New Approaches for MS Lesion Characterization with Ultrahigh Field MRI: Comparison of T2*/Phase Susceptibility Weighted Images with T2- and Inversion Recovery Fast Spin Echo Sequences

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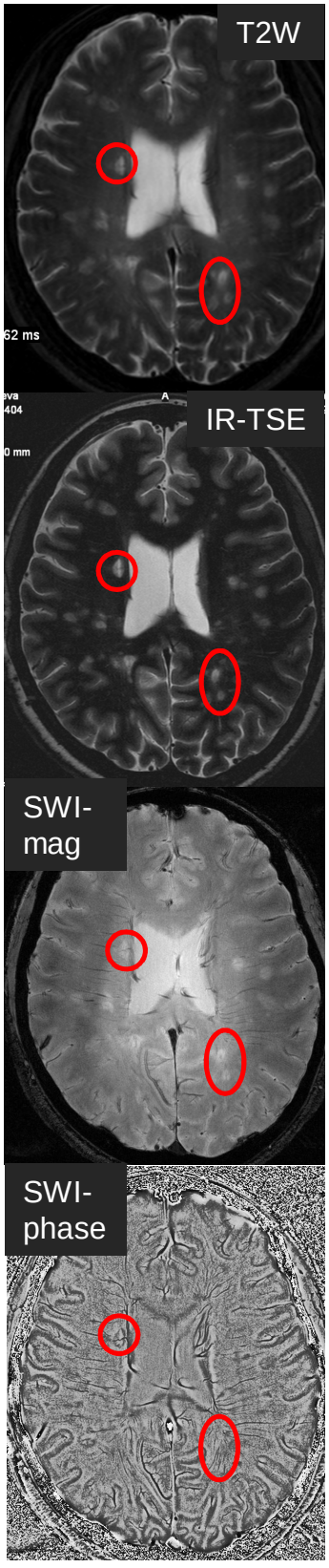
Introduction: MRI is the method of choice in the diagnosis and follow-up of Multiple Sclerosis due to the sensitivity for depiction white matter lesions reflecting demyelination. However, MRI findings are non-specific, and lesion burden is not a sensitive predictor for disease progression and/or therapy assessment. Gd contrast enhanced MRI indicates blood-brain barrier disruption, but enhancing lesions are transient and do not reflect long term outcome. Thus there is significant interest in non-invasive tools that might further characterize the disease. Susceptibility weighted phase and magnitude imaging has demonstrated potential to better delineate lesion morphology such as association of lesions with small veins [1,2] and internal lesion structure [3]. The objective of this work was to evaluate 7T susceptibility weighted imaging for characterization of MS lesions and to compare lesion depiction with T2-weighted images and white matter attenuated inversion recovery sequences.

Methods: Ten MS patients (33-53y, 2 male/8 female) were examined at 7T (Philips, Achieva, Cleveland, OH) using a transmit/receive coil and a 2D gradient echo sequence with TR/TE/flip angle=1600ms/12ms/50°, FOV 230, 512 matrix, 2.5 mm slice thickness and a 10 min scan time. High pass filtered phase images susceptibility weighted (SWI-phase) were reconstructed off-line using IDL [4] and compared to magnitude images (SWI-mag). In addition, T2-weighted gradient Spin Echo (GraSE: TR/TE=4000ms/70ms, 6 spin echoes, 3 gradient echoes), and inversion recovery – TSE images (TR/TI/TE 8000ms, 500ms.14ms, 10 echoes) were acquired. All images were spatially matched, and visually inspected. Lesions were counted in the image region that was covered by all sequences, and lesion features were evaluated. All patients also underwent standard MRI with and without Gd contrast agent.

Results: Figure 1 shows comparison T2-weighted, white matter attenuated IR-TSE, magnitude and phase SWI images. Lesion contrast was higher on T2-weighted and IR-TSE sequences than on the predominantly proton density weighted SWI-magnitude images. The reduced contrast likely explains why up to 15% of the lesions were missed on SWI magnitude images (Table 1). Conversely, only a fraction of the lesions seen on the magnitude images were seen on the corresponding phase images (average 55%, range 34-74%, Table 1). Nevertheless, if lesions were seen, they were best characterized on phase images, where lesions were seen as dark focal regions, or as hypointense rims. Furthermore, the majority of the lesions were associated with small veins. One on one lesion comparison between 3T and 7T was not possible, because of the time lapse between the studies.

Table 1: Clinical, Standard MRI and 7 T Findings

ID	Age/Sex	Clinical	Std MRI	T2/ WHAT	SWI mag	SWI phase	Percentage mag/phase
002	32/m	Active, 2nd prog	Enhancing	50	45	17	34%
003	33/f	Relapse, Mild		51	46	30	65%
004	49/f	Mild		6	6	2	33%
006	46/f	Relapse/remit		21	22	9	41%
007	33/f	Active, new	Enhancing	13	11	6	55%
008	39/f	Relapse/remit	Enhancing	96	84	62	74%
009	53/m	2nd prog, severe		43	41	14	34%



Discussion: SWI phase images add a considerable amount of information on MS lesion morphology. Lesions seen on magnitude, but not phase images, are likely due to increased free water from myelin injury, inflammation or subtle edema. Lesions that are seen on SWI-phase have a paramagnetic component [5]. This may be due to locally increased tissue iron or due to increased deoxyhemoglobin which may be indicative of increased vasculature (angiogenesis). However, with the limited number of cases in this preliminary study, there is no clear evidence for correlation between lesions seen on SWI-phase and clinical findings. Further studies are needed to fully understand the contrast features in SWI-phase images in general [6] and for MS lesions.

References:

[1] Tan L et al, AJNR 21: 10039-1042, 2000, [2] Kangarlu A et al , Springer 2003; [3] Haacke et al, ISMRM 2007, 2302, [4] Abduljalil AM., et al, JMRI, **2003,** 18, 284-290, [5] Deistung et al, ISMRM 2007, 2075, [6] Mihai G et al, ISMRM 2007