Simultaneous T2* mapping and anatomical imaging using a fast radial multi-gradient-echo acquisition

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Introduction

For MRI based molecular imaging the quantification of targeted contrast agents is an important prerequisite for the accurate determination of molecular processes. In addition, detection of small amounts of agents is supported by relaxation time mapping, which can be used for real time tracking of labeled stem cells. Also within a wider scope quantification in MRI is of increasing importance, e.g. for use of FDA approved contrast agents in the clinical routine. Especially the group of small and ultra small paramagnetic iron oxide particles (U)SPIOs is currently under investigation, since they efficiently shorten the T2 and T2* relaxation time. The distribution of these iron oxides is usually determined by measuring T2* weighted images. One step closer towards quantification is the measurement of the T2* relaxation time itself. This can be done with dedicated EPI sequences at the cost of extend measurement time. We present a novel method to perform a fast T2* relaxation time mapping while simultaneously imaging the morphology without lengthening the measurement time.

Materials and Methods

In order to map the T2* relaxation time, a number of images has to be measured at different echo times. The spatial distribution of the T2* relaxation time can be determined by evaluating the decay of the amplitude within each voxel. Our method is based on a radial multi-echo readout [1]. After slice excitation, a number of echoes are obtained under different projection angles. In Figure 1, the profile order is depicted, which provides a homogeneous distribution of projections. Therefore, an image with low spatial resolution can be reconstructed for each echo (since Nyquist's theorem is fulfilled for the k-space center). From these low-resolution images, the T2* decay can be estimated by fitting an exponential decay to different relaxation times of each voxel. In addition to the T2* map, a high resolution anatomical image can be reconstructed from all gradient echoes. The B_0 inhomogeneity can be corrected by means of a field map obtained from different gradient echoes [2]. The T2* map may be displayed as an overlay on the high-resolution anatomical image.

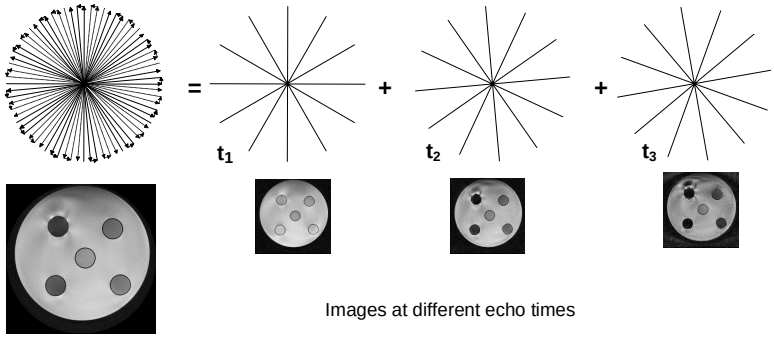

Fig. 1

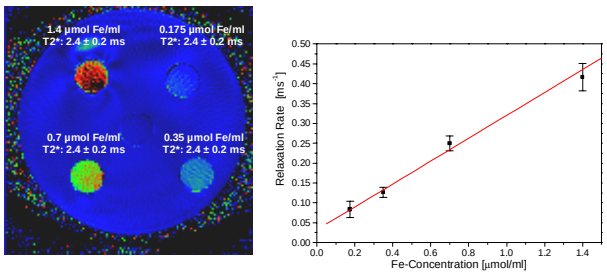

Fig. 2

Results and Discussion

First investigations were performed on a clinical 1.5T system by using phantoms with known concentrations of Resovist (SPIO, Schering AG). The prepared concentrations are on the same order commonly found in vivo. Fig. 2 shows the correlation between the measured relaxation rate and the concentration. The results also reveal that even small concentrations on the order of 0.2 µmol Fe/ml can be detected. In order to utilize this method for real time applications, a fit routine was used, which speeds up the exponential fitting procedure of each voxel. It is based on a numerical integration method [3]. Our current implementation performs exponential fitting at a speed of 180.000 voxel/second on a standard 2.4 GHz Pentium 4 processor. These phantom studies also revealed a non-exponential behavior of T2* in some parts of the image which is predicted by static dephasing regime [4]. Further steps will be to account for this non-exponentiality and apply this method to SPIO labelled stem cells.

Conclusion

Our method is well suited for a rapid detection of contrast agents. It can furthermore be applied to the near real-time tracking of targeted contrast agents and labeled stem cells, in particular due to the high speed of data acquisition and a rapid T2* calculation.

References

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