Full Signal Intensity for Short Echo Time Localized Spectroscopy on a Clinical Scanner

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Introduction Stimulated-echo acquisition mode (STEAM) (1) or point-resolved spectroscopy (PRESS) (2) have been the major methods used for localized single voxel spectroscopy (SVS). In this context, it is highly desirable to combine the best of the two "worlds": short TEs from STEAM and full signal intensity from PRESS. The advantage of short TEs on the order of ms was recently combined with a twofold increase in sensitivity using the spin echo full intensity acquired localized (SPECIAL) spectroscopy technique and applied to in vivo rat brain (3). The aim of the current study was to adapt and implement SPECIAL on a clinical 3T system.

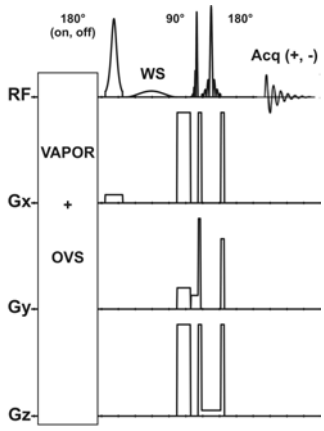

Fig. 1. SPECIAL pulse sequence. The first 180° pulse is adiabatic and is applied in alternate scans, together with alternating the phase of the receiver. WS represents an additional water saturation pulse.

Methods All scans were performed on a 3T Trio system (Siemens Medical Solutions, Erlangen, Germany) using a Tx/Rx CP head coil. SPECIAL is a hybrid pulse sequence that combines a 1D image-selected in vivo spectroscopy (ISIS) (4) approach with a slice-selective spin echo (SE) sequence. Full localization was accomplished by using an add-subtract scheme, where the signal was added in odd scans and subtracted in even scans corresponding to the application of an adiabatic inversion pulse (Fig.1). An asymmetric 90° pulse was used to reduce TE, and spoiler gradients were inserted to dephase any potential transverse magnetization. First- and second-order shims were adjusted using FASTMAP (5). Water signal suppression was achieved using VAPOR (6) plus an additional Gaussian water saturation (WS) pulse (Fig. 1). Application of outer volume saturation (OVS) pulses was included to reduce contaminating signals originating from extracranial lipid. ^{1}H spectra were acquired from the human brain using the SPECIAL sequence with TE=9 ms and NA=256 (TR=4000 ms, T_{Acq}=409 ms, and VOI=20x20x20 mm^3). For comparison, data from the same VOI were measured using the SPECIAL and the STEAM sequence (TM=10 ms) with TE=20 ms and NA=128.

Results As seen from Figs. 2(a) and (b), even when using the same TE, the modulation of J-coupled multiplets is slightly different in SPECIAL than in STEAM. However, comparison of noise levels in both spectra reveals an increase in the signal-to-noise ratio (SNR) by a factor of about 1.8 in the data measured with the SPECIAL sequence. This gain in sensitivity demonstrates the successful performance of the add-subtract scheme based on adiabatic inversion. A short TE of 9 ms was effortlessly achieved for the SPECIAL technique. Due to B_1 limitations, the pulse length of the refocusing pulse was set to 5 ms, thus currently limiting further reduction of TE. However, the spectrum acquired with the short TE exhibits reduced modulation of J-coupled multiplets and increased signal due to shortened T_2 relaxation (Fig. 2(c)). In all cases, lipid contamination was sufficiently suppressed by the application of OVS. Peaks of Glu (Glx), Ins, and Cr were clearly resolved.

Discussion The localized spectroscopy technique SPECIAL was successfully implemented on a clinical scanner. Only one refocusing pulse is used by this method, which shortens the minimum achievable TE. Due to lower RF peak power and weaker gradients, TEs achievable on a clinical system are slightly longer than those obtained with experimental animal scanners (3), as observed previously for experimental human scanners. However, employing an adiabatic 180° pulse results in a uniform inversion of the magnetization in the selected VOI, thus minimizing signal loss and reducing B_1 dependencies. The latter renders this technique specifically attractive for the application at high fields and with surface coils for Tx. In conclusion, combining the SNR advantage of PRESS with the short TE and relative B_1 insensitivity of STEAM is feasible on a clinical scanner.

References and Acknowledgements (1) J. Frahm et al., JMR, 72(3), 502-508, 1987; (2) P.A. Bottomley, Ann NY Acad Sci, 508(1), 333-348, 1987; (3) V. Mlynarik et al., MRM, 56(5), 965-970, 2006; (4) R.J. Ordidge et al., JMR, 66(2), 283-294, 1986; (5) R. Gruetter, MRM, 29(6), 804-811. 1993; (6) I. Tkac et al., MRM, 41(4), 649-656, 1999.

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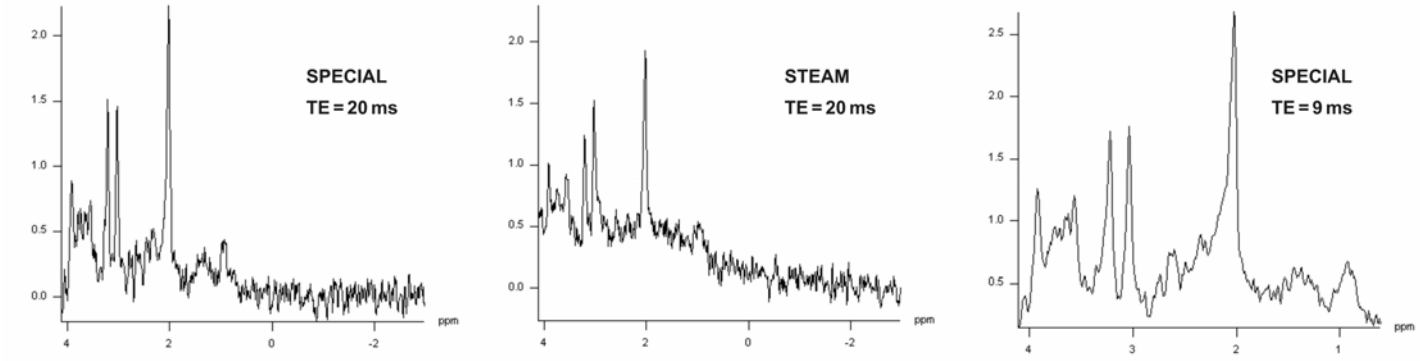

(a) **(b)** **(c)**

Fig. 2. ^{1}H spectra from parietal white matter of a human volunteer acquired at 3T using the (a) SPECIAL sequence with TE=20 ms compared to the (b) STEAM sequence with TE=20 ms; (c) SPECIAL sequence with TE=9 ms. Parts (a) and (b) are adjusted to the same noise level and show an extended x-axis. Data processing consisted of zero-filling up to 4-k data points, Gaussian weighting of the FID, Fourier transformation, and phase correction. Note the increased SNR of the data acquired with SPECIAL (b) over STEAM (c) (same TE) owed to the different localization scheme.