Quantitative susceptibility of thalamus, basal ganglia and normal appearing white matter in multiple sclerosis

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Synopsis

Quantitative susceptibility mapping (QSM) is an emerging technique that can noninvasively characterize the iron content of brain tissues. The link between susceptibility and disease markers is not yet well defined. This study investigated the relationships between basal ganglia, thalamus, and normal appearing white matter susceptibility and lesion load, based on a fully automated pipeline for lesion and tissue segmentation. Significant correlations were found between lesion load and susceptibility in thalamus, basal ganglia, and normal appearing white matter, as well as between white matter and cortical iron metabolism.

Introduction

QSM [1] is an emerging MRI technique that can provide additional information on brain tissues beyond structural and functional imaging applications in multiple sclerosis (MS) patients [2]. In MS, myelin and iron content are changed, which may affect the local magnetic field of the brain tissue in the form of susceptibility distortions [3,4]. Several studies investigated the relationship between iron concentration and lesion load in multiple sclerosis [5-8]. Moreover, thalamic damage seems to be related to NAWM damage [8]. However, because of technical differences, studies are not fully comparable [9]. Therefore, this study aimed to evaluate the association between MS and NAWM, and MS and DGM susceptibility in relation to disease status and lesion load.

Methods

We performed a retrospective study on a cohort of 73 MS patients, mean age 39.3+12 years, standard deviation = 12 years, range 17-66 years (MS1 = 59 women, mean age 39.9 ± 12.3 years, standard deviation = 12 years, range 17-66 years, MS2 = 14 men, mean age 39.7 ± 10.9 years, standard deviation = 10.9 years). All patients were scanned on a 3T Siemens Magnetom Skyra using a 32-channel head coil. We scanned both occipital and posterior parietal normal appearing white matter (NAWM), basal ganglia, and thalamus to compare their susceptibility with lesion load. The MS1 cohort was divided into three subgroups: Minimal MS (MS1M; n = 15), Early MS (MS1E; n = 19), and Persistent MS (MS1P; n = 29) according to the 2017 revisions of the McDonald criteria [10]. The MS2 cohort was also divided into three subgroups: Minimal MS (MS2M; n = 3), Early MS (MS2E; n = 7), and Persistent MS (MS2P; n = 4) according to the 2017 revisions of the McDonald criteria [10]. All patients gave informed consent. The study was approved by the local ethics committee.

In this study, we found several correlations between lesion load per lobe and susceptibility values of the thalamus, NAWM and basal ganglia. From our results, there is a significant negative correlation between susceptibility and lesion load. Assuming that lesion load is related to disease duration and disability (although not conclusive), we found the same correlation for thalamus, NAWM and basal ganglia, as well as for basal ganglia and NAWM. We found that susceptibility of the thalamus and NAWM was significantly lower in patients with persistent MS compared to minimal and early MS disease activity.

Discussion

We found significantly positive correlations between both right and left putamen and the supratentorial lobes (rho = [0.25 to 0.35], p-value < 0.0001). We also found a positive correlation between right and left thalami, NAWM and basal ganglia (rho = 0.32, p-value = 0.005). Assuming that lesion load is related to disease duration and disability, we found the same correlation for thalamus, NAWM and basal ganglia, as well as for basal ganglia and NAWM. Our findings are consistent with previous studies in multiple sclerosis [11-13].

Conclusions

In summary, this study investigated the relationship between lesion load and susceptibility in the thalamus, basal ganglia, and normal appearing white matter. Significant correlations were found between lesion load and susceptibility in thalamus, basal ganglia, and normal appearing white matter, as well as between white matter and cortical iron metabolism.

Acknowledgements

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References

9. Fartaria MJ, et al. Automated prototype method LeManPV [9, 10] was used for the segmentation of MS lesions taking 3D FLAIR and T1-MP-RAGE pre-Gd images as input.