Dynamic magnetic property of multiple sclerosis lesions at various ages measured by quantitative susceptibility mapping

Weiwei Chen[1], Susan Gauthier[2], Ajay Gupta[2], Joseph Comunale[2], Tian Liu[2], Shuai Wang[3], Mengchao Pei[2], David Pitt[4], and Yi Wang[2]

[1]*Radiology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei, China,* [2]*Weill Cornell Medical College, New York, NY, United States,* [3]*School of Electronic Engineering, University of Electronic Science and Technology of China, Chengdu, Sichuan, China,* [4]*The Ohio State University, Columbus, Ohio, United States*

Target Audience Anyone interested in multiple sclerosis (MS).

PURPOSE MRI is the main imaging method for diagnosing and monitor treatment of MS patients, yet conventional MRI (T2 weighted, T2w; T1 weighted pre and post contrast, T1w and T1w+c) is only poorly correlated to dynamic clinical disability. Quantitative susceptibility mapping (QSM) is a recently developed MRI method to study tissue magnetism. Our purpose is to explore new information on MS from QSM by adding QSM to MRI in a longitudinal study.

METHODS 316 clinically definite MS patients (consecutive 8/2011-5/2012) whose MRI included QSM acquired on 3T were retrospectively enrolled with IRB approval. A subset of 12 patients (2 m, 10 f, age 42.4 ± 9.8 yrs) who were scanned twice (baseline and follow up, 18.8 ± 7.0 wks interval) was selected for a longitudinal study using available prior MRI (performed 0.7 - 10.6 yr ago).

Images were co-registered for analysis. T2w hyperintense lesions were presumed to be MS lesions. Three experienced neuroradiologists characterized all lesions consensually with differences resolved by majority. 3D ROI for an MS lesion was defined by compounding 2D lesion boundaries segmented on consecutive slices for measuring lesion magnetic susceptibility relative to normal appearing white matter (NAWM).

RESULTS A total of 293 MS lesions were detected in 12 patients. An example case is shown in Fig.1. Five of the 8 possible patterns (absence/presence in T1w, T1w+c and QSM) were observed: Pattern +-+ (black hole on T1w, not enhancing on T1w+c, and hyperintense on QSM) had the highest incidence (208 lesions at baseline and 215 at follow up, see also Fig.2). An additional lesion pattern Q (present on QSM but absent on T2w, T1w, and T1w+c) was found for 5 lesions in 2 patients at baseline and for 6 lesions in 3 patients at follow up.

120 of the 293 MS lesions (41%) could be estimated their ages. The relative susceptibilities of lesions at all age groups are shown in Figure 2, along with their patterns and traditional classifications. The new contrast enhancing lesion (nCEL, pattern ++-) susceptibility was initially similar to that of NAWM, then increased quickly in 0.5 yr ($p < 0.001$), reached a peak in 0.5-3 yr (mostly pattern +-+), gradually decreased in 3-7yr, and returned to that of NAWM beyond 7 yrs (pattern +--).

CONCLUSION & DISCUSSION This longitudinal study of susceptibilities of MS lesions of different ages using QSM suggests the following findings. 1) There are 6 patterns of lesions manifested in MRI, with various patterns in individual patients. 2) QSM can detect lesions that are not detectable on conventional MRI (pattern Q). 3) Susceptibilities of MS lesions increase at early stage, peak in 1-3 yrs, subsequently decrease in 3-7 yrs, and return to normal after 7 yrs.

Susceptibility increase may be caused by iron accumulation in activated macrophages/microglia in MS lesions, and later susceptibility decrease may indicate repopulation of lesions with oligodendrocytes and remyelination.

REFERENCES 1. De Rochefort, et al, MRM 2010, 63:194. 2 Liu, et al, NeuroImage 2012, 59:2560.

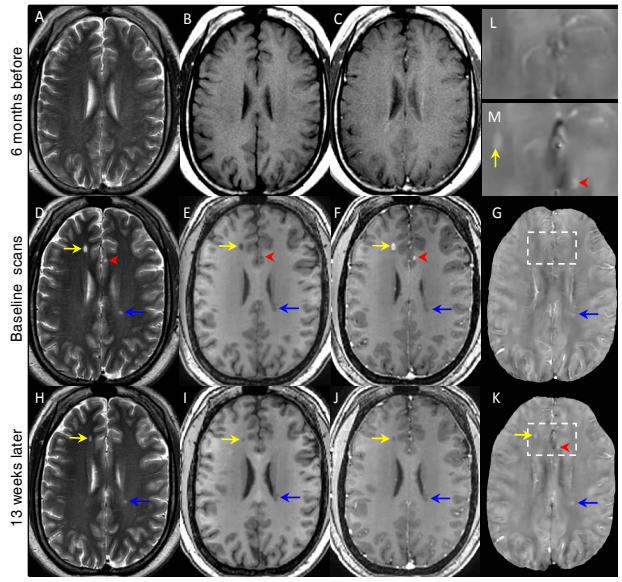

Fig. 1. Example of MS lesion evolution. 1st col (A, D, H): T2w; 2nd col (B, E, I): T1w; 3rd col (C, F, J): T1w+c; 4th col (G, K, L, M): QSM (L, M are the magnification of the white box in G and K). A-C) scans 6 months before baseline show no lesion. D-G) baseline scans show two nCELs (yellow arrows and red arrowheads in D-F, pattern ++-) and a non-enhancing lesion (blue arrows in D-G, pattern +-+). H-K) 13-week follow-up scans show the two nCELs at baseline have changed from QSM absent to present (pattern +-+ for one pointed by yellow arrows and pattern Q for the other pointed red arrowheads in K and M), and the nonenhancing lesion at baseline (blue arrows in D-K) remained in pattern +-+ with increased QSM value.

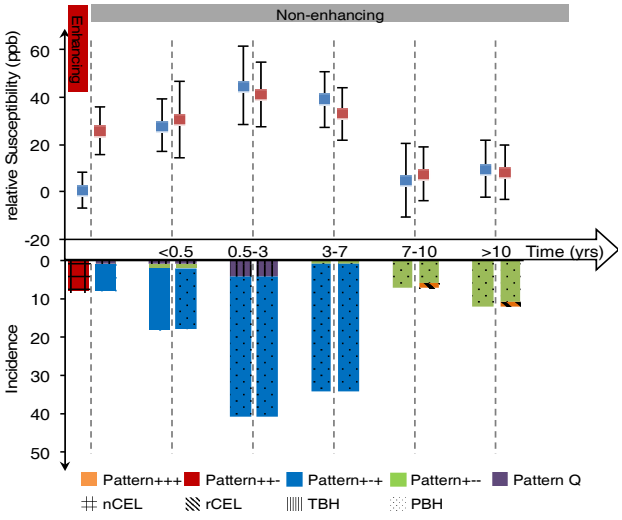

Fig. 2. Lesion relative susceptibilities+patterns vs. age. Baseline and follow up data are divided by a dotted vertical line for each age group. Corresponding incidence, patterns and traditional classifications of these lesions in our data are shown in the lower half.