VERSE Implementation for STEAM at 7 T

O. Khorkhordin[1], F. Godenschweger[1], K. Zhong[1], and O. Speck[1]

[1]Biomedical Magnetic Resonance, Otto-von-Guericke University, Magdeburg, Germany

Introduction:

MR imaging and spectroscopy suffer from the strong RF inhomogeneity at 7 T, which can vary as much as 100% over the field of view. This additionally creates problems for MRS due to the limited available transmitter voltage. Standard spectroscopic sequences such as STEAM or PRESS require short and thus high bandwidth 90° or 180° pulses for selective volume excitation in locations with low B_1. In this study, the variable-rate selective excitation (VERSE) concept [1] was implemented in a STEAM sequence at 7 T to reduce the peak voltage requirement for the excitation pulses. The modified sequence was tested in both phantom and *in vivo* studies and the results were compared to 3 T using standard excitation pulses.

Materials and methods:

Hamming filtered sinc pulses were used for VERSE adaptation. Fig. 1A shows the pulse shapes and corresponding slice gradients before and after the VERSE modification. The reduction of the peak transmitter voltage is achieved by using higher VERSE factors (Vf), and a reduction of the peak RF voltage up to 40% can be easily achieved. The important parameters are the Vf and the relative gradient plateau length. They affect the peak voltage and the corresponding excitation bandwidth.

All studies were carried out on Siemens 3 T and 7 T scanners, using 8 channel Rx (3 T) or Tx/Rx (7 T) RF coils. Both phantom and *in vivo* data were acquired with PRESS and STEAM at 3 T. Voxel size was 20x20x20 mm^3, TR = 2500 ms, TE = 30/15 ms, TM = 10 ms, 192 averages. *In vivo* voxels were selected in the posterior-parietal lobe. Acquisition bandwidth was fixed to 7.93 ppm on both 3 and 7 T. STEAM with matched parameters and voxel locations in phantom and *in vivo* was used at 7T.

Results and Discussion:

Fig. 1B shows the signal dependency on Vf acquired in phantom. Signal increases with Vf and reaches a maximum around 1.7. This signal increase is due the factor that the pulse at low Vf does not reach the target 90° flip angle due to RF-power limitations. The signal decreases above 1.8 for Vf.

The phantom spectra from 3 T and 7 T are shown in Fig. 2. PRESS at 3 T results in twice the SNR compared to STEAM at 3 T as predicted by theory. Spectra using STEAM at 7T show comparable SNR as PRESS at 3 T (SNR ratio 0.98), and not artifacts are present in the 7 T spectra, suggesting that the VERSE adaptation for MRS at 7 T does not introduce additional noise or unwanted phase effects.

Spectra acquired *in vivo* are shown in Fig. 3. STEAM at 7 T shows an SNR advantage compared to PRESS (SNR ratio 1.10) and STEAM (SNR ratio 2.10) at 3 T. The line width is 0.03 ppm at 3 T and 0.032 ppm at 7 T. Therefore, the absolute line width scales with field strength. The short VERSE pulses of 1.2 ms duration allowed for short echo time (10 ms) for human *in vivo* studies. In addition, the glutamate and glutamine (Glx) signals around 2.3 – 2.4 ppm are greatly enhanced, allowing for better quantitation of these important metabolites. From the result of the VERSE STEAM implementation at 7 T it is foreseeable that further VERSE modifications of PRESS are feasible and should allow additional gain in SNR for standard single voxel MRS at 7 T.

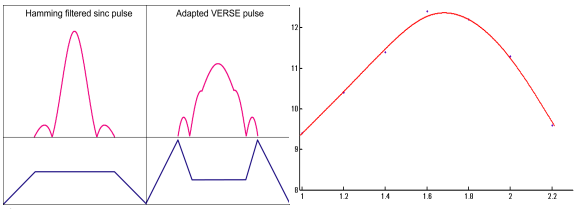

Fig. 1: A) The RF pulse and corresponding gradient shapes before and after VERSE modification. B) The signal dependency on the VERSE factor.

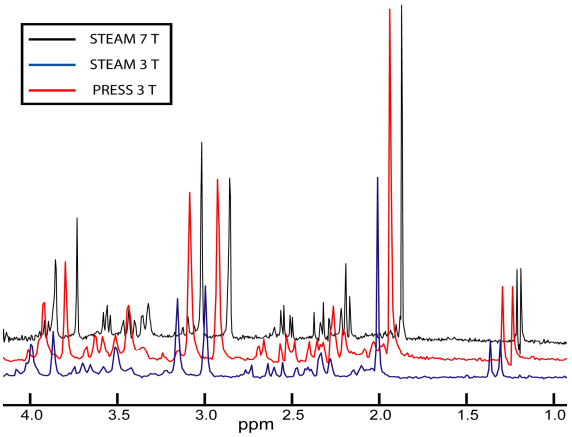

Fig. 2: Phantom spectra from 3 and 7 T. PRESS at 3 T has twice the SNR compared to STEAM at 3 T. STEAM from 7 T showed similar SNR compared to PRESS at 3 T.

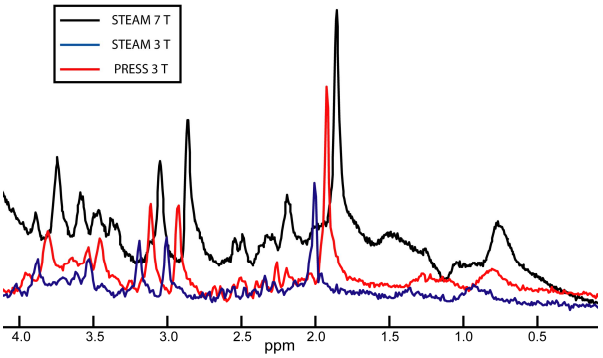

Fig. 3: In vivo spectra from the posterior-parietal lobe scaled to identical noise level. STEAM at 7 T shows higher SNR and resolution compared to PRESS at 3 T. Important metabolites, such as glutamate/glutamine can be more precisely detected.

Conclusion:

The VESRE adaptation of the STEAM sequence at 7 T showed clear improvement of the spectra compared to 3T.

Acknowledgement:

This work was supported by the BMBF INUMAC project (01EQ0605) and by Siemens.

Reference:

[1] Hargreaves *et al*. MRM 2004.