

# MAGNETIC SUSCEPTIBILITY CONTRAST VARIATIONS IN MULTIPLE SCLEROSIS (MS) LESIONS OBSERVED AT

7T

Xu Li<sup>1,2</sup>, Hongjun Liu<sup>1,3</sup>, Daniel M Harrison<sup>4</sup>, Craig K Jones<sup>1,2</sup>, Jiwon Oh<sup>4</sup>, Peter A Calabresi<sup>4</sup>, and Peter C.M. van Zijl<sup>1,2</sup>

<sup>1</sup>F.M. Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, United States, <sup>2</sup>Radiology, Johns Hopkins University School of Medicine, Baltimore, MD, United States, <sup>3</sup>Radiology, Guangdong General Hospital, Guangzhou, Guangdong, China, <sup>4</sup>Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, United States

**PURPOSE:** Previous MRI studies in MS using susceptibility weighted imaging (SWI) and SWI phase have revealed different contrast patterns in MS lesions<sup>1-4</sup>. However, high-pass filtered SWI phase data depend strongly on the high-pass filter setup and the contribution of background field gradients and therefore are not a very quantitative measure of tissue magnetic susceptibility and may deviate from the real tissue susceptibility contrast patterns. On the other hand, recent developments in QSM have made it possible to reliably obtain tissue magnetic susceptibility maps<sup>5-9</sup>. In this study, we investigated the susceptibility contrast variations in MS lesions using QSM.

**METHODS:** The imaging data analyzed are selected from a multi-contrast MRI study on MS collected at 7T (Philips Healthcare) from March 2010 to Dec 2012. For the current study, 24 MRI scans collected on 24 MS patients (12 females and 12 males) using a 3D multi-echo gradient recalled echo (GRE) sequence (1 mm isotropic resolution, TR/TE1/ΔTE=68/4/2 ms, 8 echoes, FOV=220x220x110 mm<sup>3</sup>, SENSE=2.5x1x2, FA=9°, scan time: 7min14s) were used to investigate the magnetic susceptibility contrast in MS lesions. The 12 female MS patients had a mean age of 44.7 ± 11.3 years with 10 relapsing remitting (RRMS), 1 secondary progressive (SPMS) and 1 primary progressive (PPMS). The 12 male patients had a mean age of 43.8 ± 9.0 years with 11 RRMS and 1 SPMS. For each subject, FLAIR (TR/TI/TE=8000/2175/302 ms) and T1 MPRAGE (TR/TE=4.1/1.83 ms) images both acquired at 1 mm isotropic resolution were coregistered to the GRE magnitude image (TE=12ms). MS lesions were identified by a radiologist (HL) based on their hyper-intensity in FLAIR and hypo-intensity in T1 MPRAGE over the whole brain. Phase data at TE=12 ms was used to generate the frequency and QSM maps. Phase data was first unwrapped with a Laplacian-based phase unwrapping method<sup>8</sup>. The background gradient was then removed using the SHARP method with kernel size of 4 mm and with tsvd threshold set to 0.05<sup>7</sup>. QSM images were then generated using the LSQR method<sup>8</sup>.

**RESULTS:** 320 lesions in total were identified. Among them 63 were subcortical and 257 periventricular. In all the lesion cores, R2\* showed consistent hypo-intensity relative to normal white matter (WM) and GRE magnitude consistent hyper-intensity. On the contrary, frequency and susceptibility contrast varied between lesions (Fig.1) with some showing increased susceptibility, i.e. hyper-intensity, in the lesion core (small arrow) and some increased susceptibility in both core and rim of the lesion (big arrow). As shown in Fig. 2, some lesions in the frequency and susceptibility maps do not have obvious contrast at all, i.e. iso-intensity. The lesion appearance in frequency and susceptibility images agreed with each other in all the

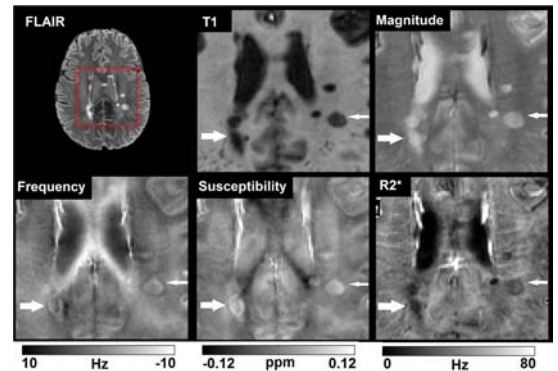


Fig. 1 MR images of a 55 y/o female patient with RRMS showing some lesions with increased susceptibility in the core (small arrow) and also at the rim of the lesion (big arrow).

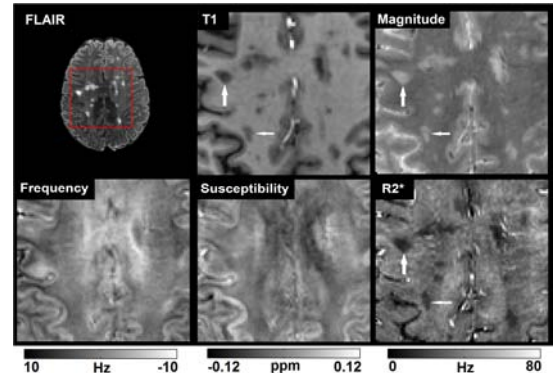


Fig. 2 MR images of a 46 y/o female patient with RRMS showing some lesions that have no contrast to surrounding white matter in frequency and susceptibility images (arrows)

Total Lesion Number	Subcortical		Periventricular	
320	63		257	
<b>Intensity in QSM</b>	Hyper	Iso	Hyper	Iso
	16 (25.4%)	47 (74.6%)	227 (88.3%)	30 (11.7%)
<b>Rim in QSM</b>	1	0	20	0
<b>Rim in Freq</b>	1	0	20	0
<b>Rim in R2*</b>	1	0	20	0
<b>Rim in Mag</b>	1	0	0	0
<b>Penetrating vessels</b>	2	2	46	7

Table 1: Lesion number counts with different contrast characteristics

to suggest myelin loss as the dominant mechanistic source of susceptibility contrast variation.

**CONCLUSION:** Variation in susceptibility contrast is observed in MS lesions using QSM, which may help better characterize pathogenic mechanisms underlying MS lesion formation and propagation. Contrast variations in QSM noted in hypointense R2\* lesions may have potential as a marker for lesion myelin concentration.

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