A new method for optimum MRSI of prostate at 3T using adiabatic RF pulses and internal water referencing

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Introduction

Proton MR spectroscopic imaging of the prostate has shown clinical potential as an increased ratio between detectable choline plus creatine over citrate levels correlates with the presence of prostate cancer tissue [1-3]. The inherent increase in SNR at higher magnetic field strengths could possibly be used to increase the spatial resolution of the MRSI experiment. The increase in field strength however comes at the expense of higher susceptibility artefacts, which affect the shim quality. This poor shim quality can cause frequency shifts and phase differences between MRSI voxels, which can lead to misinterpretation of MRS resonances obtained from for instance lipids. Prior knowledge of the local frequency offset, line width and phase can improve the fit quality. As citrate and choline can have low SNR, prior knowledge should be obtained from other signals with high SNR, like unsuppressed water. In order to obtain the water signal within the same MRSI sequence, the chemical shift artefact has to be addressed, as the chemical shift difference between the detected metabolites of interest increases from 0.6ppm (choline to citrate 3.2-2.6) to 2.1ppm (water to citrate 4.7-2.6). In this work we used a semi LASER sequence [4] optimized for minimal chemical shift displacement errors, time delays tuned to optimum citrate detection, and MEGA [5] lipid suppression at 3T. Compared to an optimized PRESS sequence [6] without water referencing, the semi LASER sequence enables detection of choline, citrate and water at a lower chemical shift displacement error and with a better citrate line shape.

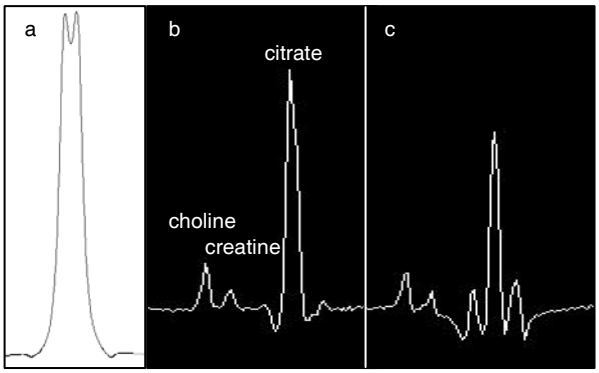

Fig. 2: Simulated (a) and measured (b,c) lineshapes of citrate using the semi LASER sequence (a,b) or an optimized PRESS sequence (c).

Methods

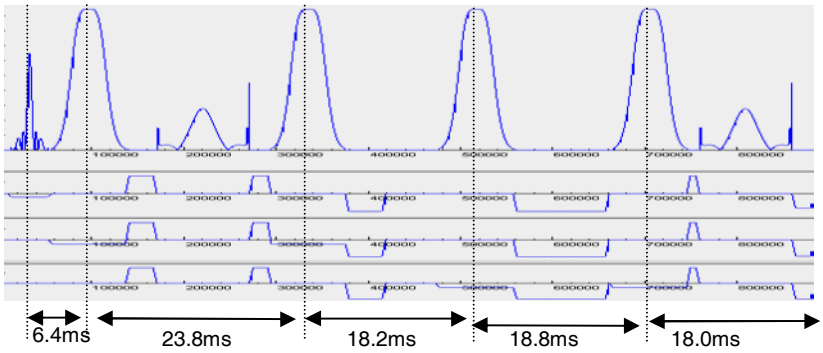

Fig. 1: Diagram of MRSI pulse sequence using adiabatic slice selective refocusing pulses and MEGA lipid suppression optimized for citrate signal detection.

The semi LASER sequence consists of a slice selective 90-degree pulse (4ms) followed by two couples of adiabatic refocusing pulses (each 8ms). The time delays between the pulses are tuned to optimum citrate resonance using a freeware quantum mechanical simulation package (Qsim [7]). The bandwidth of the adiabatic refocusing pulses are calculated using the Bloch equations to determine the chemical shift artefact. A MEGA lipid suppression is integrated in the sequence using a Shinar le Roux optimized chemical shift selective RF pulse of 10ms. The total MRSI sequence (figure 1) is tested in phantoms and validated in several patients, using either an external body array coil or an endorectal coil.

Results

The quantum mechanical result of the citrate resonance shape using optimized timing of the semi LASER sequence at an echo time of 85 ms is shown in Fig 2a. Phantom results show a similar lineshape (Fig 2b), which is different than the lineshape obtained with an optimized PRESS sequence at an echo time of 145 ms (Fig 2c). The slice profile of the refocusing pulses have a bandwidth of 3200Hz, leading to a chemical shift artefact of +/-4% (Fig 3). 3D MRSI measurements in patients obtained with the optimized semi LASER sequence show unsuppressed water signals next to choline, poli-amines and citrate.

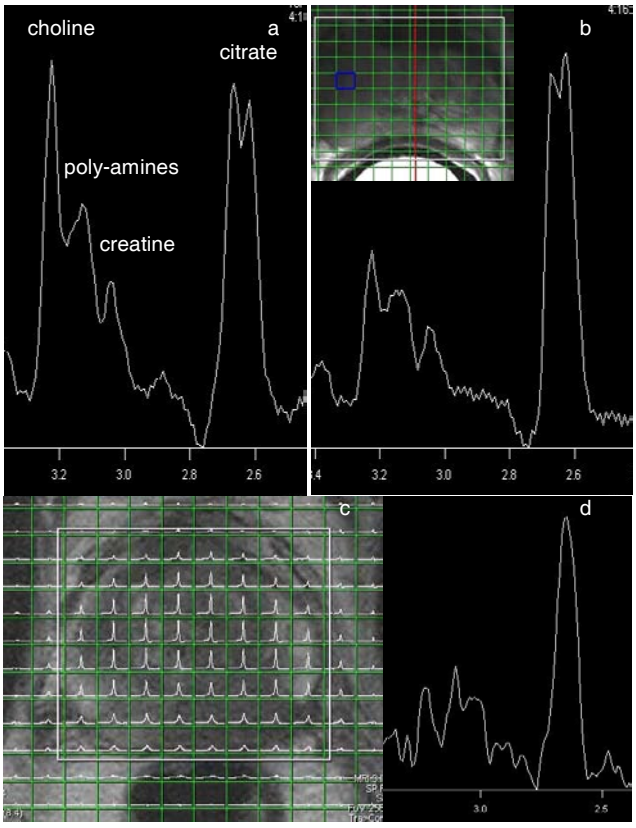

Fig. 3: MRSI results of the prostate of patients using an endorectal coil (a,b) or external body array coil (c,d). Next to the signal of water (c), the resonances of citrate, creatine, choline and poly-amines can be detected with a minimal chemical shift artifact.

Conclusion and discussion

These preliminary results indicate that a semi LASER sequence can be used to obtain 3D MRSI data from prostate in vivo with minimal chemical shift artefact. As a consequence of more refocusing pulses compared to a PRESS sequence, the line shape of citrate can be adjusted with more timing variables, which improves the spectral shape. The clinical potential of using water as an internal reference for prior knowledge of frequency, phase and linewidth for fitting of choline and citrate in the improvement of sensitivity is subject to further investigation.

References

1. Kurhanewicz J *et al.* Radiology 1996;198:795-805. 2. Kurhanewicz J *et al.* Urology 1995;45:459-466. 3. Heerschap A *et al.* Anticancer Res 1997;17:1455-1460. 4. Wijnen J *et al.* ESMRMB annual meeting 2006; 210. 5. Mescher M *et al.* J Magn Resonan A 1996; 123:226-229. 6. Scheenen TWJ *et al.* Magn Reson Med 2005;53:1268-1274. 7. Helgstrand M et al. J Biomol NMR. 2004;30(1):71-80.