# Correlating Iron with T2 Signal Intensity in Multiple Sclerosis Lesions using Susceptibility Weighted Imaging

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**Introduction:** MRI has been used routinely to diagnose and monitor multiple sclerosis spatially and temporarily. Although T2WI is highly sensitive in the detection of hyperintensitises in white matter, these studies are not specific to the status of the disease. Recently, a number of studies have suggested that there is iron deposition in dentate nucleus, cortex and adjacent subcortical white matter, brain stem, basal ganglia and thalamus. These results showed that hypointensities of T2WI highly related to brain atrophy, disease course and physical disability. For example, nonheme iron deposition has been reported to shorten T2 relaxation time in the basal ganglia [1] as well as in lesions [2] in the cortical and subcortical regions [3] of the brain in multiple sclerosis (MS) patients. These studies were based on conventional or fast-spin-echo T2W imaging, which is not sufficient for detecting a subtle iron component that may be associated with lesion development and progression [4]. The purpose of this study was to correlate signal intensity loss in lesions seen in conventional T2W images with SWI filtered phase intensity.

**Materials and Methods:** Twenty-seven clinically definite MS Patients (22 females and 5 males) were scanned on three field strengths: 14 patients at 1.5T, 7 patients at 3T and 6 patients at 4T. In addition to a conventional clinical exam (T2W, FLAIR, and T1W pre/post gadolinium), a velocity compensated 3D gradient echo sequence was used to generate susceptibility weighted images (SWI) with a high sensitivity to iron content. The SWI filtered phase images were used as a means to quantify iron content. The correlation between T2 signal intensity and phase was used to compare potential inflammation with putative iron content. We performed a region-of-interest analysis in each lesion which appeared to have iron (4) and compared the signal intensity phase using our homemade software SPIN. A total of 8 patients with at least 199 lesions shown in SWI filtered phase images showed a negative correlation of iron with T2 signal intensity. Many lesions seen with SWI were not seen with T2.

**Results:** Conventional MRI sequences (T2W, FLAIR, T1W pre/post contrast) combined together revealed a total number of 270 lesions (113 on 1.5T, 96 on 3T and 61 on 4T). In comparison, SWI phase and magnitude images revealed more lesions, a total of 387.We found a negative correlation of T2 signal intensity with SWI filtered phase and hence the putative iron content (Figure 1). The average phase over all lesions was 2186 ± 42 while that in the surrounding normal appearing WM was 2044 ± 20 (Figure 2). The difference between these two values is 142 units, representing an average iron content of 47μg Fe/g tissue [5,6]. There is a clear negative correlation between the T2 signal intensity and the putative iron deposition (Table 1).

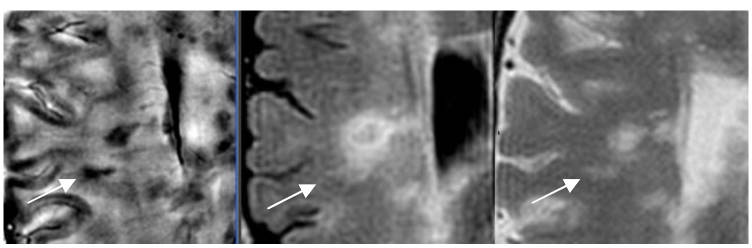

Figure 1: High iron deposition (arrows) clearly seen in SWI phase filtered image (a) but cannot be seen well in either the FLAIR image (b) or the T2 images (c) of a patient whose data was acquired on a 4T scanner. The lesion can only just be seen on FLAIR and T2.

| Patient # | Slope | $R^2$ | r | p |
|---|---|---|---|---|
| 1 | -61.02 | 0.68 | -0.87 | **0.010** |
| 2 | -12.23 | 0.04 | -0.34 | 0.230 |
| 3 | -22.71 | 0.13 | -0.39 | 0.270 |
| 4 | -29.71 | 0.37 | -0.59 | **0.020** |
| 5 | -23.55 | 0.15 | -0.11 | 0.680 |
| 6 | -60.6 | 0.09 | -0.34 | 0.320 |
| 7 | -40.32 | 0.72 | -0.78 | **0.005** |
| 8 | -12.21 | 0.49 | -0.83 | **0.022** |

Table 1: Statistical results for the correlation of SWI phase with T2 signal intensity. Significance was considered if $p < 0.05$. Patient 1 is shown in Figure 1 on the right.

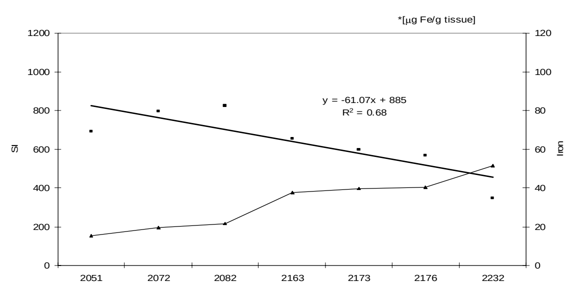


**Figure 2**: Plots of T2 signal (square dot) intensity as a function of phase (upper line) and iron in µg Fe per gm tissue (lower line).

**Conclusions:** SWI reveals iron deposition associated with MS lesions both in terms of its presence and characteristics compared to conventional imaging. Further, the SWI data suggests that there is a correlation between T2 signal intensity and phase changes (putative iron content). One may hypothesize that as the inflammatory component decreases, the tissue is compromised and there is an associated increase in iron deposition in the brain. Further work using SWI may provide some insight into the pathogenesis and mechanisms of disability in MS.

**References:** 1) Drayer B, Radiology 1989;173:311; 2) Bakshi R et al., Neurorep 2000;11:1153; 3) Russo C et al., AJNR 1997;18:124; 4) Haacke EM et al., JMRI 2007;26:256; 5) Haacke EM et al., MRI 2005;23:1; 6) Haacke EM et al., Med Phys 2006; 16:237.