Whole brain adiabatic T1rho and Relaxation Along a Fictitious Field imaging in healthy volunteers: feasibility and initial findings

Aida Kiviniemi[1], Harri Merisaari[1], Marko Pesola[1], Timo Liimatainen[2], Hannu Juhani Aronen[1], and Ivan Jambor[1]

[1]*University of Turku, Turku, Finland,* [2]*A.I. Virtanen Institute for Molecular Sciences, Kuopio, Finland*

Synopsis

The adiabatic $T_{1\rho}$ and RAFF measurements, RAFF2 and RAFF4, were performed in 28 healthy volunteers (24-69 years) and four of them had repeated MR scan within 4 weeks to evaluate short term repeatability. The relative differences on the voxel level were below 5% in gray and white matter for all of the relaxation parameters except of T_{RAFF4} in gray matter which was 7.3%. No statistically significant age related changes in white and gray matter were present as evaluated by adiabatic $T_{1\rho}$, RAFF2 and RAFF4 imaging.

Purpose

The aim of the study was to evaluate feasibility of whole brain adiabatic T1r and Relaxation Along a Fictitious Field (RAFF) (1, 2) imaging in healthy volunteers and explore age related change in gray (GM) and white matter (WM).

Methods

Twenty-eight healthy volunteers (age 24-69) provided written informed consent and underwent MRI examination performed using a clinical 3 T MR scanner. Four healthy volunteers had second MR examination performed within 4 weeks after the initial scan to evaluate short term repeatability. The adiabatic $T_{1\rho}$ and RAFF measurements were acquired using a 3D T1-FFE sequence with the following parameters: TR/TE 4.1/2.3 ms, acquisition voxel size with whole brain coverage 1.5x1.5x1.5 mm^3, FOV 240x240 mm^2, TFE factor 20, SENSE factor 2.5 in right-left and 2.0 in feet-head direction, centric k-space coding, acquisition time 3 minutes 19 seconds per frame. The adiabatic $T_{1\rho}$ data sets were obtained using hyperbolic secant (HS) pulses with the RF peak amplitude 575 Hz (corresponding to 13.50 mT, B_1), pulse duration 12 ms, pulse train duration of 72ms and 144 ms. A second-order rotating frame (RAFF2) and fourth-order rotating frame (RAFF4) were performed using RF peak amplitude 500 Hz (corresponding to 11.74 mT , B_1), 260 Hz (corresponding to 6.13 mT, B_1), respectively. The pulse train duration for both RAFF2 and RAFF4 were of 68 ms and 135 ms. In addition, T1-weighted images were acquired using a 3D T1-FFE sequence with the following parameters: TR/TE 8.0/3.7 ms, acquisition voxel size with whole brain coverage 1.0x1.0x1.0 mm^3, FOV 240x240 mm^2, SENSE factor 2.2 in right-left direction, acquisition time 5 minutes 29 seconds. All MR examinations were performed within specific absorption rate limit. The relaxation values of adiabatic $T_{1\rho}$ ($T_{1\rho\_adia}$), RAFF2 (T_{RAFF2}) and RAFF4 (T_{RAFF4}) were calculated using two parameter monoexponential model. Rigid co-registration was performed using FSL (3) 5.0.4 while SPM8 (4) with VBM8 toolbox (5) was used in re-slicing and segmentation of T1-weighted images. T1-weighted images were segmented to GM, WM, Cerebrospinal Fluid using VBM8 toolbox (5) and subcortical segments was excluded from GM and WM masks using FIRST (6) tool. Cerebellum obtained from MNI atlas was excluded from both GM and WM. In addition, voxels located between left and right caudatus and thalamus were excluded from GM masks. Absolute differences, differences, and relative differences in the relaxation values on voxel level of volunteers undergoing repeated MR examination (4 in total) were calculated following co-registration of the imaging data sets. Differences in the median values of T1r_adia, TRAFF2 and TRAFF4 between the age groups (20-29, 30-39, 40-49, 50-59, 60-69) were compared using Mann–Whitney test. The correlation of the median relaxation values with age was explored using Pearson correlation coefficient. P-values below 0.05 were considered statistically significant. All statistics were performed using SPSS 22 (7).

Results

The MR examination was successful in all healthy volunteers (Figure 1). The number of healthy volunteers in 20-29, 30-39, 40-49, 50-59, 60-69 age groups was 7, 5, 6, 6, 4, respectively. The relative differences on the voxel level were below 5% in GM and WM for all of the relaxation parameters except of T_{RAFF4} in GM which was 7.3% (Figure 2). Representative differences on the voxel level between the repeated measures are shown in Figure 3. The differences in the median relaxation values between the groups did not reach the level of statistical significance (Figure 4). Similarly, Pearson correlation coefficients were not statistically significant for any of the relaxation parameters.

Conclusion

We have demonstrated feasibility of whole brain adiabatic $T_{1\rho}$, RAFF2 and RAFF4 imaging using a clinical 3T MR scanner. All of the relaxation measurements shown high repeatability on the voxel level. In our study population no statistically significant age related changes in WM and GM were present as evaluated by adiabatic $T_{1\rho}$, RAFF2 and RAFF4 imaging.

Acknowledgements

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References

1. Liimatainen T, Sorce DJ, O'Connell R, Garwood M, Michaeli S. MRI contrast from relaxation along a fictitious field (RAFF). Magn Reson Med 2010; 64:983-994.

2. Liimatainen T, Hakkarainen H, Mangia S, et al. MRI contrasts in high rank rotating frames. Magn Reson Med 2014.

3. M. Jenkinson, C.F. Beckmann, T.E. Behrens, M.W. Woolrich, S.M. Smith. FSL. NeuroImage, 62:782-90, 2012

4. Ashburner, J., et al. "SPM8." User manual. London: The FIL Methods Group (2012).

5. Gaser, C. Voxel-based morphometry toolbox, version 8 (vbm8). (2009).

6. Patenaude, B., Smith, S., Kennedy, D., and Jenkinson, M. (2007). FIRST - FMRIB's integrated registration and segmentation tool. In Thirteenth Int. Conf. on Functional Mapping of the Human Brain.

7. IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

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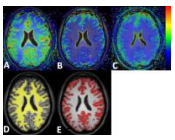
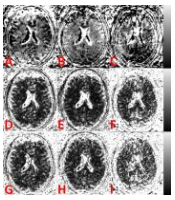
Figures

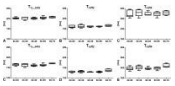


Parametric maps of adiabatic $T_{1\rho}$ (A), second order Relaxation Along a Fictitious Field (B), fourth order Relaxation Along a Fictitious Field (C) of a 37 year old female are shown as well as the white matter (D) and gray matter (E) masks overlaid over T1-weighted images.

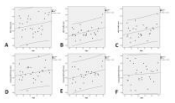
Absolute differences, differences, and relative differences in the relaxation values on voxel level of four volunteers undergoing repeated MR examination.



Absolute differences (A, B, C), differences (D, E, F), and relative differences (G, H, I) in $T_{1\rho\_adia}$, T_{RAFF2} and T_{RAFF4} relaxation values on voxel level are shown (the same 37 year old female as in Figure 1). Absolute differences of $T_{1\rho\_adia}$ (A), T_{RAFF2} (B), T_{RAFF4} (B) are scaled 0-20 ms, 0-20ms, 0-60 ms while differences -10-10 ms, -10-10 ms, -30-30 ms, respectively. The relative differences are scaled with 0 to 10%.



Median $T_{1\rho\_adia}$, T_{RAFF2} and T_{RAFF4} values per healthy volunteer derived from gray matter (A, B, C) and white matter (C, D, E) for different age groups. No statistically significant differences were present between different age groups.



Pearson correlation coefficient of white matter (A, B, C) and gray matter (D, E, F) $T_{1\rho\_adia}$, (A, B), T_{RAFF2} (B, E) and T_{RAFF4} (C, F) median relaxation values as a function of age