Faster T_1 relaxation times allow additional SNR-per-unit-time optimization in ^{31}P MRSI at 7T

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Purpose/Introduction

SNR-per-unit-time is a parameter which can be used to compare efficiency of signal acquisition at different field strengths (B_0). It has been shown that in vivo muscle ^{31}P T_1 relaxation times decrease at higher magnetic field due to higher contribution of chemical shift anisotropy (1). Shorter T_1 times allow for more efficient acquisition of signal, which is defined by the Ernst equation for given TR and T_1.

The purpose of this study was to compare SNR-per-unit-time of ^{31}P metabolites in the human calf muscle at 3T and 7T, which should be increased by both higher B_0 and shorter T_1 times.

Subjects and Methods

All data were acquired on a 3 T MR system (TIM Trio, Siemens, Erlangen, Germany) and a 7 T MR system (Magnetom, Siemens) using double-tuned surface coils (^{1}H/^{31}P). Coils for 3T and 7T were identical in geometry and built by the same manufacturer (RAPID Biomedical, Columbus, OH), with a diameter of 10 cm. The ^{31}P channel was tuned to 49.9 MHz and 120.3 MHz, respectively. For in vivo measurements (n=3) the right calf of the volunteer and during in vitro measurement a cylindrical phantom (H_2KPO_4, V=4l) were positioned on the surface coil.

Identical ^{31}P 3D k-space weighted MRSI localization sequences (FOV: 20x20x20 cm; 16x16x10 matrix; 1024 complex points; TR=1s) with an adiabatic B_1 insensitive BIR-4 excitation pulse was repeated in both scanners with identical settings. Acquisition schemes were optimized by flip angle adjustment of BIR-4 pulse (in vivo: 30° at 3T and 37° at 7T, in vitro: 65° at 3T and 63° at 7T) calculated as proposed by Bottomley (2) using respective T_1 relaxation times (1). The whole protocol including shiming and reference image acquisition took approximately 30 minutes. Data were processed offline using a MRSI software tool developed in our laboratory (3). Noise equalization was used and linewidths were calculated as full width at half maximum (FWHM) of PCr (in vivo) and Pi (in vitro). SNR was calculated after applying matched filter.

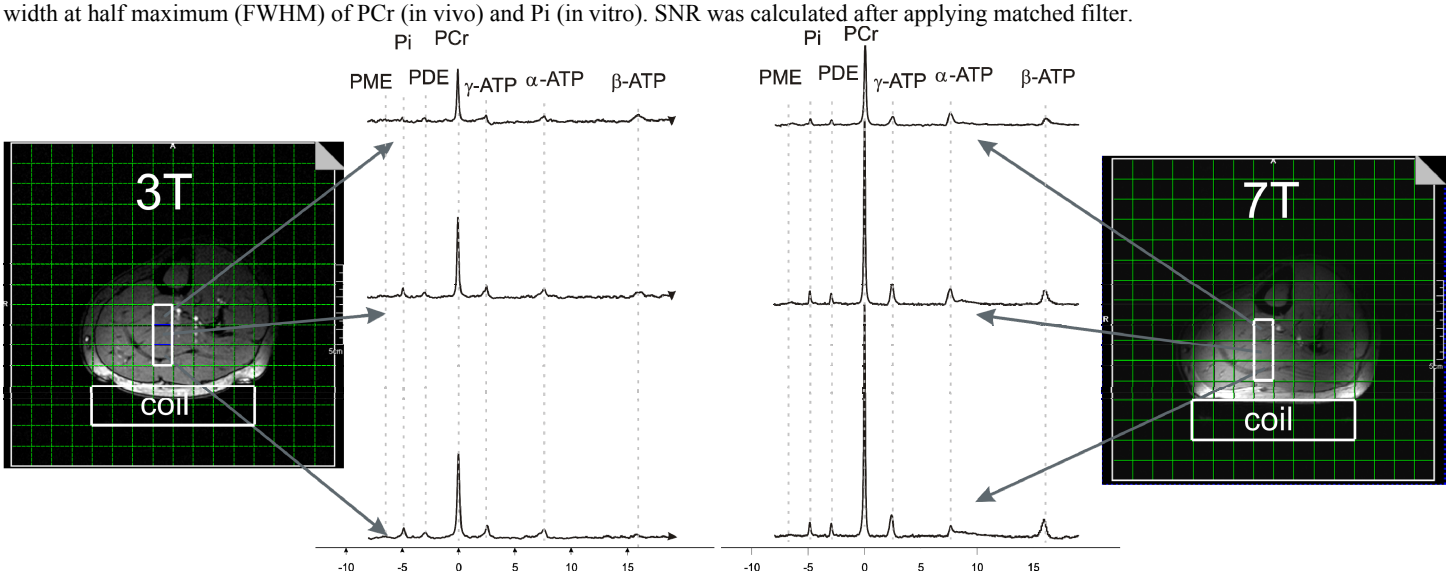

Figure 1. displays in vivo data acquired by ^{31}P 3D MRSI with optimized excitation flip angle from two B_0 magnetic fields. Spectra from corresponding locations are displayed after noise equalization and filtering by matched filter in equal scale.

	Phantom (H_2KPO_4)		PCr (volunteers=3)	
	3T	7T	3T	7T
T_1 [s]	1.18	1.36	6.7±0.4[b]	4.0±0.2[b]
FWHM [Hz][a]	3.47±0.16	4.18±0.31	6.14±0.28	9.95±0.77
$\frac{(SNR/t)^{7T}-(SNR/t)^{3T}}{(SNR/t)^{3T}}$ .100 [%][a]	(94 ± 30) %		(140 ± 27) %	

[a] result from each measurement was based on average signal calculated from region of 3x3x2 voxels
[b] T_1s data published by Bogner et al. (1)

Results

Phantom SNR-per-unit time was increased by 94% whereas in vivo PCr SNR-per-unit time was increased by 140% by higher B_0 field and additionally in muscle by higher excitation flip angle accounting for shorter T_1 relaxation.

Discussion/Conclusion

Both higher magnetic field and shorter T_1 relaxation time contribute to improvement of SNR-per-unit-time at 7T. Improved SNR-per-unit-time will allow more accurate quantification of data or can be trade off for shorter measurement time or higher spatial resolution.

References

[1] Bogner et al. MRM 2009,62:574-582
[2] Bottomley et al. MRM 1994, 32:137-41
[3] Chmelik et al. ESMRMB 2006

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