Implementation of GOIA-Wurst(16,4) pulses in the semi-LASER sequence for SAR-reduction in prostate MRSI

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Target audience:
Researchers interested in MRSI of prostate cancer and sequence development.

Introduction:
Proton MR Spectroscopic Imaging (MRSI) can improve the detection and localization of prostate cancer [1]. An increased ratio of choline plus creatine over citrate (CC/C) is often used as a marker for tumor tissue. Selection of a Volume of Interest (VOI) is commonly done by PRESS, but insufficient slice bandwidth may cause chemical shift displacement artifacts (CSDA) resulting in fat signal contamination that may artificially raise the citrate signal, complicating detection of tumors, in particular at the margin of the prostate, where a large fraction of tumour foci reside. The semi-LASER sequence provides a more precise volume selection, has a smaller CSDA, reducing signal contamination from outside the VOI, and is less sensitive to B1 inhomogeneity's [2]. However, because it contains adiabatic refocusing pulses, its use in body applications is limited because of the high RF power deposition, exceeding the specific absorption rate (SAR) limit. In prostate applications, where repetition times (TR) can be as short as 700 ms for optimal SNR per unit time [3], the necessary increase in TR to adhere to the SAR-limit leads to impractically long acquisition times. Moreover, when using an endorectal coil (ERC), SNR of signals in the prostate increase, but the allowed maximum RF power deposition is reduced to 50% to account for potential residual coupling between body transmit coil and ERC. In this study the 4th order Hyperbolic Secant (HS) pulses normally used in the semi-LASER sequence are replaced by frequency and gradient modulated GOIA-WURST(16,4) pulses [4,5], which require much less RF power to achieve the same BW. Here we present initial results obtained with this sequence.

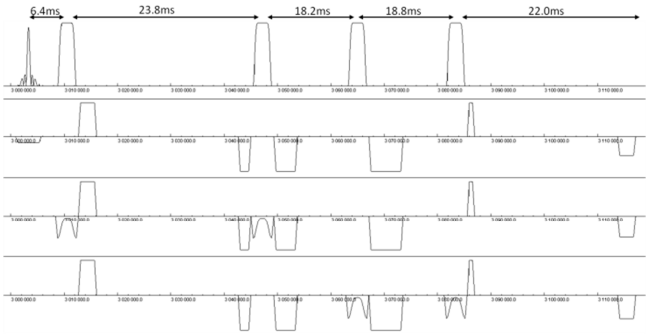

Fig.1 Semi-LASER sequence with GOIA-W(16,4) refocusing pulses. The proposed timing results in an in-phase spectral shape of citrate at 3T.

Methods:
The standard semi-LASER sequence contains a conventional slice selective excitation pulse (4ms) and two pairs of slice selective HS pulses for refocusing. The HS pulses have a duration of 6ms each, a bandwidth of 3.2kHz and require an RF power of γB_1=958Hz. The modified sequence used GOIA-WURST(16,4) pulses with a pulse duration of 3.5ms, a bandwidth of 8.5kHz, and an RF power of only 534Hz. The timing of the RF pulses was optimized for an in-phase spectral shape of the center lines of citrate [3], a strongly coupled spin system. The modified MRSI sequence (Fig.1) was tested on a prostate phantom containing choline, creatine, citrate and spermine, surrounded by sunflower oil (2D, voxel size 10×10×20mm^3, TE=89ms, 4 averages). In addition, the sequence was tested on a healthy volunteer (3D MRSI, voxel size 5.6×5.6×5.6mm^3, TE=89ms, 4 averages, TR=2000ms, TA=6min). No ERC or suppression of peristaltic motion was used. A repetition time of TR=2000ms (approximately 3×T1 of citrate) was used to counteract citrate saturation effects.

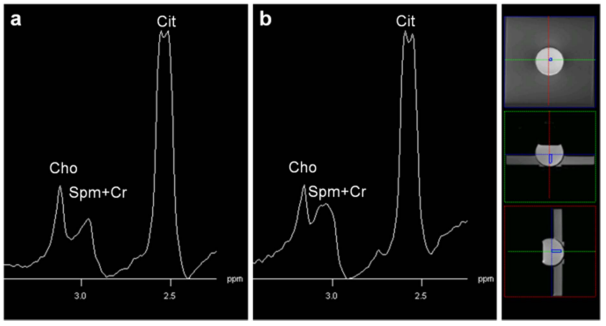

Fig.2 Spectra of the prostate phantom acquired with a 2D semi-LASER sequence with (a) HS or (b) GOIA-W(16,4) refocusing pulses.

Results:
Phantom spectra are shown in Fig. 2, acquired with a 2D semi-LASER sequence either with HS (a) or GOIA-W(16,4) (b) refocusing pulses. Both spectra show a similar spectral resolution of citrate, choline and creatine with overlapping spermine in between. An in vivo spectrum of a healthy volunteer is displayed in Fig. 3. Citrate as well as the peaks of choline, spermine and creatine are clearly visible. The GOIA pulses resulted in a RF power deposition of approximately 50% of the corresponding measurement with HS pulses.

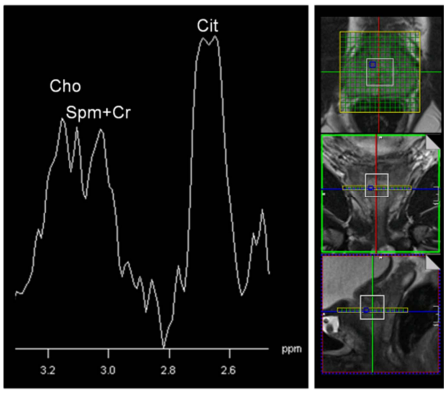

Fig.3 Spectrum from 3D MRSI data, acquired with the semi-LASER with GOIA-W(16,4) sequence, of a healthy volunteer, with body array coil only.

Discussion and Conclusion:
The increased bandwidths of the refocusing pulses of the semi-LASER sequence may help improve prostate MRSI by reducing the CSDA of the volume selection around the prostate. Using GOIA pulses can strongly reduce SAR in this sequence. In combination with the improved SNR - but reduced RF power limits - of an endorectal coil, larger scan matrices for increased spatial resolution are still feasible within clinically acceptable scan times. The GOIA-W(16,4) pulses used in this work had a higher bandwidth than the standard HS pulses (8.5kHz instead of 3.2kHz). The optimal balance between bandwidth, SAR, lipid contamination and acquisition time for a protocol suitable for clinical use is currently being investigated.

References:
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