

Magnetic Resonance Relaxometry in Studying the Human Brain Matter: Possibilities of MAGiC

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Abstract

In the current work, we used MAGiC (Magnetic Resonance Image Compilation) method to study brain relaxometric values (T1, T2, proton density) in normal-appearing gray and white matter of 40 volunteers aged 24 to 59 years. Healthy patients and patients with microvascular lesions were enrolled. The study revealed differences between supratentorial and infratentorial regions of interest in both white and gray matter which may be related to different myelination of these regions. For frontal white matter, age-related increase in T1 and T2 was shown. We also demonstrated hippocampal T1 decrease with ageing. These changes may be linked to structural and metabolic changes. In further analysis, differences in relaxometric values between right and left hemispheres were found which may be due to increased myelination of cortex and white matter of the dominant hemisphere.

Key words: Magnetic Resonance Relaxometry, Synthetic Magnetic Resonance Imaging.

References

1. *Badve C., Yu A., Rogers M., Ma D., Liu Y., Schluchter M., Sunshine J., Griswold M., Gulani V.* Simultaneous T1 and T2 brain relaxometry in asymptomatic volunteers using magnetic resonance fingerprinting // *Tomography*. 2015. V. 1. № 2. P. 136–144.
2. *Baranovicova E., Kantorova E., Kalenska D., Lichardusova L., Bittsan-Sky M., Dobrota D.* Thalamic paramagnetic iron by T2* relaxometry correlates with severity of multiple sclerosis // *J. Biomed. Res.* 2017. V. 31. № 4. P. 301–305.
3. *Carey D., Caprini F., Allen M., Lutti A., Weiskopf N., Rees G., Callaghan M. F., Dick F.* Quantitative MRI provides markers of intra-, inter-regional, and age-related differences in young adult cortical microstructure // *Neuroimage*. 2018. V. 182. P. 429–440.
4. *Cheng H. L., Stikov N., Ghugre N. R., Wright G. A.* Practical medical applications of quantitative MR relaxometry // *J. Magn. Reson. Imag.* 2012. V. 36. № 4. P. 805–824.
5. *De Blank P., Badve C., Gold D. R., Stearns D., Sunshine J., Dastmalchian S., Tomei K., Sloan A. E., Barnholtz-Sloan J. S., Lane A., Griswold M., Gulani V., Ma D.* Magnetic resonance fingerprinting to characterize childhood and young adult brain tumors // *Pediatr. Neurosurg.* 2019. V. 54. № 5. P. 310–318.
6. *Hofer S., Wang X., Roeloffs V., Frahm J.* Single-shot T1 mapping of the corpus callosum: a rapid characterization of fiber bundle anatomy // *Front. Neuroanat.* 2015. V. 9. P. 57.
7. *House M. J., St Pierre T. G., Foster J. K., Martins R. N., Clarnette R.* Quantitative MR imaging R2 relaxometry in elderly participants reporting memory loss // *AJNR. Am. J. Neuroradiol.* 2006. V. 27. № 2. P. 430–439.

8. *Körzdörfer G., Kirsch R., Liu K., Pfeuffer J., Hensel B., Jiang Y., Ma D., Gratz M., Bar P., Bogner W., Springer E., Lima Cardoso P., Umutlu L., Trattinig S., Griswold M., Gulani V., Nittka M.* Reproducibility and repeatability of MR fingerprinting relaxometry in the human brain // *Radiol.* 2019. V. 292. № 2. P. 429–437.
9. *Lonnfors-Weitzel T., Weitzel T., Slotboom J., Kiefer C., Pollo C., Schupbach M., Oertel M., Kaelin A., Wiest R.* T2 relaxometry predicts outcome of DBS in idiopathic Parkinson's disease // *Neuroimage Clin.* 2016. V. 12. P. 832–837.
10. *Ma D., Gulani V., Seiberlich N., Liu K., Sunshine J. L., Duerk J. L., Griswold M. A.* Magnetic resonance fingerprinting // *Nature.* 2013. V. 495. № 7440. P. 187–192.
11. *Moon H. J., Chang Yu., Lee Yu. S., Song H. J., Chang H. W., Ku J., Cho Y. W.* T2 relaxometry using 3,0 tesla magnetic resonance imaging of the brain in early- and late-onset restless legs syndrome // *J. Clin. Neurol.* 2014. V. 10. № 3. P. 197–202.
12. *Moon W. J., Park J. Yu., Yun W. S., Jeon J. Yu., Moon Yu. S., Kim H., Kwak K. C., Lee J. M., Han S. H.* A Comparison of substantia nigra T1 hyperintensity in Parkinson's disease dementia, Alzheimer's disease and age-matched controls: volumetric analysis of neuromelanin imaging // *Korean J. Radiol.* 2016. V. 17. № 5. P. 633–640.
13. *Papadaki E., Kavroulakis E., Kalaitzakis G., Karageorgou D., Makrakis D., Maris T. G., Simos P. G.* Age-related deep white matter changes in myelin and water content: A T2 relaxometry study // *J. Magn. Reson. Imaging.* 2019. V. 50. № 5. P. 1393–1404.
14. *Sato S., Iwasaki M., Suzuki H., Mugikura S., Jin K., Tominaga T., Takase K., Takahashi S., Nakasato N.* T2 relaxometry improves detection of non-sclerotic epileptogenic hippocampus // *Epilepsy Res.* 2016. V. 126. P. 1–9.
15. *Tanenbaum L. N., Tsiouris A. J., Johnson A. N., Naidich T. P., DeLano M. C., Melhem E. R., Quarterman P., Parameswaran S. X., Shankaranarayanan A., Goyen M., Field A. S.* Synthetic MRI for clinical neuroimaging: results of the magnetic resonance image compilation (MAGiC) prospective, multicenter, multireader trial // *AJNR/ Am. J. Neuroradiol.* 2017. V. 38. № 6. P. 1103–1110.

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