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Neurosurgical Forum

LETTERS TO THE EDITOR

Structural retinotopic analysis at 7-Tesla MRI in pituitary macroadenomas

TO THE EDITOR: We read the article by Rutland et al.[1] with great interest (Rutland JW, Delman BN, Huang K-H, et al. Primary visual cortical thickness in correlation with visual field defects in patients with pituitary macroadenomas: a structural 7-Tesla retinotopic analysis [published online October 18, 2019]. *J Neurosurg*. doi:10.3171/2019.7.JNS191712).

First, we would like to congratulate the authors for using 7-Tesla (7T) MRI to investigate the secondary damage of the visual cortex that may be attributed to the remote effect of chiasmatic compression in patients with pituitary macroadenomas (PMAs). They found that the global thickness of V1 in patients with PMA was greater than that in controls, although the differences were not statistically significant. Interestingly, the cortical thickness was significantly decreased at the median bottom 10th percentile of V1 thickness in PMA patients. Moreover, positive correlations between V1 thickness ratios and pattern deviation metrics were demonstrated in all patients. We appreciate the significance of these findings and the application of 7T MRI in the clinical setting for the quantitative assessment of the posterior visual pathway. However, we would like to highlight some methodological issues that should be addressed in future studies.

It still remains controversial whether 7T MRI is superior to 3T MRI in cortical thickness estimation. The 7T MRI scanners can generally acquire images with a higher signal-to-noise ratio, and the magnetization-prepared 2 rapid acquisition gradient echo (MP2RAGE) sequence has been widely used in imaging the brain microstructure at a submillimeter scale.[2] However, it is known that T1-weighted images acquired on 7T scanners suffer the transmit and receive B_1-related imaging inhomogeneities, and T1-weighted image quality can heavily affect cortical construction.[2] Seiger et al.[3] performed a systematic comparison between conventional 3T MPRAGE scans and 7T MP2RAGE scans in the estimations of gray matter volume (GMV). They found a higher GMV in several visual regions (including fusiform gyrus, middle, and inferior occipital gyrus) and a higher test-retest reliability at 3T.[3] Moreover, the residual B_1 transmit imaging inhomogeneities, even after the self-correction of MP2RAGE, may still lead to biased classification among gray matter, white matter, and CSF, resulting in misestimation of cortical thickness.[4] Haast et al. have found that additional B_1 transmit imaging inhomogeneity corrections on MP2RAGE images significantly improve the accuracy of cortical thickness measurements compared with uncorrected ones.[4] These results raise a crucial question: are 7T scanners necessary for detecting atypical anatomical structures in patients with PMA?[5] Given the lower accessibility and higher cost of 7T compared to 3T scanners,[5] the necessity of using 7T MRI in the structural retinotopic analysis in PMAs still needs to be further explored.

We note that this study has been classified as a prospective study; however, the neuroophthalmological data was collected retrospectively, and therefore it would be useful to conduct this part of the study prospectively. The study includes a small sample size, and therefore strict inclusion criteria must be used. The patient and control groups were indeed matched by age and sex; however, we would like to highlight that the visual field may also be affected in people with high myopia, glaucoma,[6,7] and macular disease,[8] and therefore additional steps to reduce confounding factors should be taken into account. We suggest that detailed eye examination results from participants such as intraocular pressure and diopter inspection be recorded. To visualize the anatomy and rule out other diseases, we recommend that fundus photography and optical coherence tomography scans should be conducted on all patients with PMA. We hope our discussions and suggestions can foster greater research interests in the mechanisms of PMAs.

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Disclosures

The authors report no conflict of interest.

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Response

We thank Yao et al. for their interest in our recent publication. In this study we sought to take advantage of available high-resolution 7T scans to perform cortical thickness assessments. Although ultrahigh-field MRI may not be necessary for detecting changes in cortical thickness, 7T is a useful tool for studying structural retinotopic changes in the context of pituitary adenoma due to the resolution and contrast advantage imparted by high-field scanners. These results may eventually be translated to performing similar studies at 3T with lower permitted resolutions and larger sample sizes. Furthermore, 7T scanners are increasingly available since recent FDA and Conformité Européenne approval, with at least 87 whole-body MRI systems of 7T or greater field strength installed worldwide as of December 2019. These 7T scanners offer exquisite sensitivity and resolution for imaging modalities required to detect subtle alterations in structure, metabolism, and connectivity in various neurological diseases.[1–3]

While we acknowledge that signal-to-noise ratio and contrast in certain brain regions suffer from increased B_1 inhomogeneity at ultrahigh field, in our experience, this is less of a problem in the primary visual cortex than in portions of the brain in closer proximity with the skull base. Careful placement of dielectric pads and adjustment of the transmit B_1 to provide the most uniform B_1 profiles in the regions of interest were employed in this study to minimize transmit B_1 inhomogeneity. We used the MP2RAGE sequence in which flip angles are optimized to create image contrast that was independent of the reception B_1 field [B_1^-] and largely independent of the transmission B_1 field [B_1^+].[4] This more homogenous T1-weighted image, called the UNIDEN image, is created by combining two different gradient echo images with two different inversion times produced by MP2RAGE.[4,5]

Reducing the effect of inhomogeneous transmit B_1 field at 7T is an active area of research. Solutions include the use of parallel transmit coils and universal radiofrequency pulses to achieve a more uniform B_1 profile.[6,7] This could provide whole-brain uniform MP2RAGE images at the higher resolution achievable by 7T MRI.

Lusebrink et al. systemically compared thicknesses of the human cerebral cortex using 3T and 7T and found consistent results across field strengths, confirming the validity of cortical thickness measurement at ultrahigh field.[8] However, the average cortical thickness was shown to be greater at 3T and Lusebrink et al. concluded that 3T overestimates cortical thickness as a result of partial volume effects, which are greater at lower field strength. This potential overestimation could contribute to the higher gray matter volumes reported by Seiger et al. using 3T, suggesting that 7T MRI may be useful in mitigating volume averaging effects.[9] Due to a small number of studies comparing 3T and 7T, there is currently not a final consensus on the optimal magnetic field strength for high-resolution precision volumetric quantification of cortical thickness. More research in this area is warranted to determine preferred field strengths for specific applications such as retinotopic imaging of pituitary adenoma.

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