Considerations in applying 3-D PRESS 1-H MRSI for studies of patients with brain tumors at 3T relative to 1.5T

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Introduction

Previous studies have shown that 3-D PRESS 1-H MRSI is important for the evaluation of the spatial extent and functional characterization of primary brain tumors. Despite the increasing availability of clinical MR scanners with field strengths of 3T and the possibility of using multi-channel radiofrequency coils for data acquisition, the relative benefits of using such capabilities have not yet been adequately explored. Considerations that are expected to influence the use of such data are the increased magnitude of the chemical shift artifact at 3T and the method used to combine the signals from the phased array coils. The purpose of this study was to examine the differences in signal to noise between the volume head and 8 channel phased array coils at 1.5T and 3T and to investigate how the details of the data acquisition and post-processing influence the quality of the spectra that are obtained.

Methods

Spectral data were simulated to assess the effects of very selective saturation (VSS) bands and over-PRESS factors as described previously [1]. The spectra were created using Lorentzian peak shapes with linewidths of 2 Hz, 512 dwell points, and sweepwidth of 1000 Hz for 1.5T, and Lorentzian peak shapes with linewidths of 4Hz, 1024 dwell points, and sweepwidth of 2000 Hz for 3T spectra. Water suppression was 20:1. Choline (Cho), creatine (Cr), N-acetyl aspartate (NAA), and lactate (Lac) relative ratios were 0.5:0.5:1:0.25. VSS saturation bands were simulated as 30 and 40mm in thickness, and the over-PRESS factors considered were 1.0, 1.1, 1.2, and 1.3. Empirical data were obtained from a head phantom, two volunteers, and six patients on 1.5 and 3T GE Signa scanners (GE Healthcare Technologies). The anatomical MR images consisted of axial FLAIR and 3D SPGR images. For the studies performed with the 8 channel coil, proton density weighted GRE images were acquired using the manufacturer provided parallel imaging calibration sequence to get an estimate of the coil sensitivities. The 3D MRSI data were obtained using PRESS volume selection, VSS outer volume, and CHESS water suppression with TR/TE=1100/144 ms. The PRESS volume selection used pulses with bandwidths of 933 Hz for the 180°pulse and 2400 Hz for the 90°pulse at 1.5T and 3T. Spectral array sizes were 12x12x8 or 16x16x8 acquired with k-space sampling restricted to an elliptical region [2] with fields of view corresponding to a nominal spatial resolution of 1 cc. Phantom spectra were acquired with the head and 8 channel coils at both field strengths, with and without VSS and over-PRESS. Two volunteers were scanned with the head and 8 channel coils at 1.5T and 3T. Three of the patients were scanned at 1.5T and 3T field strengths using the 8 channel coil. The other three patients were scanned with 12x12x8 at first, and 16x16x8 spectral array sizes at a later, two month follow up scan. All the spectra were quantified as published previously [1]. The spectral arrays from each of the 8 channel coils were each analyzed individually and the signals combined using in-house software that weights the data by their coil sensitivities.

Results

Simulations showed that 40 mm VSS saturation bands and over-PRESS of 1.3 times are needed to eliminate the chemical shift artifact at 3T. Because of the concern with exciting subcutaneous lipids with this large over-PRESS factor, we used a more conservative over-PRESS factor of 1.2 for the in vivo data. Phantom data clearly showed this effect on the edges of the PRESS box. At 1.5T, the mean Cho/NAA height ratio was 0.33 versus 0.63 on the right and left (RL) edges, and 0.49 versus 0.38 on the anterior and posterior (AP) edges of the PRESS box without the VSS and over-PRESS, but were 0.40/0.52 (RL) and 0.45/0.44 (AP) when both options were used. Corresponding values at 3T were 0.35/1.61 (RL), and 0.65/0.35 (AP) compared with 0.46/0.75 (RL) and 0.55/0.45 (AP). The signal to noise ratio (SNR) from the phantom and in vivo spectra acquired with the 8 channel coil and standard head coil at 1.5 T and 3T are given in Table 1, and the SNR of metabolites from segmented normal white matter are shown in Figure 1. The 3T spectra showed high SNR and good quality as compared with 1.5T data (see Figure 2). When corrected for filtering, the estimated linewidths for Cho, Cr, and NAA at 1.5T were 4.5±1.1 Hz, 4.4±0.9 Hz and 5.2±1.2 Hz at 1.5T, and at 3T were 7.5±2.2 Hz, 6.8±1.8 Hz and 8.4±3.0 Hz (mean ± s.d.). This means that with its 2-fold higher spectral dispersion, the peak separation at 3T is still marginally better than 1.5T. The SNR of the NAA peak in the 3T spectra that were acquired with 16x16x8 phase encoding steps (acquisition time of 17 minutes) was 1.29±0.12 times higher than for the corresponding12x12x8 data (acquisition time of 8 minutes).

		8 channel coil			head coil		
		Cho	NAA	Cr	Cho	NAA	Cr
phantom	1.5T	105	234	153	78	162	108
	3T	220	428	297	136	254	183
	3T/1.5T	2.09	1.83	1.94	1.75	1.57	1.70
in vivo	1.5T	24	40	18	17	33	12
	3T	37	56	31	21	38	19
	3T/1.5T	1.55	1.42	1.69	1.20	1.16	1.55

Table 1: SNR of metabolites in 1.5T and 3T

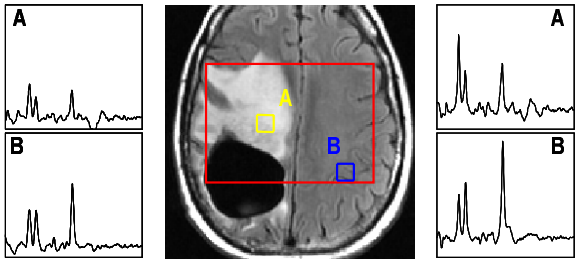

Figure 2: MRSI for a grade 4 GBM patient at 1.5T (left) and 3T (right) at the same noise scale.

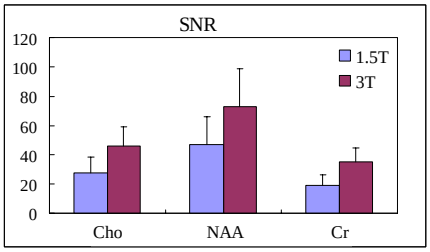

Figure 1: SNR comparison in normal white mater

Discussion

This study demonstrated that the SNR was improved at 3T relative to 1.5T as well as with the 8 channel coil relative to the head coil. The use of VSS pulses and over-PRESS significantly reduced the chemical shift artifact in both coils, but at 3T numerical corrections would still need to be applied to the edge voxels to obtain accurate Cho/NAA ratios. The SNR at 3T with the 8 channel coil was on average 1.95 times higher in the phantom but only 1.55 times higher for the in vivo data at 3T relative to 1.5T. This was attributed to known differences in relaxation time at the two different field strengths. The SNR in the 8 channel coil was higher than in the standard head coil at both 1.5T and 3T. Reconstructed spectra from the 8 channel coil using the empirical profiles were robust but required independent phase and frequency correction for each channel before being combined. This approach also gives the potential for applying parallel imaging techniques to either reduce the scan time or unfold lipid contamination. The improved SNR that is obtained at 3T with the 8 channel coil could be utilized to provide finer spatial resolution with the same acquisition time or to reduce the acquisition time to the more clinically relevant range of 5-8 minutes.

References

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