31P Spectroscopic Imaging with GRAPPA

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Introduction

Applying 31P magnetic resonance spectroscopic imaging (MRSI) for the assessment of changes in liver metabolism may provide additional information for the diagnosis and treatment monitoring of various liver diseases [1]. However, due to the low abundance of 31P nuclei in tissue, resulting in lower sensitivity compared to protons, acquisition parameters in 31P MRSI are ruled either by large voxel sizes or abundant averaging. 3D MRSI is a possibility to achieve a reasonable amount of signal to noise (SNR) without the need of averaging, which usually comes at the cost of long scan times. Applying fast MRSI techniques to 31P MRSI is challenging due to the short T2 relaxation times of 31P metabolites and the necessity to sample a large bandwidth. However approaches combining echoplanar sampling with 31P MRSI have been successfully demonstrated [2]. Parallel imaging techniques are another attractive approach and have proven successful for acceleration of 1H MRSI [3,4]. However, this approach has not been easily possible so far, due to limited availability of 31P coils with multiple receiver channels. In this work we investigate the feasibility of using GRAPPA [5] to accelerate and reconstruct 31P MRSI acquisitions in a phantom using a novel 8-channel phased-array dual-tuned 31P/H coil.

Methods

Coil & phantom design: Phantom data were acquired on a Siemens 3T TIM Trio whole body system scanner (Siemens Healthcare, Erlangen, Germany). A novel dual tuned 8-channel 31P/H coil, designed for liver, was used for 31P MRSI. The coil array consists of two plates (30x30cm) each with four receiver (RX) 31P elements of about 24x20 cm with filters for proton decoupling, one 31P transmit (TX) element of about 30x30cm, and one 1H TX-RX element of about 27x25 cm (STARK CONTRAST MRI Coils Research) (Fig.1). A 10 L plastic carboy (20x15x30 cm³) filled with a 100 mM potassium phosphate (Pi) solution and containing two plastic spheres filled a) with 100 mM methylphosphonic acid (MPA) plus 300 mM Pi and b) with 500 mM MPA plus 200 mM Pi, served as phantom for this feasibility study.

Sequence: A slice selective axial FID MRSI sequence with 24x24 spatial encodings, slice thickness = 25 mm, TE/TR = 2.3ms/1500 ms, bandwidth = 4000 MHz, and 1024 spectral points was used to acquire data from a 400 x 400 mm FOV with one average. To evaluate the potential parallel imaging capabilities of the coil, synthetic data sets were generated by sub-sampling the fully acquired data. A central calibration region of 12x12 was retained for computing coil weights with a 4x3 kernel. In this case acceleration factors of Rx x Ry = 2 x 1 and 2 x 2 were investigated and compared to the fully sampled case (Rx x Ry = 1 x 1). The deleted points in the synthetic data were then reconstructed using the GRAPPA kernel. The GRAPPA-reconstructed spectra from each coil were first phase-corrected relative to one reference coil and then combined using vector summation. Metabolite maps were generated by integrating over the two peaks Pi and MPA.

Results

Metabolite maps of Pi and MPA for the axial slice depicted in the 1H survey image are shown in Fig.2 for varying values of acceleration factors. The reconstructed spectra from the outlined voxel are shown adjacent to the corresponding metabolite maps. As can be seen, the spectral signal to noise ratio (SNR) decreases with increasing acceleration factor as predicted and the MPA maps show minimal aliasing artifacts. However, the metabolite images and spectra reconstructed from undersampled data are of similar quality as the ones reconstructed from fully acquired data.

Discussion

GRAPPA is particularly attractive for 31P MRSI since it obviates the need for separate sensitivity maps, which can not easily be provided for 31P coils. However, SNR will remain problematic. Work in progress includes the reconstruction of a 3D dataset undersampled in two dimensions, as 3D MRSI will probably be the only sequence allowing for the necessary SNR in vivo within a single average to be able to benefit from parallel imaging.

Conclusion

In conclusion, metabolic imaging with 31P can in principle be combined with parallel imaging.

References:
