In-vivo wavelet encoding spectroscopic imaging results at 3 tesla: comparison to chemical shift imaging.

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Introduction: We present our first *in vivo* results demonstrating wavelet encoded 3D spectroscopic imaging (WE-SI) at high magnetic field (3T) compared with standard, Fourier-encoded, chemical shift imaging (CSI). As previously demonstrated with phantom results [1], we confirm a reduction in acquisition time for equivalent number of encodes as compared to CSI, with the predicted drop in SNR accounting for both the alternate encoding method and the reduction in time. The primary drawback of CSI - elevated voxel contamination - is much reduced with WE-SI [1, 2].

Method: Shaped RF pulses representing the dilated and translated prototype wavelet functions are used in a modified PRESS sequence to acquire 3D WE-SI data [1, 2]. The localization properties achieved through dilation and translation of the wavelet functions (RF pulses), enable WE-SI to excite groups of adjacent voxels sequentially without waiting a full TR time in between excitations [1,2] to reduce total acquisition time. Wavelet dilation and translation are achieved by increasing the selection gradient strength and shifting the centre frequency of the shaped RF pulses respectively. A specific pattern should be followed in order to prevent voxel interference and reduce acquisition time [1, 2]. Single and dual band RF pulses with 90° and 180° flip angles, and with profiles resembling Haar wavelet functions, are used to acquire 4x4x4, 8x8x2 and 8x8x4 3D WE-SI and CSI data on a 3T Siemens scanner. The bandwidth of the single band 180° RF pulse is set to 2 kHz and the rest are set to 2.5 kHz, with 5.2 ms duration. ADC bandwidth is set at 2 kHz, and 1K points are collected for all tests. FOV is set to 80mm x 80mm x 40 mm. Other acquisition parameters are set as: 4x4x4: TR=2000ms, TE=75ms, NEX=2; 8x8x2: TR=1500ms, TE=35ms, NEX=4; 8x8x4: TR=1500ms, TE=35ms, NEX=4.

Results/Conclusion: Comparison of WE-SI versus CSI is shown in Fig.1 for 4x4x4 encodes and in Fig.2 for 8 x 8 x 2 encodes. Signal to Noise Ratio (SNR) comparisons are shown in Table 1, with the mean SNR for the NAA peak and standard deviation over all voxels within 6 datasets from 6 different healthy volunteers, for the three encoding strategies tested (4x4x4, 8x8x2, and 8x8x4), along with the expected WE-SI SNR from theoretical calculations. The SNR is calculated as the ratio of the NAA peak intensity and the noise standard deviation. As expected, the SNR is lower in WE-SI as compared to CSI by factors of 1.5, 2.7, and 3.2, for the 4x4x4, 8x8x2, and 8x8x4 acquisitions, respectively. The experimentally measured loss in SNR is quite close to that expected from calculations (see equation 5 in Ref.2). Table 2 summarizes the reduction in total acquisition time for equal number of encodes in WE-SI compared to CSI, using a TR of 2 seconds for the 4x4x4 and TR of 1.5 seconds for the other 2 acquisitions. The metabolite ratios of NAA/Cr and Cho/Cr are summarized in Table 3, showing equivalent ratios for the two encoding strategies.
In conclusion, we demonstrate the first *in vivo* wavelet encoded 3D spectroscopic imaging results as compared to chemical shift imaging. A further reduction in acquisition time is planned by incorporating parallel imaging to the acquisition strategy [3].

Table 1: Experimental and calculated SNR values for WESI and CSI at three different resolutions.

SNR	4x4x4	8x8x2	8x8x4
CSI	18.2 ± 7.2	18.7 ± 7.2	15.7 ± 6.2
WE-SI (experiment)	12.5 ± 3.5	7.5 ± 2.3	4.9 ± 1.6
WE-SI (calculated)	11.8	6.8	4.6

Table 2: Experimental acquisition time duration.

	WESI	CSI
4x4x4	3min20sec	4min16sec
8x8x2	8min42sec	12min48sec
8x8x4	17min14sec	25min36sec

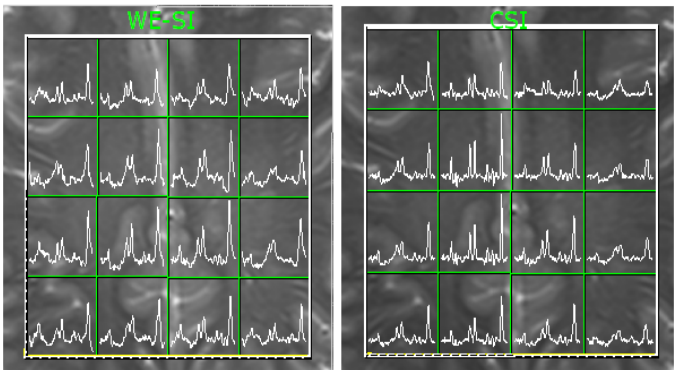

Figure 1: In vivo spectra from the second axial slice of the 4x4x4 WESI (left) and CSI (right) data.

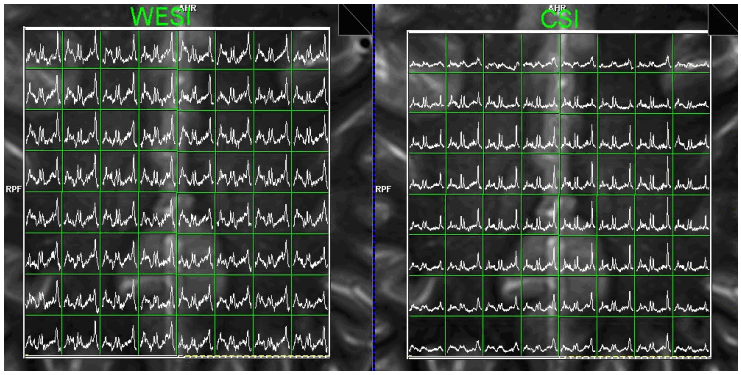

Figure 2: In vivo spectra from the back axial slice of the 8x8x2 WESI (left) and csi (right) data.

Mean ± SD		NAA/Cr	Cho/Cr
4x4x4	wesi	1.72 ± 0.45	0.27 ± 0.08
	csi	1.77 ± 0.67	0.29 ± 0.07
8x8x2	wesi	1.40 ± 050	0.29 ± 0.11
	csi	1.50 ± 0.68	0.30 ± 0.08
8x8x4	wesi	1.48 ± 0.69	0.28 ± 0.16
	csi	1.60 ± 0.68	0.28 ± 0.09

Table 3 The mean and standard deviation values of the relative concentrations of NAA/Creatine and Choline/Creatine ratios for different resolutions.

Acknowledgement: Sponsored by NSERC-Discovery Grant. RGPIN 327593-06, MHRC-311180-332200-2000.

References:

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