OHBM2020 MS abstract

Title

Voxel-Based Quantitative MRI reveals spatial patterns of grey matter alteration in Multiple Sclerosis

Authors

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Abstract

Introduction

Despite robust post-mortem evidence and potential clinical importance of grey matter (GM) pathology in multiple sclerosis (MS), assessing GM damage by conventional magnetic resonance imaging (MRI) remains challenging.

Our aim is to characterize the topography of GM microstructural and volumetric alteration in MS using, in addition to brain atrophy measures, three quantitative MRI (qMRI) parameters: magnetization transfer (MT) saturation, longitudinal (R1) and effective transverse (R2*) relaxation rates.

Methods

This prospective cross-sectional study involved 35 MS patients (14 relapsing-remitting MS and 21 primary or secondary progressive MS pooled together) and 36 age-matched healthy controls (HC) [1]. MRI data were acquired either on a 3T Allegra or Prisma MRI scanner. MRI acquisitions included a multi-parameter mapping (MPM) protocol, consisting of 3 co-localized 3D multi-echo FLASH acquisitions (MT-, PD- and T1-weighted contrasts,1x1x1 mm³ resolution) and additional calibration sequences to correct for inhomogeneities in the RF transmit and B0 field. A FLAIR sequence was also recorded with spatial resolution of 1x1x1 mm³ for the MS patients. The qMRI maps were computed with the hMRI toolbox [2].

For the MS patients, a preliminary lesion mask was derived from the FLAIR image using the LST toolbox [3] then the qMRI's were segmented and normalized in MNI space with the US-with-Lesion toolbox [4]. HC qMRI's were simply segmented and normalized in MNI space with SPM12 [5]. For both groups, the resulting modulated warped GM maps were smoothed with a 6mm FWHM kernel. Similarly tissue-weighted smoothing, focusing on GM only, was applied on the 3 quantitative maps, as in [6]. Group comparison for the 3 quantitative maps and GM was performed separately with a 2-sample t-test model accounting for subject age, scanner and total intracranial volume as regressors of no interest.

Results

Inferences were conducted at $p < 0.05$ after FWER correction for multiple comparisons at voxel level across the whole brain and only clusters of at least 10 mm^3 were considered, see Fig. 1.

We identified significant loco-regional reductions of MT and R1 in GM of MS patients compared to HC in bilateral superior temporal gyri, Heschl's gyri, insulae, primary sensory-motor cortices and posterior hippocampi. R1 and R2* were significantly reduced in MS patients, compared to HC, respectively in the right cingulate cortex and left sensory-motor cortex (Fig. 1, C and D). Extensive GM loss was observed in MS compared with HC in bilateral sensory-motor cortices and paracentral lobules as well as bilateral temporal lobes (Heschl's gyri), right posterior hippocampus, right thalamus and hypothalamus, supero-inferior colliculi and the left putamen (Fig. 1, B)

Overall, three configurations of GM microstructural/volumetric alterations were identified. (1) Co-localization of significant GM atrophy with reduction of MT, R1 and R2*, usually observed in primary cortices. (2) Microstructural modifications without significant GM loss: hippocampus and paralimbic cortices, showing reduced R1 and MT values without significant atrophy. (3) GM atrophy without significant change in microstructure, identified in deep grey matter nuclei.

Fig. 2 illustrates the distribution of each GM parameter (GM volume, MT, R1, R2*) extracted from four different regions of interest (ROIs), across MS and HC participants.

Conclusion

This quantitative multiparametric voxel-based approach identifies three different spatially-segregated patterns of GM microstructural and volumetric alterations in MS patients, that might be associated with different neuropathology. The results highlight the complementarity of qMRI and volumetric techniques in assessing GM status in MS.

References

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Figures

Figure 1.

VBM and VBQ results superimposed on the group mean MT map.

Figure 1. Average WM lesion probability map of MS patients, thresholded at 90% (*green, A*); Voxels showing a significant difference between MS and HC: decreased grey matter (GM) volume (*violet, B*), MT reduction (*blue, C*), R1 reduction (*yellow, D*) and R2* reduction (*circled, bright green, D*). The right most column (*MERGE*) overlays the maps displayed in columns B, C and D, same color scheme, and highlights the three different patterns : 1 = Primary Neocortical Regions, 2 = Hippocampus, 3 = Deep Grey Matter Nuclei.

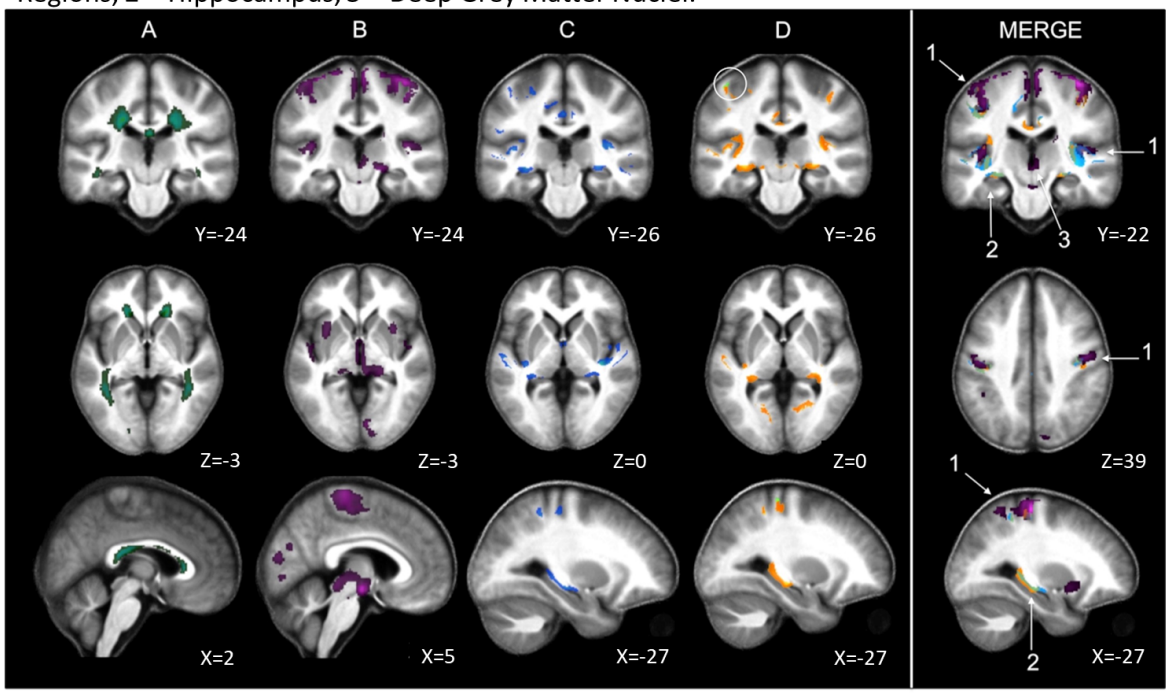

Figure 2.

Distribution of each GM parameter extracted from four different regions of interest.

Figure 2. Violin plots for each GM parameter (GM volume, MT, R1, R2*) extracted from four different voxels, across MS and HC subjects; MNI coordinates: **(1)** Right precentral gyrus ([38 -11 36]), **(2)** Right Heschl gyrus ([45 -18 6]), **(3)** Left hippocampus ([-31 -26 -7]), **(4)** Right thalamus ([2 -21 -4]). Statistical significance (*) set at $p < 0.05$ FWE-corrected for the whole GM volume. Black line = mean, blue line = median.