ROBUST 3D 1H MRSI OF THE PROSTATE WITHOUT ENDORECTAL COIL AT 3T

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Target Audience: Clinicians and researchers interested in MRSI of the prostate

Introduction: Proton MR Spectroscopic Imaging (MRSI) can improve detection, localization and the determination of aggressiveness of prostate cancer [1,2]. ^{1}H MRSI of the prostate is mostly performed with PRESS volume selection [3]. Recently, it was shown that a semi-LASER sequence adapted with low power, high bandwith GOIA-WURST refocusing pulses, in combination with an endorectal coil (ERC) and shortened echo times provides well-resolved spectra with high SNR and little lipid contamination [4]. Since the positioning of an ERC is time consuming and uncomfortable for patients, hospitals increasingly prefer to perform prostate MR without an ERC. Therefore it becomes very relevant that good MRSI data of the prostate can be obtained without this coil. The purpose of this study is to test if high quality ^{1}H MRSI data of the prostate can be acquired with the GOIA-sLASER pulse sequence in patient examinations without an ERC.

Methods: MR was performed on a 3T MR system (MAGNETOM Skyra Siemens Healthcare, Erlangen, Germany) with a 32 channel body coil for signal reception. Seven patients, suspicious of prostate cancer (PCa), received Buscopan to reduce peristalsis and underwent a multi-parametric MRI exam. As these measurements involved a cancer detection protocol, whole mount validation of PCa presence was not routinely performed in these patients. For MRSI a non-product sLASER sequence with GOIA-Wurst (16,4) refocusing pulses was used [4]. All measurements were performed with TE=88ms, variable TR (SAR limited) and matrix size (see table), 3 averages and weighted phase encoding, resulting in measurement times between 4:50 and 8:44 min. Nominal voxel size was 6x6x6 mm^3 for one patient, and 7x7x7 mm^3 for the others (after apodization corresponding to spherical voxels of 0.64 and 1.01 cc, respectively). MR spectra were fitted with LCModel using a basisset of simulated metabolite signal shapes of citrate (Cit), creatine (Cr), spermine (Spm), choline (Cho) and myo-inositol (mI) [5].

Results: Magnitude shim values for the selected volumes around the prostate were 21-33 Hz. Without ERC the GOIA-sLASER sequence produced MR spectra with little lipid contamination and resonances for Cit, Cr, Spm, Cho and mI, as shown in the Fig.(a) for 2 MRSI voxels with the LCModel fit in Fig (b). From the Cit signal a metabolic map was reconstructed showing a variable distribution of this compound over the prostate (Fig. (c))
To quantify the performance of the sequence we determined the voxel fraction of high quality signals (CRLB <30%) in 6x6 voxels in 3 transversal slices through the prostate (108 voxels/patient). For Cit, this fraction was >90% in all patient measurements (Table). For the other metabolites the fraction of reliably quantifiable voxels was more variable. e.g. for Cho, the most important other metabolite in PCa detection, it was between 38 and 77% (Table). The best overall results were obtained in the patient measured with longest TA (8:44 min, see Table). In the exam with nominal voxels of 6x6x6 mm^3 the fraction of good Cho signals was least (Table).

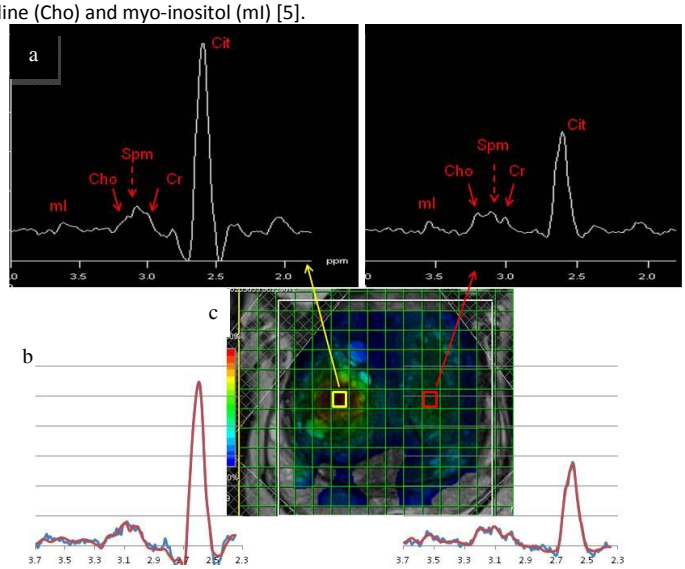

Figure. a) 3D MRSI spectra, acquired with the sLASER sequence with GOIA pulses, of a detection patient examination with body array coil only. The measurement time was 8:44. b) LCModel fitting for the two spectra . Fit is shown in red. c) Citrate map

Discussion: The GOIA-sLASER sequence without an ERC shows excellent performance as reflected by small lipid contamination, almost 100% voxel detection of Cit, which is due to its high SNR (favorable modulation of citrate spins with this sequence and TE [4]), and distinguishable signals for Cho, Spm, Cr and mI.
To detect PCa at least also the Cho signal is needed to calculate a relevant metabolite ratio. The current measurements indicate that voxels of 1.01 cm^3 with a TR of at least 900ms or an acquisition time of about 9 min are required for proper detection of Cho in the majority of voxels (at shorter TR there is more saturation of the Cho signal). This is comparable to GOIA-sLASER measurements with ERC, but with voxels of 0.64cm^3 (4). Shorter examination times down to about 5 min still may be of value in tumor detection, as the Cho signal is expected to increase. Compared to an endorectal coil, the phased array has the advantage of a more homogenous reception profile, enabling the reconstruction of single metabolite maps.
In conclusion, the GOIA-sLASER sequence allows robust ^{1}H MRSI examinations of the prostate in patients *without* an endorectal coil in a time acceptable for widespread clinical implementation.

	TR	Shim	Matrix Size	TA	Cho	Cit	Cre	Spm
1	740	21	14x10x12	8:11	15%	100%	87%	47%
2	630	22	12x14x11	8:44	69%	100%	92%	72%
3	630	21	12x10x10	4:50	59%	92%	50%	23%
4	630	25	12x10x10	4:50	38%	100%	67%	67%
5	820	22	12x10x10	6:45	77%	100%	80%	83%
6	900	28	12x10x10	6:55	76%	100%	73%	28%
7	900	33	12x10x10	6:55	48%	100%	68%	43%

Table. Percentages of voxels in which the fit of the metabolite signals of Cit, Cho, Cr, Spm reached a CRLB <30 %. The central 6x6 voxels of three slices within the prostate of the patients were taken for this analysis (voxel size for patient one is 6x6x6 mm^3 and7x7x7 mm^3 for the others)

References: [1] T.Scheenen et al., Invest. Radiol 2011;46(1):25-33; [2] Kobus et al. NMR Biomed 2104;27:39–52 [3] T.Scheenen et al., MRM 2005;53:1268–1274; [4] Steinseifer et al., Magn Reson Med 2014; [Epub ahead of print] [5] Provencher et al., Magn Reson Med 1993;30

Acknowledgments: This project received funding from the European Union's Seventh Program for research, Technological Development and Demonstration under Grant Agreement No ITN-GA-2013-316679 and ERC Grant agreement n° [243115].