Improved proton spectroscopy at 7T using localized B_1 calibration

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Introduction

At high magnetic fields of 7 T and above there is a large variation of B_1 over the subject due either to the sample-induced inhomogeneities and the frequent use of local Tx/Rx coils in the absence of a transmit body coil. Therefore, accurate tip angle calibration techniques are very important, and simple slice-selective methods which are normally used at lower field strengths can lead to suboptimal results at high field. Many different approaches already exist for tip angle mapping, based on repeated measurements with different tip angles [1], repetition times [2], or ratios between spin echoes and stimulated echoes [3, 4]. However, these are either lengthy procedures, or measure the average tip angle in a slice which is suboptimal when there is a large variation within the slice. The technique introduced in this abstract is very fast (less than 5 s), is volume selective and is integrated into the scanner software to automatically calibrate the scanner for subsequent scans. In this study, we compared the signal to noise ratio (SNR) of spectra acquired with this new technique with the standard technique available on the scanner [3]

Methods

The tip angle is determined in a volume of interest using the ratio of two stimulated echoes for a four-pulse sequence (figure 1). A 3D volume is selected using four slice selective RF pulses played out on the frequency, phase and slice axes. Two stimulated echoes (STE) are acquired while carefully spoiling all other FID and echo pathways. The ratio of these two stimulated echoes is given by:

$$\frac{STE_2}{STE_1} = \cos\beta \exp(-\tau_M/T_1)$$

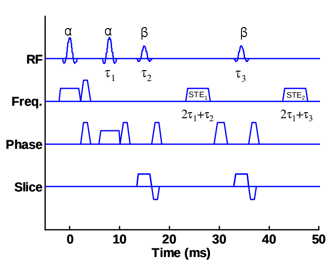
Where τ_M is the time between the last two RF pulses and β is the tip angle. Since TM<<T1 and the T1 values of different tissues are very similar for the examples considered here, the tip angle can be calculated from the selected volume. The scan was introduced before a single voxel STEAM scan on an Achieva 7T Philips MRI scanner (Philips Healthcare, Best, The Netherlands). We have tested this technique in several STEAM spectra of the calf muscle and brain. The spectra shown in this abstract were acquired in the calf muscle (n=2) using a custom-built quadrature transmit / receive coil with the following scan parameters: 10x10x10 mm^3 voxel, TR/ TM / TE = 2000 / 25 / 25 ms, 64 averages. In addition a non-water suppressed scan was acquired for SNR measurements. The results were compared with the standard technique available on the MRI scanner which measures the tip angle averaged over a slice through the voxel using the ratio of a spin echo and stimulated echo.

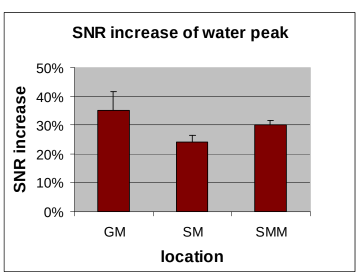
Results and Discussion

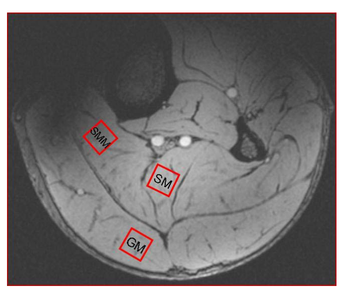
An increase in SNR of 20 - 45% (figure 2) was found in all regions in the calf muscle (figure 3). A spectrum of the soleus muscle (figure 4) shows the difference between a slice selective calibration (lower spectrum) and a volume selective calibration (upper spectrum). The spectrum acquired with the volume selective calibration clearly has a better SNR. Signal increases in the brain spectra were less pronounced, an increase of around 20% was found in inhomogeneous regions using a quadrature transmit coil and 16-channel receive array: in this case the B1 inhomogeneity is predominantly caused by the dielectric properties of the brain.

Conlcusion

This abstract shows that the inhomogeneous B_1 distribution at high field leads to suboptimal SNR. Volume selective calibration can compensate for this distribution and leads to higher SNR spectra.







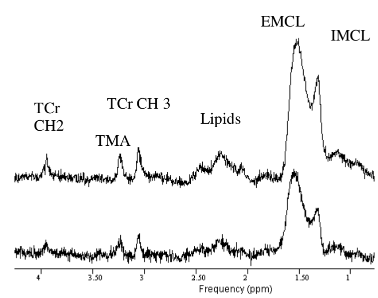


Figure 1: Schematic diagram of pulse sequence

Figure 2: SNR of volume selective optimization vs. slice selective optimization in the calf muscle. GM: gastronemicus medialis, SM: soleus muscle, SMM: more medial in the soleus muscle

Figure 3: T_1w anatomical image of the calf muscle with the boxes depicting the locations of the acquired spectra

Figure 4: Spectrum of the soleus muscle for one volunteer, top: volume selective optimization, bottom: slice selective optimization.

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