Parallel 2D and 3D spectroscopic imaging using GRAPPA

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Introduction: In spectroscopic imaging (chemical shift imaging CSI), in addition to the two (or three) spatial dimensions, a spectral dimension is acquired. In contrast to normal imaging, in CSI all spatial dimensions are encoded using phase gradients requiring long experiment times. For this reason especially 3D CSI imaging is an appropriate candidate for acceleration by the parallel imaging concept. In previous work, CSI acceleration using the SENSE reconstruction algorithm has been presented [1]. However, significant artifacts could be induced by SENSE, due to the low-resolution nature of spectroscopic imaging [2]. Therefore, in this work we focused on parallel CSI acquisition using the GRAPPA [3] algorithm, which does not have this limitation. Furthermore, the flexibility of the GRAPPA approach allows one to derive the reconstruction weights either from a few extra acquired CSI data in the center of k-space or from a fast fully-encoded low-resolution reference pre-scan [4].

Methods: 2D phantom and 3D *in vivo* CSI head experiments were performed on a 1.5T clinical scanner (Avanto, Siemens, Erlangen, Germany) equipped with a 12 channel head array. The 2D CSI phantom was made up of 3 bottles containing Na-Acetate and Li-Lactate in different compartments. The acquisition parameters were: FOV=160x160mm^2, slice thickness 15mm, matrix=32x32, TR=1500ms, TE=135ms, bw=1kHz with 1024 spectral data points. In addition, a fast, fully-encoded low-resolution FLASH pre-scan experiment of the phantom was performed, which served as a coil calibration reference for the GRAPPA reconstruction.

The 3D head in-vivo acquisition parameters were FOV=200x160x120mm^3 , matrix=16x16x8, TR=1070ms, TE=135ms, bw=1.6kHz with 1024 spectral points.

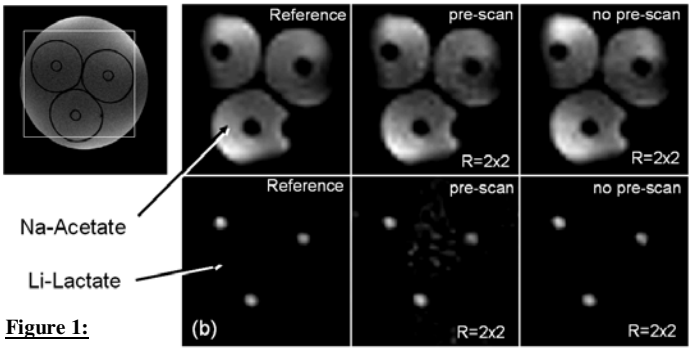

Figure 1:

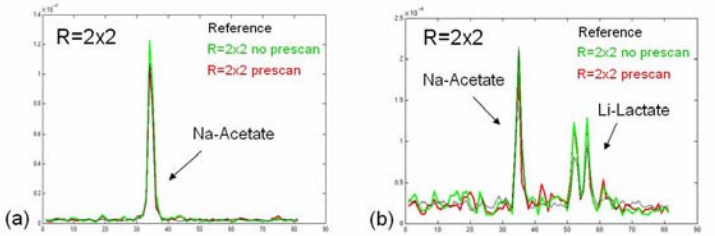

Figure 2: R=2x2 accelerated example spectra showing (a) only Na-Acetate and both (b) Na-Acetate and Li-Lactate –peaks after GRAPPA reconstruction using a pre-scan (red line) and using a (8x8) CSI data block (green line) to derive the GRAPPA reconstruction weights. All spectra are shown as absolute spectra.

Results: In Fig. 1 four-times (R=2x2) accelerated CSI images are shown after GRAPPA reconstruction using a fast low-resolution pre-scan (middle column) and a small data block (8x8) in the centre of the 2D phase encoding k-space (right column) to calculate the GRAPPA reconstruction weights. Additionally, the unaccelerated reference CSI images are shown for both Li-Lactate and Na-Acetate (left column). At the upper left, the proton image of the phantom is displayed including the excitation volume for the CSI experiment. In order to demonstrate the good spectral quality for both of the strategies, the R=2x2 accelerated spectra are shown for both cases in two different image pixels containing only Na-Acetate (Fig.2a) and both Na-Acetate and Li-Lactate (partial volume voxel) (Fig2b.). In Fig.3 R=4 accelerated *in vivo* 3D CSI images and spectra are presented.

Discussion and Conclusion: The GRAPPA reconstruction method has been successfully applied for up to R=4 accelerated 2D CSI phantom and 3D CSI head *in vivo* experiments. Furthermore, it has been demonstrated that the reconstruction coefficients for the GRAPPA algorithm can be derived from an additional fast pre-scan and from a small number of additionally acquired CSI data in the canter of the two-dimensional (three-dimensional) phase encoding k-space (autocalibration). Both strategies provide reasonable spectra and image quality. *In vivo* 3D CSI acquisition can be accelerated by factor 4 with sufficient SNR. In further work, optimized 2D and 3D CAIPIRINHA-type [5] sampling patterns will be tested in order to further improve reconstruction quality due to a more efficient usage of sensitivity variations.

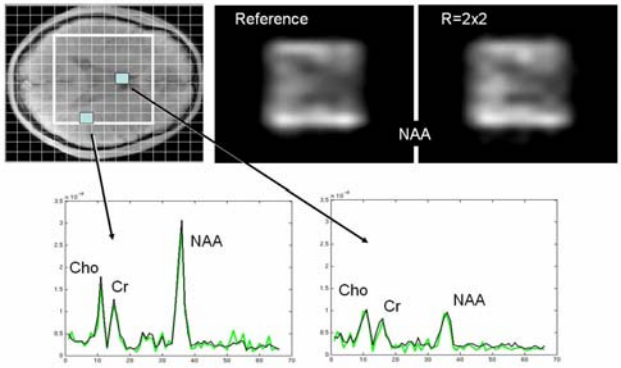

Figure 3: For demonstration purposes one partition of the accelerated (R=2x2) 3D CSI in-vivo experiments after GRAPPA reconstruction is shown. The integral under the NAA peak is displayed at the top right. Additionally, the corresponding unaccelerated reference CSI image is displayed (middle top). At the bottom row, representative spectra are displayed corresponding to different voxel volumes in the volume of interest. The spectra are shown for both GRAPPA reconstruction (green line) and the corresponding reference (black line).

References:

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