Real-Time Undersampled Radial IR-TrueFISP for Fast Quantitative T1, T2 & M0 Mapping

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Introduction:

One of the primary advantages of MRI in routine clinical practice is the variety of contrasts that can be obtained. While most clinical exams consist of T1, T2 & proton density (M0) weighted images, there are clearly many applications were quantitative estimates of these parameters are of great interest. However, the acquisition of quantitative T1, T2 & M0 maps is very time consuming, normally requiring over 10-15 mins. Schmitt et al [1] have recently demonstrated that quantitative T1, T2 & M0 values can be simultaneously derived from an inversion recovery True FISP (IR-TrueFISP) sequence [2]. Using this sequence, parameter maps could be acquired on the order of 2-3 mins. In this abstract, we apply this same methodology using a real-time radially sampled IR-TrueFISP sequence combined with an echo sharing reconstruction [3-7]. With this sequence and reconstruction, we are able to derive all 3 parameters at clinically useful resolutions in a time comparable to the T1 times of interest (i.e. several seconds.) Using these parameters, we retrospectively reconstruct simulated T1-weighted, T2-weighted & FLAIR images and potentially useful hybrid color images.

Methods

Imaging was performed on a 1.5T Quantum Symphony (Siemens Medical Solutions, Erlangen, Germany) using an 8 channel head array (MRI Devices, Waukesha, WI, USA). The imaging sequence consisted of a slice selective inversion pulse followed by a real-time radial TrueFISP readout. The TrueFISP module consisted of 8 interleaves of 31 projections each with each interleave covering 360º. The TR was 5 ms for 256 read-out points at a bandwidth of 568 Hz/pix. The slice thickness was 8mm with a FOV of 250 mm^2. The duration of each interleave was 155 ms. The total image acquisition time was 5 s per slice.

For reconstruction, a echo-sharing based filtering scheme was used wherein only the center 32 points of all projections from one interleave contributed in the middle of k-space, while the signal from all 8 interleaves contributed to the outer parts (248 projections) [6]. Images were generated using a normal regridding algorithm. Following reconstruction, the time series of images was fit pixelwise to a 3 parameter monoexponential fit. Based on these parameters, T1, T2 & M0 were determined using the method found in [1]. Once these parameter maps were determined, synthetic images with normal clinical contrasts were retrospectively calculated, along with hybrid color images which simultaneously display information from all three parameters in a single image.

Results

Images were reconstructed with good image quality. Some residual low spatial frequency artifacts were visible, however, these were essentially filtered out by the following fitting process, so that the final parameter maps appear artifact free (Fig 1). The resulting values are shown in Table 1 and are in general agreement with literature values. However, the slice-selective acquisition increases the flow sensitivity of the sequence, leading to slightly shortened relaxation times, especially for CSF. The simulated images reconstructed from these parameter maps (Fig 2) appear essentially identical to normally acquired clinical images even though the acquisition time of these images was only 5s. Since these maps were acquired simultaneously, it may be beneficial to combine all 3 maps into a single view, such as the hybrid color image shown in Fig 2. Various other image schemes are possible, including color segmentation of the various tissues based on their relaxation parameters.

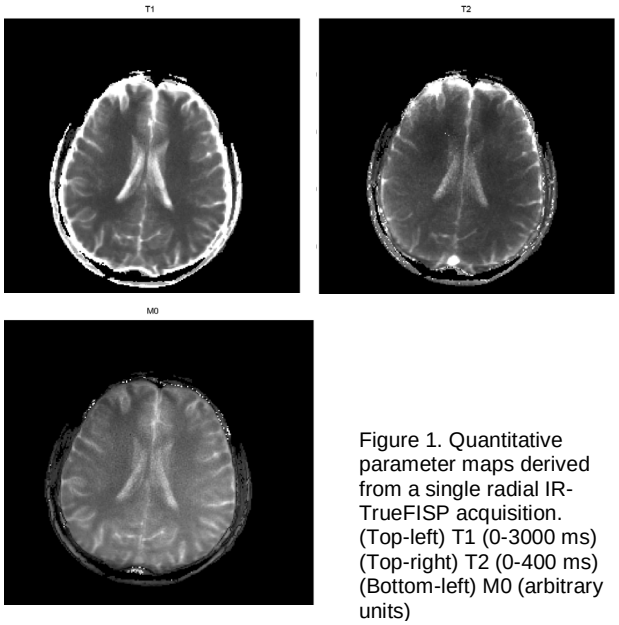
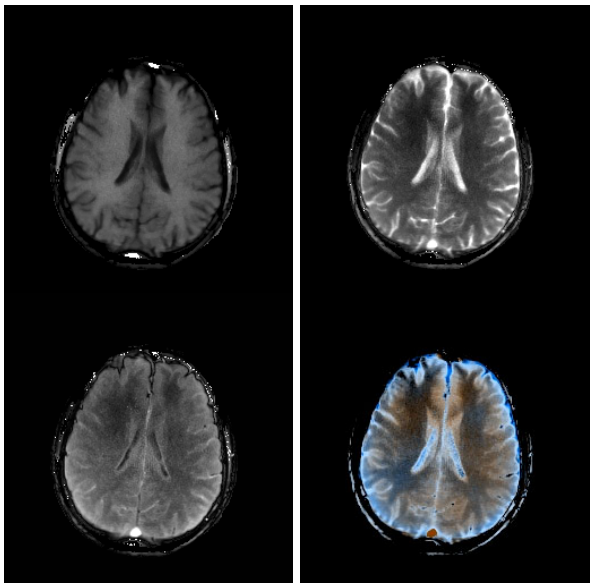


Figure 1. Quantitative parameter maps derived from a single radial IR-TrueFISP acquisition. (Top-left) T1 (0-3000 ms) (Top-right) T2 (0-400 ms) (Bottom-left) M0 (arbitrary units)



Conclusions

In this work, we have demonstrated that it is possible to quantify T1, T2 & M0 in a time on the order of T1 (i.e. several seconds.) Simulated images were retrospectively generated with essentially identical image appearance to normal clinical images, even though the acquisition time was only a fraction of the normal time. The use of these methods could revolutionize clinical brain exams, since the total acquisition time for an entire series of images with various different contrasts would be on the order of a few minutes for a full 3D scan. In the future, it would be beneficial to combine this technique with a parallel imaging reconstruction for reduced artifacts and potentially increased imaging speed.

	T1 (ms)	T2 (ms)	M0 (w.r.t CSF)
WM	705	80	0.73
GM	1100	98	0.80
CSF	2380	190	1.00

Table 1: Calculated relaxation parameters

References

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