Faster T1 relaxation times allow additional SNR-per-unit-time optimization in 31P MRSI at 7T

M. Chmelík\(^1,2\), W. Bogner\(^1,2\), S. Gruber\(^1,2\), S. Trattnig\(^1,2\), and M. Krššák\(^1,2\)

\(^1\)Department of Radiology, Medical University of Vienna, Vienna, Austria, \(^2\)MR Centre of Excellence, Medical University of Vienna, Vienna, Austria

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 31P T1 relaxation times decrease at higher magnetic field due to higher contribution of chemical shift anisotropy (1). Shorter T1 times allow for more efficient acquisition of signal, which is defined by the Ernst equation for given TR and T1.

The purpose of this study was to compare SNR-per-unit-time of 31P metabolites in the human calf muscle at 3T and 7T, which should be increased by both higher \(B_0\) and shorter T1 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 (\(\text{H}^1/\text{P}31\)). 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 31P 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 (\(\text{H}_2\text{KPO}_4\), \(V=4l\)) were positioned on the surface coil.

Identical 31P 3D k-space weighted MRSI localization sequences (FOV: 20x20x20 cm; 16x16x10 matrix; 1024 complex points; TR=1s) with an adiabatic B0 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 T1 relaxation times (1). The whole protocol including shimming 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.

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 T1 relaxation.

Discussion/Conclusion
Both higher magnetic field and shorter T1 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

Acknowledgment Authors would like to acknowledge the financial support from Jubiläumsfonds of Austrian National Bank (Grant Nr. 13249)