31P Spectroscopic Imaging with GRAPPA

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Introduction

Applying ^{31}P 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 ^{31}P nuclei in tissue, resulting in lower sensitivity compared to protons, acquisition parameters in ^{31}P 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 ^{31}P MRSI is challenging due to the short T2 relaxation times of ^{31}P metabolites and the necessity to sample a large bandwidth. However approaches combining echoplanar sampling with ^{31}P MRSI have been successfully demonstrated [2]. Parallel imaging techniques are another attractive approach and have proven successful for acceleration of ^{1}H MRSI [3,4]. However, this approach has not been easily possible so far, due to limited availability of ^{31}P coils with multiple receiver channels. In this work we investigate the feasibility of using GRAPPA [5] to accelerate and reconstruct ^{31}P MRSI acquisitions in a phantom using a novel 8-channel phased-array dual-tuned ^{31}P/^{1}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 ^{31}P/^{1}H coil, designed for liver, was used for ^{31}P MRSI. The coil array consists of two plates (30x30cm) each with four receiver (RX) ^{31}P elements of about 24x20 cm with filters for proton decoupling, one ^{31}P transmit (TX) element of about 30x30cm, and one ^{1}H TX-RX element of about 27x25 cm (STARK CONTRAST MRI Coils Research) (Fig.1).

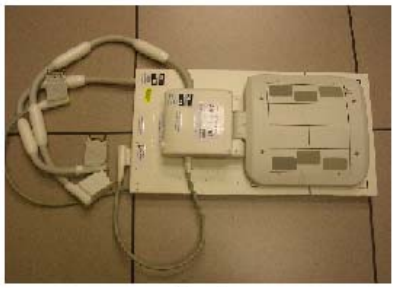

Fig.1: 8-channel phased-array dual-tuned ^{31}P/^{1}H coil for ^{31}P MRS with proton decoupling and ^{1}H MRI.

A 10 L plastic carboy (20x15x30 cm^3) 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^2 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 R_x x R_y= 2 x 1 and 2 x 2 were investigated and compared to the fully sampled case (R_x x R_y= 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.

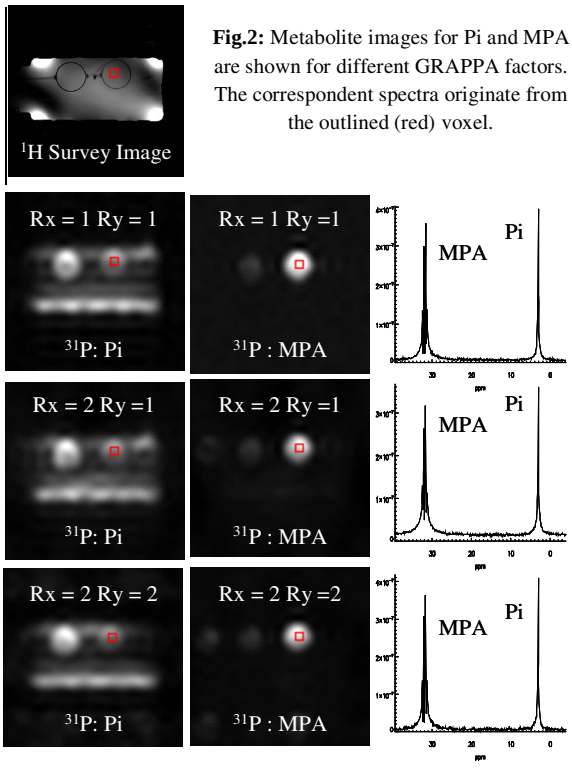

Fig.2: Metabolite images for Pi and MPA are shown for different GRAPPA factors. The correspondent spectra originate from the outlined (red) voxel.

Results

Metabolite maps of Pi and MPA for the axial slice depicted in the ^{1}H 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 ^{31}P MRSI since it obviates the need for separate sensitivity maps, which can not easily be provided for ^{31}P 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 ^{31}P can in principle be combined with parallel imaging.

References

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