue (patients)	T1 (ms) in control ROIs of healthy controls
GM hem	1548±280	1390±31	1383±97
WM hem	1265±103	827±31	778±95
GM/WM hem	1521±161	1117±11	1087±100
WM cer	1222±149	849±16	806±98
GM cer	1440 (#1)	1326±28	1290±137
GM/WM cer	1294±169	1092±18	1051±118

Table 2: Inter-subject mean and standard deviation of the T1 relaxation times (hem = brain hemisphere, cer = cerebellum).

Conclusion

In this study, we applied 5 MR contrasts including two novel sequences to investigate the contrast of highest sensitivity for early MS diagnosis. In addition, we characterized for the first time the T1 relaxation time in cortical and sub-cortical regions of the hemispheres and the cerebellum. Results are in agreement with previous publications and meaningful biological interpretation of the data.

References [1] Mugler et al., 2000; [2] Marques JP et al., 2009; [3] MacKay A.L. et al., 2009; [4] Watties et al., 2007; [5] Wiggins GC et al., 2006

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