Simultaneous two-channel mice brain chemical shift imaging using a 'standard' Biospec spectrometer

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Introduction

The advantages of array coil imaging on clinical MR systems have gained relevance in many applications. In the field of small animal, the interest for this concept is growing. Array-coil imaging is an advanced method to enhance SNR using superior sensitivity of several small coil elements compared for example to a larger single element covering the same FOV [1,2]. Another benefit of phased-array technique is the possibility to use parallel imaging techniques such as SENSE and GRAPPA to increase acquisition speed [3,4]. However, high field MR experimental systems with multiple receiver channels are still rare and the upgrade of existing systems is relatively expensive. In this work, reconfiguration of a "standard" 4.7T Bruker Biospec Avance II spectrometer with two broadband chains, one usually dedicated to proton (1H), one dedicated to nuclei X (with X=31P, …) was realized to allow two-channel 1H acquisitions. Advantages of this feature were used to perform *in vivo* spectroscopic acquisitions on mouse brain.

Material and Methods

The experiments were performed on a Bruker 4.7T Biospec system (Bruker, Ettlingen, Germany). The routing which defines the connections between the hardware parts involved in the acquisition pipeline was modified to allow the acquisition of two channels simultaneously [5]. Briefly, the excitation was performed using the X-nucleus amplifier, which is a broadband amplifier, and the reception was made with the standard ^{1}H-nucleus chain together with the X-nucleus chain which however was interconnected with a second proton preamplifier. The methods (RARE, PRESS, CSI) including the pulse programs were modified to activate the second receiver channel. A home-designed two-channel phased array coil for reception was interfaced with the "decoupling box" accordingly. The two-channel array coil operating at 200.3 MHz consists in two rectangular loops decoupled using the shared inductor decoupling method. *In vivo* experiments were performed on mouse brain. The ethical guidelines for experimental investigations with animals were followed. Gaseous anesthesia was performed on mice placed in prone position. The home-designed phased-array coil was placed on top of the skull. For brain imaging an axial T2-weighted fat suppressed (FS) RARE sequence was used with the following parameters: TR/TE = 4000/75 ms; RARE factor = 8; 30 x 30 mm^2 FOV, 256 x 192 matrix, 19 slices, 1 mm slice thickness and 17 kHz receiver bandwidth. Spectroscopic acquisitions were performed using a short–echo time PRESS sequence (TR/TE=5000/20ms, Tacq = 21 min, 4096 data-points, bandwidth of 4 kHz). The volume of interest (2.5 x 2 x2 mm^3) was centered in the right hippocampus. For chemical shifting imaging the following parameters were used TR/TE=1200/50 ms; 28 x 28 x2 mm^3 FOV, 15x15 in-plane CSI matrix, 1024 data-points, bandwidth of 4 kHz, Tacq = 45 min. Signal from the outer volume was suppressed by many blocks of saturation pulses interleaved in the water suppression pulses (VAPOR). The positioning of the spatial saturation bands is an important issue to avoid fat contamination (Fig. 1). First- and second-order shim terms were adjusted using FASTMAP. The Spectroscopy data from the two channels were combined using Matlab 7.4 (Mathworks Inc, Natick, MA, USA) in the time-domain using a sum of squares weighting function. Prior to the combination, the signals from the two channels were zero-order phase corrected. The coil intensity weighting factors, for each coil were obtained from the mean value of the four first absolute time-domain data point of the corresponding unsuppressed-water signal. The signal-to-noise ratio (SNR) was measured in different regions of interest on images and was determined relative to the NAA singlet amplitude for the spectroscopy.

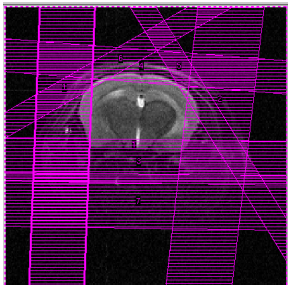
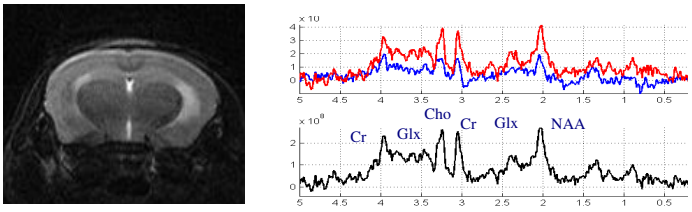


Fig. 1. Spatial saturation bands positioning around the brain to remove fat contamination of the CSI data.

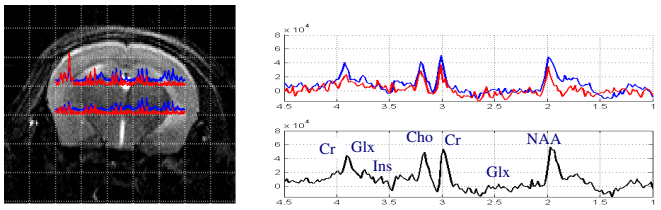
Results

T2-weighted image and a PRESS spectra acquired with the two-channel phased-array-coil are showed in Fig. 2. The mean SNR measured on T2-weighted images in the mouse brain was 32.1±4.0 for combined channels (27.3±3.1 and 25.8±3.2 for the first and second elements respectively). This represents a 20% SNR improvement compared to our 15 mm reference surface coil. The signal uniformity was also improved with reduced standard deviations. Independently of the coil element connected, SNR measured on the X-channel was 5 to 10% higher compared to the H-channel. Magnetic field homogeneities derived from PRESS spectra was comparable with usual experimental conditions with a full width half maximum (FWHM) of the NAA singlet of 13 Hz (ranging 12 to 15 Hz). The CSI spectra are shown in Fig. 2. The resonances of NAA, Cr, Cho, Glx are well detected. At TE=50ms, the contamination of the spectra by the macromolecules is reduced. Both channels are equivalents with a mean SNR of 3.1 for NAA, or 2.9 for Cr for each channel and with a combined value of 3.7 for NAA or 3.5 for Cr.



a b

Fig. 2. Acquisitions performed with the home-designed phased array coil: (a) T2-weighted mouse brain image with neurological disorders; (b) Spectra acquired using the short-echo time PRESS sequence on the mouse brain before (top) and after (bottom) the combination. Numbers of metabolites are detected including NAA, Cr, Cho, Glx, Tau, Ins. At TE=20ms, the contamination of the spectra by the macromolecules is clearly visible.



a b

Fig. 3. The CSI spectra showed on a zoomed image of the mouse brain (a). For a voxel, the spectra are shown before (top) and after (bottom) the combination of the two channels (b). The resonances of NAA, Cr, Cho, Glx are well resolved. At TE=50ms, the contamination of the spectra by the macromolecules is reduced.

Conclusion

Simultaneous two-channel PRESS and CSI acquisitions were demonstrated after reconfiguration of a standard 4.7T Biospec spectrometer. Further steps will be to implement parallel acquisition techniques together with k-space weighted CSI spin-echo sequence in order to improve SNR for a given scan time.

References

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