Method for accurate brain atrophy follow-up using functional relaxometric classification

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Introduction

Quantitative Magnetic Resonance Imaging (qMRI) of multiple (*n*) MR parameters can be used to create an *n*-dimensional parameter space for Functional Relaxometric Classification ('FRC-space'). Since each tissue has a unique combination of MR parameters it will form a cluster in the FRC-space, characterized by its position and its statistical distribution. If an image-voxel contains two tissue types, it has coordinates in between the cluster positions of the separate tissues. Hence an estimation of tissue probability can be retrieved geometrically from FRC-space, assuming a certain model for the contribution of each tissue corresponding to the weighted parameter average. Using this approach accurate estimations can be retrieved for white matter (WM), grey matter (GM) and cerebrospinal fluid (CSF) volumes. Additionally 'remaining tissue', that is not recognized as WM, GM or CSF, may indicate pathology. The validity of both the approach and the hypothesis was explored in this contribution.

Materials and Methods

A recently published rapid quantification method (Warntjes *et al.*, Magn Reson Med 2008:60;320-329) was applied to a group of young volunteers (n = 21, age 29 ± 7 years) and elderly patients (n = 3, age 74 ± 14 years). Using this method the T1 relaxation and T2 relaxation and the proton density (PD) was simultaneously measured for 24 slices with a resolution of 1 mm and a slice thickness of 5 mm on a 1.5 T Achieva scanner (Philips Healthcare, the Netherlands). The scan time was 5:34 minutes. Reference cluster positions and distributions of WM, GM and CSF were established from the volunteers. Tissue probability was calculated assuming a linear relation of cluster distance in R1-R2-PD parameter space (where the relaxation rate R1 = 1/T1 and R2 = 1/T2). The brain edge was defined as the line with 50% GM and 50% CSF on the outside of the cortex.

Results

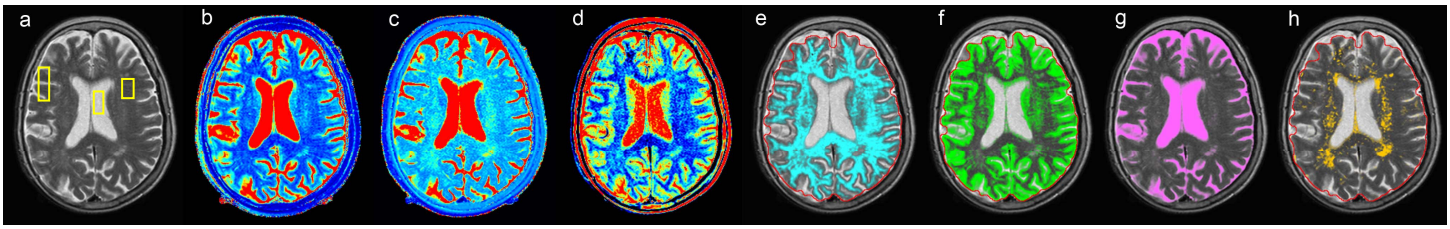

Fig. 1. *Example of qMRI on an axial slice of the brain (female, 89 years old). a T2W image, b) T1 relaxation (scale 0-2000 ms), c) T2 relaxation (scale 0-200 ms), d) PD (scale 50-100% water),e) Colored overlay to indicate white matter, f) grey matter, g) CSF and h) remaining tissue.*

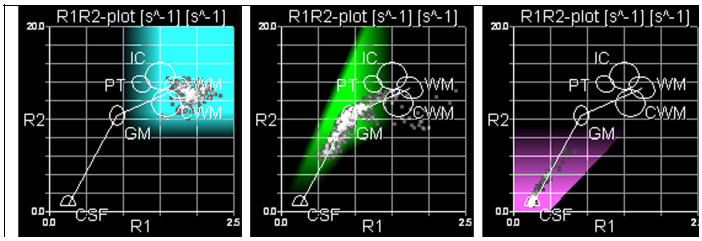

Fig. 2. *The reference cluster regions of healthy CSF, GM, subcortical WM, central WM (CWM), putamen (PT) and internal capsule (IC) in a relaxation rate plot of R1 versus R2 (a projection of the R1-R2-PD space). The colors (blue, green, purple) shows the probability regimes of WM, GM and CSF [0-100%]. The clusters from the ROIs of Fig. 1a with predominantly WM, GM and CSF are also plotted as individual data points.*

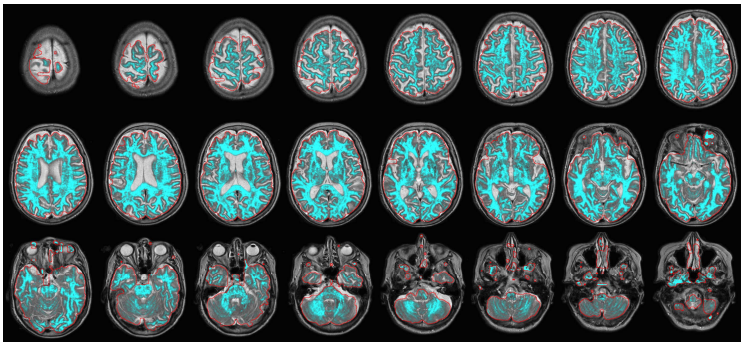

Fig. 3. *Colored classification overlays corresponding to white matter on a scale 0 – 100% probability of the patient displayed in Fig. 1, based on the probability regimes in the plots of Fig. 2. The brain is estimated 362 mL WM, 592 mL GM and 43 mL remaining tissue, in total 997 mL. This volume is 24% lower than the average 1305 mL of the young volunteers.*

Conclusion

Tissue recognition from a multi-parametric functional relaxometric classification space seems to be a promising method to apply in follow-up studies for brain atrophy since the total brain volume can be accurately estimated simultaneously with its components white matter, grey matter and potential pathology.