ENHANCEMENT OF NATIVE T1 CONTRAST AT 4.7, 11, AND 17.6 T FOR SMALL ANIMAL IMAGING

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Introduction

The push to higher magnetic field strengths has necessitated the re-evaluation of standard MR protocols to account for changes in image contrast mechanisms. Of particular interest has been the degradation of T1 relaxation contrast at high fields due to the increase in tissue T1s. The Modified Driven Equilibrium Fourier Transform (MDEFT) preparation (1-3) has proven to be especially useful in human neurological imaging because it provides T1 contrast enhancement over a wide range of T1 values and is less sensitive to B1 inhomogeneities. In this study, MDEFT is compared to standard saturation recovery (SR) and inversion recovery (IR) techniques at three magnetic field strengths (4.7, 11 & 17.6 T) that are pertinent to animal imaging. To assess the benefits and drawbacks of each T1 preparation technique, physiologically relevant phantoms were constructed for the three field strengths. These phantoms cover a range of field dependant T1 values matched to T1s from the brains of normal C57BL6/J mice. Using these phantoms, preparation times were determined for the three T1 contrast techniques at the three field strengths to provide optimal contrast enhancement over a range of T1 values. These optimal values were utilized to generate enhanced MDEFT images of *in vivo* mouse and rat brains.

Experimental

To determine biologically relevant T1 values, living C57BL6/J mice were scanned at the three field strengths using a SR multi-slice spin-echo sequence. White matter (WM) in the corpus callosum, gray matter (GM) in the cortex and CSF in the ventricles were segmented to provide a range of T1 values. Phantoms covering a range of T1s were created through the use of copper sulfate-doped deionized water. Phantoms were imaged using SR, IR and MDEFT techniques. The MDEFT and IR sequences made use of a non-segmented gradient echo that utilized adiabatic hyperbolic secant pulses during the preparation period. To assess contrast enhancement, the preparation time (t) was incremented (0.05-5 sec) for MDEFT acquisitions, the inversion time (TI; 0.05-5 sec) was incremented for IR acquisitions, and the TR was incremented (0.05-5 sec) for SR spin-echo acquisitions. Regions of Interest (ROIs) were placed in each of the sample containers. The contrast-to-noise ratio (CNR) was determined by taking the absolute difference of the SNR of different ROIs. CNR curves that represent phantom-equivalent WM, GM and CSF T1 values were generated as a function of total acquisition time. Simulations were run for comparison at all fields. To test the optimal values for (t) determined from phantom experiments, animals were imaged using the three acquisition methods at the three field strengths. SR, IR and MDEFT images were acquired over a range of acquisition times.

Results and Discussion

There is excellent agreement between the experimental and analytical results for SR, IR and MDEFT. Although the MDEFT sequence is effectively a special case of IR, one of the benefits of the MDEFT sequence may be its relative insensitivity to B1 inhomogeneities (2), which may account for the closer agreement of simulation and test results.

Conclusions

Overall, *in vivo* MDEFT images displayed superior image contrast for a wider range of structures. Future work will include (i) the incorporation of fast spin echo (FSE) imaging with MDEFT to reduce magnetic susceptibility artifacts and (ii) dynamic contrast studies. As frequencies near 1 GHz, preparations like MDEFT may be essential to maintain contrast.

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References

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