Spin-Echo Based T1-Contrast at 3T: the Problem and a Simple Solution

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INTRODUCTION

With the introduction of 3T MRI system for clinical use, a transfer of standard sequences commonly used at 1.5T is needed. To ensure proper image interpretation, similar contrast behavior and image appearance are desired for 1.5 and 3T. With increasing field strength, the relaxation times change and thus image contrast. While clinical T2-contrast can easily be achieved at 3T using TSE-sequences with slightly shorter echo times, T1-contrast in spin-echo sequences at 3T is frequently judged as being inferior to 1.5T. As a solution, an adaptation of the excitation flip angle to higher values or the use of gradient-echo or inversion recovery methods has been proposed [1]. However, these methods often do not show the same appearance and contrast enhancement of pathologies as at 1.5T [2].
The goal of this study was to examine the contrast behavior of spin-echo based methods for T1 contrast at 1.5 and at 3T and find a solution that allows the use of standard spin-echo T1 imaging at 3T with commonly known image appearance.

MATERIALS AND METHODS

Spin-echo based T1 imaging has been performed in the brain of healthy human subjects at 1.5T (Siemens Magnetom Sonata) and at 3T (Siemens Magnetom Trio) using identical pulse sequences (TR 600ms, TE 12ms, FOV 256mm, slice thickness 5mm, slice distance 10mm). The measurement was repeated with excitation flip angles varying from 30° to 150° in single-slice or multi-slice mode. The signal intensity in gray matter (GM), white matter (WM) and CSF was quantified.
T1 relaxation times in the human brain have been measured using an inversion recovery sequence with inversion times ranging from 50ms to 3s. The theoretical signal intensities for different brain tissue have been calculated from these values employing the Bloch equations.

RESULTS

T1 values for GM, WM, and CSF were 1250, 725, and 3750ms for 1.5T and 925, 1500, and 5700ms for 3T. Signal intensity simulations showed a pronounced excitation flip angle dependency of the GM to WM contrast (Fig. 1). For 3T, the highest contrast is achieved at higher excitation flip angles compared to 1.5T. The measured single slice data support these findings.
For multi slice measurements, the results are significantly different. At 3T, the maximum contrast is shifted to much smaller excitation flip angles (Fig. 2). This shift can be explained by the higher magnetization transfer (MT) effect at 3T. The MT has been quantified as the quotient of the single slice and the multi slice data. It shows a linear dependency of the square of the flip angle at 3T with strongest signal reduction in the WM, intermediate in GM and no flip angle dependency in CSF.

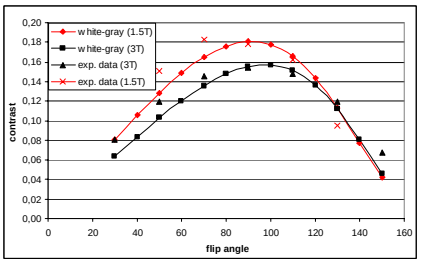

Fig. 1: theoretical and experimental contrast (single slice) between WM and GM for different flip angles

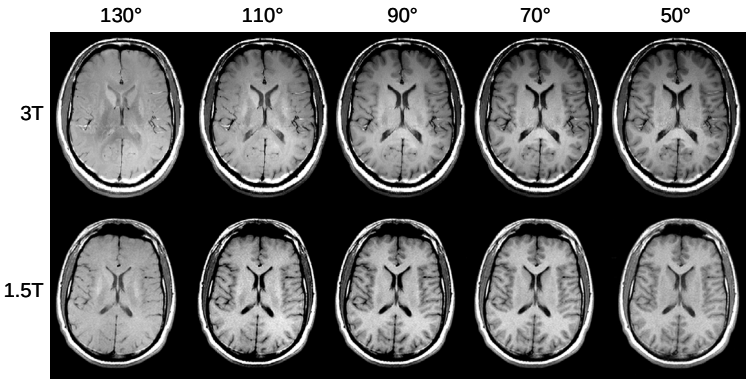

Fig. 3: multi-slice T1-images at 1.5T and 3T. The highest contrast-to-noise is achieved at 90° for 1.5T and at 70° for 3T.

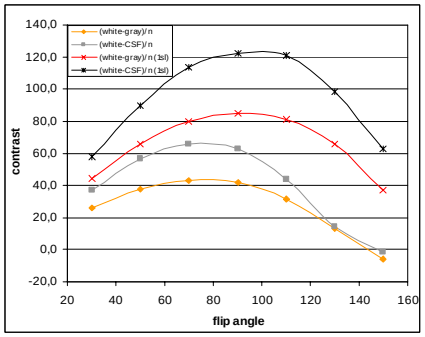

Fig. 2: measured contrast-to-noise at 3T for single slice and multi slice measurements at different flip angles

DISCUSSION

This study demonstrates that T1-weighted imaging at 3T with high signal and contrast can be performed with standard spin-echo methods. The highest contrast can be achieved with a lower excitation flip angle of about 70°. This simple modification of the sequence parameters optimizes the contrast-to-noise ratio. In addition, the small but welcome reduction in SAR often allows the measurement of a few more slices in the same measurement time. Using this method, the appearance of pathologies and contrast agent enhancement are very similar for 1.5T and 3T, allowing more consistent diagnoses.

REFERENCES

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[2] W. Schwindt et al., *Eur. Radiol.* 13: 2170-9 (2003)