Heterogeneity of susceptibility mapping of cortical lesions in MS

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Introduction

Multiple Sclerosis (MS) cortical lesions (CLs) could be detected by using Double Inversion Recovery (DIR) sequences optimized to suppress both WM and CSF contents. However a better characterization of those lesions in term of microstructure has not been completely investigated. Susceptibility weighted imaging (SWI) has shown its ability to provide information on iron accumulation and demyelination [1].

Aim of the study

We employed a high resolution Quantitative Susceptibility Mapping technique [2] and a 3D EPI SWI sequence [3]. Susceptibility appearance of CLs, identified by using a 3D DIR sequence, is investigated in a MS cohort composed of both RR-MS a SP-MS patients.

Materials and methods

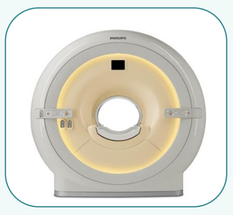
Material

Subjects data

- 29 patients (21 RR-MS/8 SP-MS)
- Age 42.8±5.9y (range 32– 60)

Clinical data

- EDSS 3.3±1.5
- Disease duration 10.6±5.9y



MRI scanner: Philips Achieva 3Tesla

3D Segmented EPI SWI

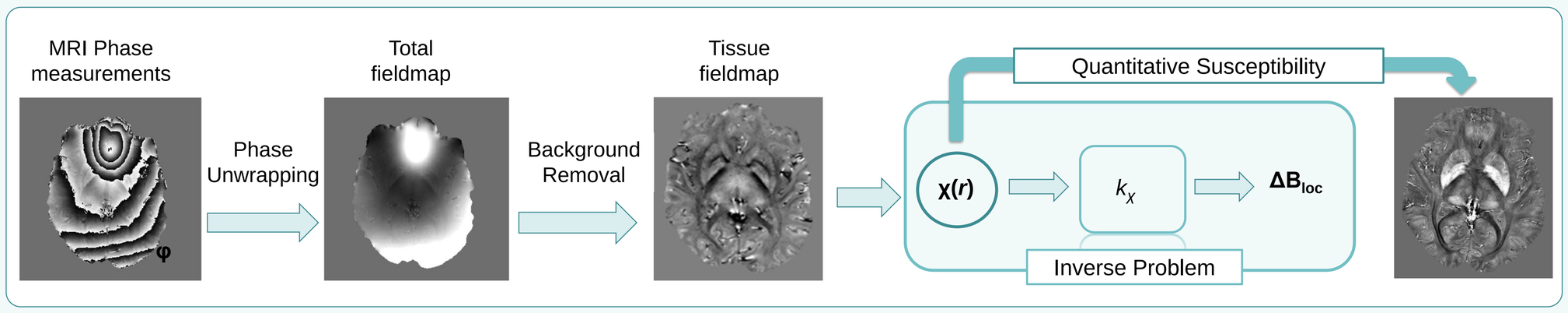
- TR/TE: 51/29 ms
- Voxel size: 0.55x0.55x0.55 mm

3D DIR

- TR/TE 5500/268 ms
- Voxel size: 1 mm^3

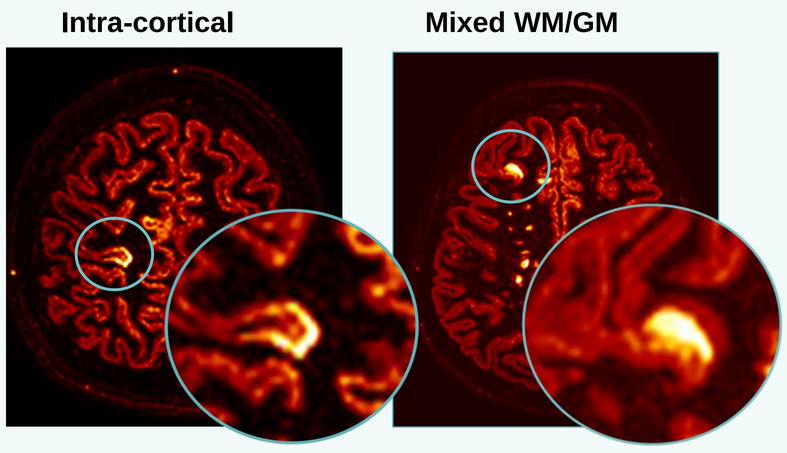
Theory of QSM

Quantitative Susceptibility mapping was performed using a recently introduced technique that uses a total-generalized-variation (TGV) based method [2], which incorporates individual steps of phase unwrapping, background field removal and dipole inversion in a single iteration.



CLs individuation

- CLs identified by visual inspection of 3D DIR images
- Classification based on the portion of GM and WM affected by the lesion (**Intra-cortical** and **mixed WM/GM**).
- Inclusion criteria was the size of lesion. Only CLs with at least 20 voxels (20 mm^3) was considered.



CLs susceptibility appearance

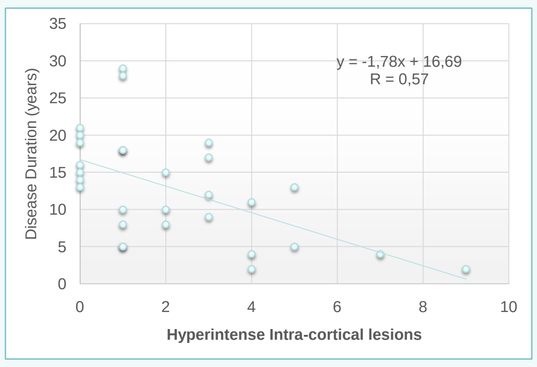
Visual inspection of QSM maps and classification of CLs susceptibility respect to the surrounding normal appearing tissue in three categories: **Hyperintense**, **Isointense** or **Hypointense**

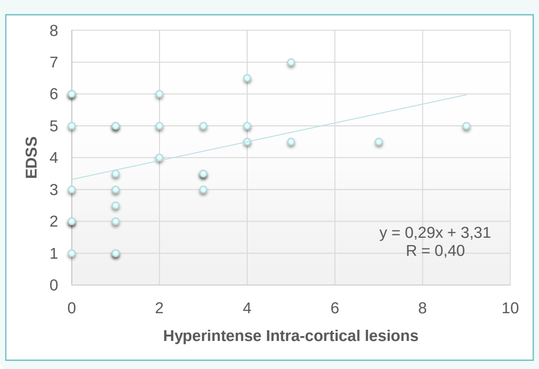
Clinical score correlations

Relation of susceptibility with clinical state of the patients was assessed respect to both EDSS and Disease duration with the Pearson correlation coefficient.

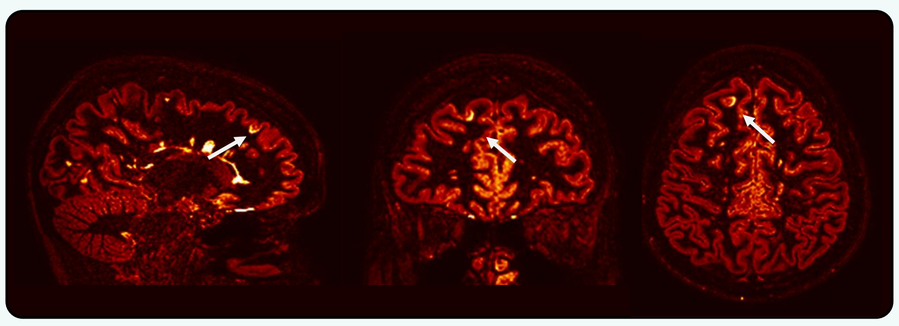
Results

- 177 CLs were identified in the study population. Based on QSM map 104 were hyperintense , 28 were isointense and 45 were hypointense. Twenty seven patients showed at least 1 QSM-hyperintense CL, 12 showed at least 1 QSM-isointense CL and 16 showed at least 1 QSM-hypointense CL. Sixteen patients (55.2%) showed at least 2 QSM-subtypes of CLs and 4 patients showed all QSM-subtypes of CLs at the same time.
- **The number of hyperintense lesions was significantly higher in RRMS** (4.1±1.4) compared to SPMS (2.2±1.5, p=0.009) while the number of hypointense CLs was significantly higher in SPMS patients (0.8±1.1 in RRMS; 3.5±3.5 in SPMS, p=0.005). Indeed, in RRMS 71.5% of CLs were hyperintense and 16.4% hypointense, whereas in SPMS 39% of CLs were hyperintense and 43.0% were hypointense (p<0.00001).
- Moderate correlation was observed between the number of hyperintense CLs and EDSS (0.429, p=0.020) in the entire group. **However in RRMS patients, the correlation between Hyperintense CLs and EDSS was marked (r=0.736, p>0.001)**

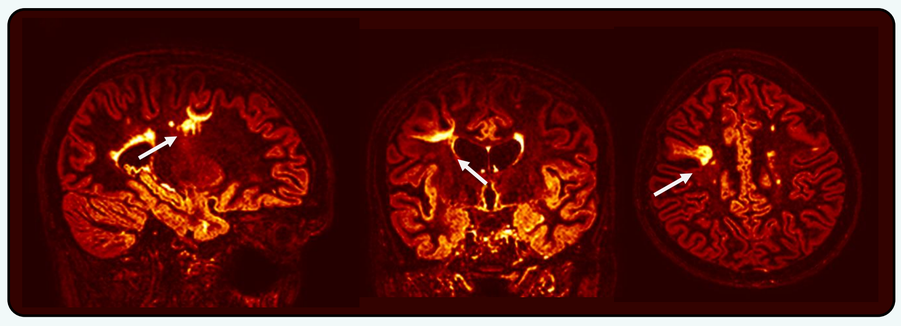




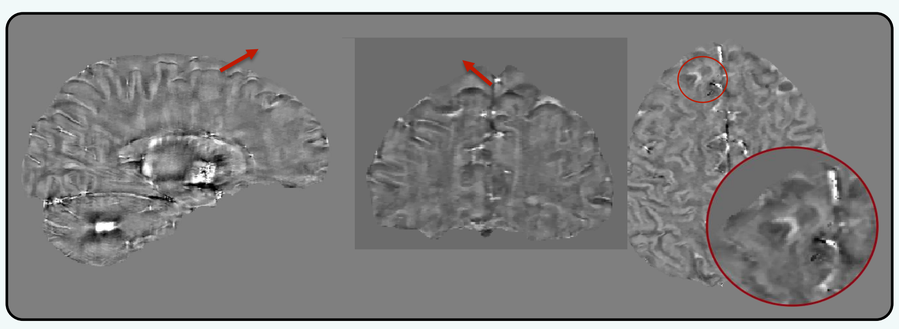
Example of Intra-cortical lesion on 3D DIR



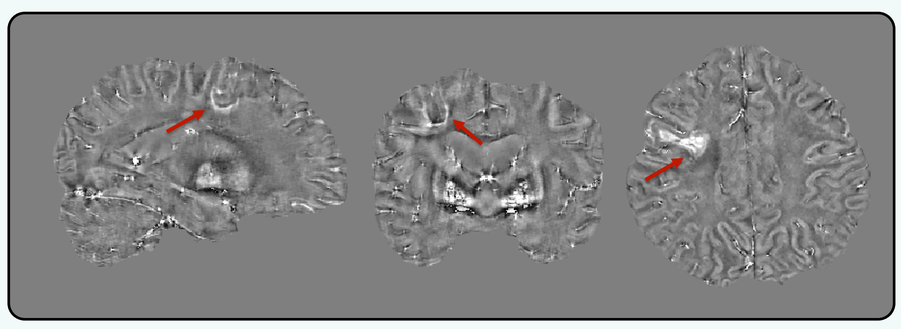
Example of Mixed GM/WM lesion on 3D DIR



Example of Intra-cortical Hyperintense lesion on QSM map



Example of Mixed GM/WM Hyperintense lesion on QSM map



Conclusions:

Grey matter lesions in MS show significant heterogeneity of the susceptibility map which is probably linked to the temporal evolution of each lesion. It looks like in the early and more inflammatory phase of the disease, hyperintense lesions are predominant while in the progressive and more chronic phase the majority of grey matter lesions become hypointense. Whether such changes of the susceptibility map are due to variation of the iron content, of the myelin content or both is currently under investigation.

References

[1] Langkammer et al. Radiology 2013 267;2:551-559
[2] Langkammer et al. Neuroimage. 2015 May 1;111:622-30
[3] Sati et al. Msj 2014 Oct. 20;11:1464-1470

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