Fast ^{1}H-MRSI of the prostate with GOIA-sLASER localization and spiral acquisition

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Introduction

Proton MR Spectroscopic Imaging (MRSI) can improve the detection and localization of prostate cancer (PCa)[1]. An increased ratio of choline plus creatine over citrate (CC/C) serves as a biomarker to discriminate cancerous from non-cancerous tissue. However, low signal to noise ratio (SNR) and long acquisition times limit the clinical use of prostate MRSI. The SNR can be improved substantially by using an endorectal receive coil (ERC) and shortening the echo time (TE). Reducing TE leads to increased lipid contamination, which can be reduced using high bandwidth volume selection pulses, e.g. using adiabatic sequences such as semi-LASER[2]. However, the high specific absorption rate (SAR) of such sequences leads to long acquisition times. Frequency and gradient modulated GOIA refocusing pulses can strongly reduce SAR in semi-LASER acquisitions while retaining a high bandwidth[3,4]. Aside from SAR constraints, Cartesian k-space sampling requires long acquisition times and is inflexible if the field of view (FOV) needs to be adapted to cover large prostates. Both problems can be alleviated by spiral k-space acquisition[5], as long as SNR is sufficient.

The *aim* of this study was to modify a semi-LASER MRSI sequence with low RF power demanding GOIA-WURST pulses and spiral k-space acquisition and to demonstrate its feasibility for human prostate applications in combination with an endorectal coil.

Methods

We implemented a semi-LASER sequence with low power demanding adiabatic GOIA-Wurst(16,4) refocusing pulses and spiral acquisition for fast k-space sampling. The GOIA pulses had a duration of 3.5ms, a 10kHz bandwidth and an RF power of about 500Hz, depending on the VOI size. Water and lipid signals were suppressed by frequency selective MEGA pulses [6] and by outer volume suppression bands placed around the prostate. For in-plane k-space sampling we used a constant density spiral trajectory (6 angular and 2 temporal interleaves, 1200Hz bandwidth), the third spatial dimension was sampled by phase encoding.

In vivo measurements of five patients with suspicion of prostate cancer were performed on a 3T scanner (Magnetom TRIO, Siemens Healthcare, Erlangen, Germany). A rigid, double channel endorectal coil (Hologic, Inc., Bedford, USA) was used for signal reception. Butylscopolamine was used to reduce peristaltic motion. T2 weighted turbo spin echo images in the transverse plane were used as background images (FOV=178×180mm^2, slice=3mm, TR/TE=5070/99ms, TA=2:32min).

Parameters for the GOIA-sLASER-spiral sequence were: FOV=80×80×60mm^3, VOI=50×56×44mm^3, matrix=16×16×12, nominal voxel size=0.125cc, 100% Hamming filtering, resulting real voxel size=0.37cc, TR /TE=1000/90ms, 2 averages and a resulting measurement time TA=4:52min.

Conventional PRESS measurements were performed for comparison: FOV=70×60×60mm^3, VOI=50×56×44mm^3, matrix=14×12×12, nominal voxel size=0.125cc, 100% Hamming filtering, resulting real voxel size=0.37cc, TR/TE=750/145ms, 2 averages, weighted Cartesian k-space sampling and a resulting TA=8:44min.

Results

The echo time of the GOIA-sLASER-spiral sequence was optimized for an absorptive shape of the central lines of citrate, a strongly coupled spin system. An optimal TE was found at 90ms instead of 145ms for the PRESS, due to additional 180° pulses. Spectral maps of prostate MRSI by the GOIA-sLASER–spiral sequence show that spectra with relevant metabolic information can be obtained from the complete prostate (Fig 1b), similar to that obtained by a PRESS sequence (Fig 1a), even though the TA is < 5 min. The spectral shapes differ due to the different RF pulses and timings, but all spectra show a comparable separation of choline (Cho), spermine (Spm), creatine (Cr) and citrate (Cit) (Fig 1c – f). At the shorter TE in the GOIA-sLASER-spiral additional signals, e.g. myo-inositol (mI), became more obvious (Fig 1g+f). Due to the coil profile, SNR drops in the ventral parts of the prostate, but is still high enough to separate the metabolites. Similar quality spectra were obtained in all patients, showing that metabolic data can be acquired reproducibly with this sequence.

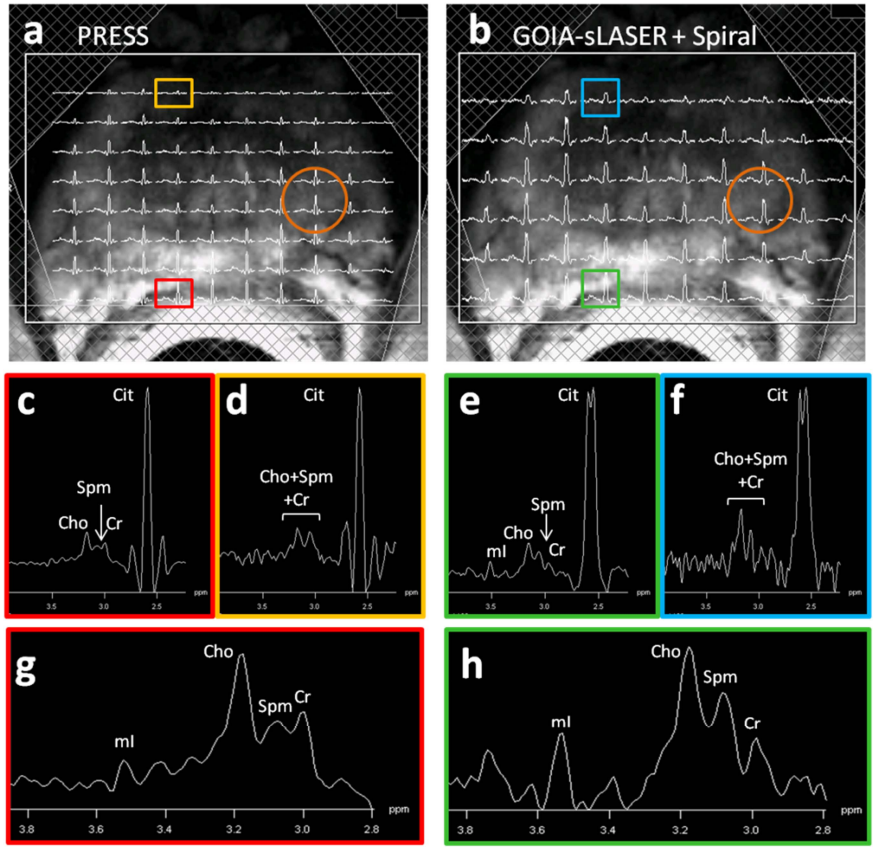

Figure 1 Spectral maps of *in vivo* prostate MRSI obtained with (**a**) conventional PRESS (TE=145ms) and (**b**) GOIA-sLASER with spiral acquisition (TE=88ms). Spectra close and distant to the ERC are shown for PRESS (**c, d**) and GOIA-sLASER-Spiral (**e, f**), respectively. Spectra close to the ERC (**c, e**) are zoomed in on a range from 2.8ppm to 3.8ppm (**g, h**). Due to interpolation to a 16×16×16 matrix, voxel sizes appear to be different, but both MRSI were acquired with nominal voxel sizes of 0.125cc. The real voxel sizes of 0.37cc, enlarged due to Hamming filtering, are illustrated by the circles.

Discussion

We demonstrated that *in vivo* prostate MRSI with a GOIA-sLASER-spiral sequence is feasible and can be applied robustly. Because of its use of adiabatic pulses this new sequence strongly reduces chemical shift displacement, resulting in a better volume selection and less fat contamination, which limits conventional PRESS acquisition at lower TEs. The GOIA pulses have lower RF power deposition compared to non-gradient modulated adiabatic refocusing pulses, reducing SAR and therefore enabling short TR acquisitions. The shorter TE provides less dispersive components in the citrate peak shape and also enables the detection of myo-inositol. The increase in SNR due to the ERC allows the combination with spiral acquisition, permitting shorter acquisition times and reducing the chances of motion artifacts.

Conclusion

The GOIA-sLASER-spiral sequence in combination with the ERC enables high quality prostate MRSI within a measurement time of 4:52min and a voxel size of 0.37cc. This will facilitate more routine acquisition of metabolic data for clinical purposes.

References

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