ROBUST AND FAST T1 MAPPING BY SLAB-SELECTIVE INVERSION RECOVERY TURBOFLASH

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Introduction Fast T1 mapping of human brain is very useful in the quantification of brain tissues in certain diseases, such as Parkinson and multiple system atrophy [1]. 3D T1 mapping is prone to motion due to its long scan time of several minutes. Rapid 2D T1 mapping methods based on EPI [2] has low resolution and is susceptible to distortion, especially at high field. Segmented Look-Locker (LL) FLASH using selective inversion pulse can achieve high in-plane resolution [3] but the segmentation increases scan time and makes the technique motion sensitive. We propose a fast and robust 2D T1 mapping method that uses real time imaging to sample the recovery of the slice selective inversion pulse. The technique was capable of acquiring two T1 maps in 6 seconds and full brain coverage (18 slices) in 1 min with a high spatial resolution of 1.1mm x 1.1mm x 4mm.

Materials and method Theory: The sequence (referred as IR-rttfl here) applies a slab selective IR pulse, followed by realtime turboflash to sample the recovery of inverted magnetization. Parallel imaging and partial Fourier are used to improve temporal resolution. Depending on temporal resolution requirements, interleaved acquisition can be optionally used to improve SNR and reduce the number of IR pulses, and hence the SAR values (see Fig.1). The sequence was implemented on a 3T scanner (TIM Trio, Siemens, Erlangen) where subsequent experiments were carried out. Experiments: The new technique was first validated on uniform gadolinium doped phantoms whose T1 and T2 values were measured by a spin echo sequence. *In-vivo* validation of the technique was performed under an IRB approved healthy volunteer study (volunteers were given informed consent). 7 volunteers were recruited. A 32 channel head coil was used for signal reception. T1 map of one slice from each volunteer was measured by fast spin echo (FSE) as gold standard. Imaging parameters for FSE were: TR/TE=10s/5.4ms, 7 echoes per TR, 4 TIs were used (200, 500, 800 and 1100ms). In the *in-vivo* experiment, 2 interleaved slices per slab was used, giving a temporal resolution of ~250ms. Other imaging parameters were: TR/TE=6.04ms/1.42ms, flip angle=5°, in-plane resolution=1.1mm, slice thickness=4mm, TGRAPPA rate 3 and partial Fourier factor=3/4 were used to accelerate the acquisitions. 26 measurements were performed after each inversion pulse. 18 slices (i.e., 9 slabs) covering the whole brain were acquired in 1 min.

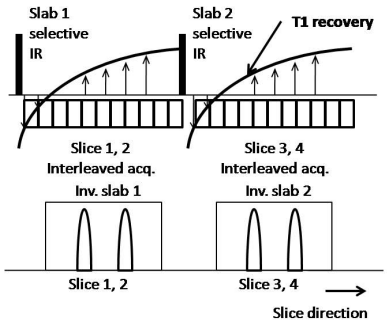

Figure 1. Timing diagram of the new technique.

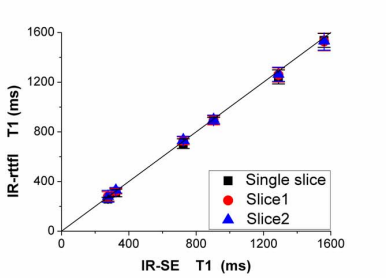

Figure 2. T1 values from IR-rttfl single / 2 slices vs. IR-SE in phantoms. The straight line is the line of the identity, error bars indicate standard deviation.

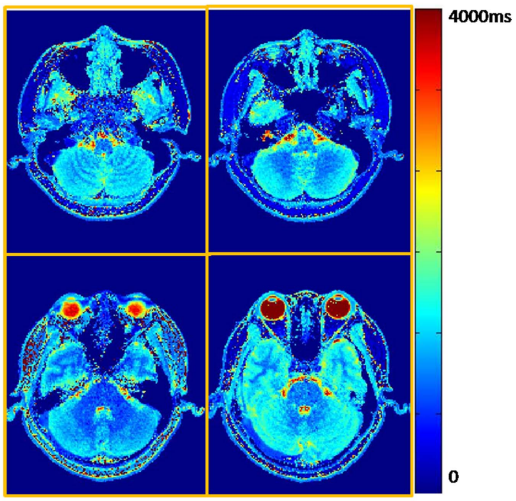

Figure 3. Typical T1 maps from one volunteer

Result Phantom results shown in Figure 2 demonstrated a good agreement between IR- SE and IR-rttfl with one and two slices. T1 maps of 4 successive slices from one volunteer were shown in Figure 3. The average T1 values (mean ± standard deviation) in different regions of the brain from 7 healthy volunteers measured using IR-FSE and IR-rttfl were given in Table 1 and compared to earlier results from [4]. The results matched closely.

Discussion The present study demonstrates the feasibility of IR-rttfl for fast and robust T1 mapping of the brain. The use of real time turboflash to sample the magnetization recovery eliminates the need for segmentation and the associated long wait for fully recovered T1 recovery. Interleaved multislice increases TR and hence SNR. It reduces SAR also. The advantage of turboflash over EPI is particularly obvious near the skull base (Figure 3) where EPI would suffer from serious image distortion in that vicinity [2]. The technique will be particular useful at 7T or higher where SAR is a major concern, T1 recovery wait time is long , field inhomogeneity is an issue and SNR would benefit fast imaging.

Table 1 Comparison of T1 measurements with IR-FSE, IR-rttfl and literature

Region	T1(ms) /IR-FSE	T1(ms)/ IR-rttfl	T1(ms) from [4]
Genu of corpus callosum	722±41	691±46	724±33
Splenium of corpus callosum	762±42	729±45	746±24
Frontal white matter	745±22	719±32	761±25
Posterior white matter	781±23	757±25	791±22
Thalamus	1013±31	981±41	1034±37
Putamen	1086±57	1045±64	1129±42
Caudate nucleus	1209±43	1148±62	1190±41

Reference [1] Vymazal J et.al., Radiology. 1999; 211: 489-495; [2] Clare S et.al., MRM. 2001; 45: 630-634; [3] Deich- mann R, M RM .2005; 54: 20-27; [4] Zhu DC et.al., MRM. 2005; 54725: 731;

Acknowledgement This work is funded by grant no.2013CB733800/2013CB733803