T1 Mapping in Real Time: Single Inversion-Recovery Radial FLASH with Nonlinear Inverse Reconstruction

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Target Audience

Researchers working in the fields of quantitative MRI, MR relaxometry, T1 mapping, brain MRI

Introduction

Rapid mapping of the spin-lattice relaxation process and quantitative evaluations of T1 relaxation times find widespread applications in clinical MRI. However, it is not used more routinely because of the long acquisition time based on the conventional methods, i.e. repetitive inversion-recovery pulses and segmented *k*-space acquisition. In particular, this is critical when large volume coverage with good spatial resolution is needed for clinical diagnosis. In this work, a recently introduced real-time MRI technique [1, 2] was exploited together with a single inversion-recovery excitation strategy to solve this problem.

Materials and Methods

The approach is based on a highly undersampled radial fast low-angle shot (FLASH) imaging technique for acquisition and regularized nonlinear inversion for reconstruction without any temporal image filter. Consecutive images were obtained following a volume-selective inversion-recovery pulse and in a spoke-slice interleaved manner, which allows for simultaneous multi-slice imaging. Typical acquisition time for one slab is between 80 to 350 ms, depending on the number of radial spokes and slices to measure. Studies of healthy subjects (n = 6) were performed on a 3 T MRI system (Tim Trio, Siemens Healthcare, Erlangen, Germany) on different parts of the body. T1 values within the selected regions are calculated pixel-by-pixel using a three parameter nonlinear curve fitting method: $A - B \cdot \exp(-t / T1^*)$, where A, B, and T1* are the parameters and the final T1 after correction equals $T1^* \cdot (B / A - 1)$ [3]. Corresponding T1 maps are created in Matlab (The MathWorks, Natick, MA).

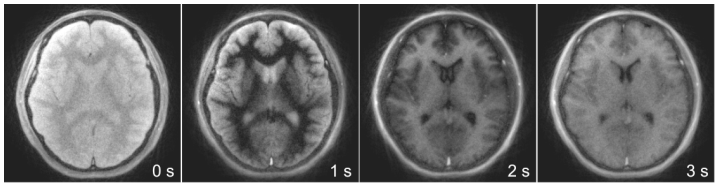

Figure 1. Real-time MRI of T1 recovery (series of consecutive images) after one single inversion pulse.

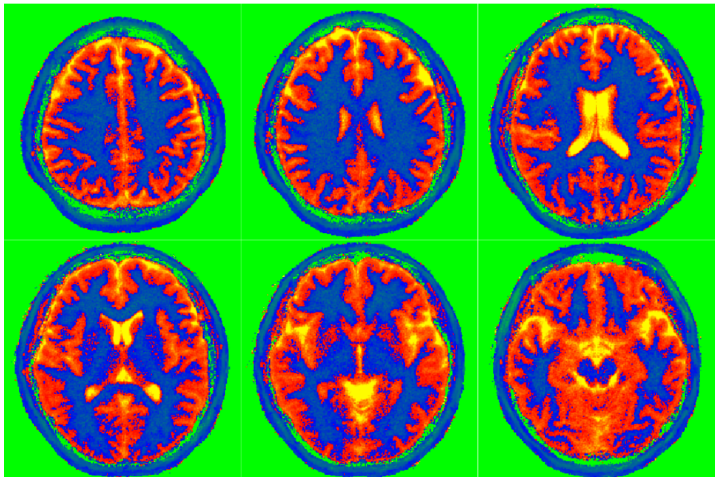

Figure 2. T1 maps covering 6 slices obtained within 4 s showing white matter (blue) and gray matter (red).

Results

Preliminary applications focus on quantitative brain MRI. Real-time MRI movies (0.75 × 0.75 × 5 mm^3, flip angle 4º, 25 spokes, TR/TE = 3.3/2.1 ms, FOV 192 × 192 mm^2) demonstrated magnetization recovery of spins in different tissues (**Fig. 1**). T1 maps from 6 anatomical slices were obtained in 4 s (15 spokes, TR/TE = 293/2.1 ms) and showed clear distinction between different structures (**Fig. 2**). Quantitative T1 measurements are in good agreement with previous literature findings (**Tab. 1**).

Conclusion

The proposed method demonstrates advanced potential for fast and dynamic T1 mapping. Applications may be realized as a single-shot experiment that accurately maps the entire T1 relaxation process for multiple sections after inversion.

Table 1. Quantitative T1 measurement (ms) of different brain tissues: frontal and occipital white matter (FWM, OWM), frontal and occipital gray matter (FGM, OGM), caudate (CA), putamen (PUT), and thalamus (THA).

FWM	OWM	FGM	OGM	CA	PUT	THA
802 ± 24	833 ± 19	1431 ± 65	1310 ± 99	1166 ± 39	1014 ± 43	1058 ± 34

References

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