Improving Image Quality for Single Echo Acquisitions (SEA): Introducing two novel approaches

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Introduction: The single echo acquisition (SEA) method [1] offers ultra-fast imaging by generating images from only a single k-space line. Conventional phase-encoding is replaced by spatial encoding using a linear coil array. However, the number and size of the individual coil elements limit the achievable resolution. An additional resolution-degradation originates from non-ideal coil sensitivity profiles. Previously, a deconvolution method was proposed for enhancing the resolution in SEA imaging [2]. In this work, we present a resolution enhancement method based on the GRAPPA-Operator [3] and compare it with a modified deconvolution method.

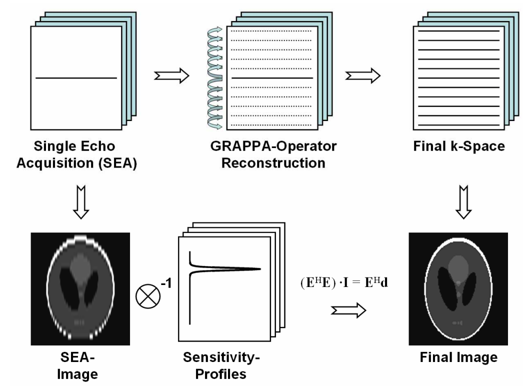

Fig 1: Reconstruction schemes using the GRAPPA-Operator (top row) and the deconvolution method (bottom row).

Methods: Using the GRAPPA-Operator formalism [3], signals can be shifted in k-space by repeatedly applying an appropriate coil weighting matrix. Here, the GRAPPA-Operator approach has been applied to SEA experiments to generate images. As an alternative, high-resolution images can be generated by deconvolving SEA images with high-resolution coil sensitivity profiles as shown previously [2]. Here, we propose a conjugate-gradient approach for solving the normally ill-conditioned deconvolution problem. The reconstruction schemes for both approaches are illustrated in Fig 1. A SEA experiment was simulated by extracting a single k-space line from a fully Fourier-encoded experiment acquired with a 64-channel linear array [1] which used spin tagging to better visualize the resolution enhancement effect. A high-resolution experiment without spin tagging was performed for calculating the reconstruction parameters for both approaches. Images (matrix size 128 x 256) were generated using the proposed methods. To investigate the robustness of both approaches, a SEA experiment with spin tagging was performed on a slowly rotating phantom (~ 0.5 rotations per second).

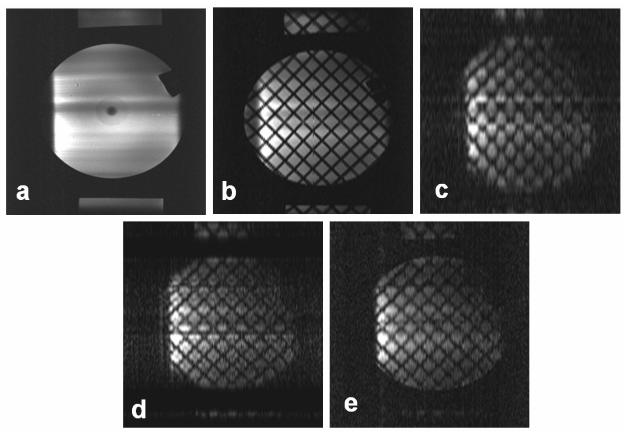

Fig 2: Fully Fourier-encoded image for calculating reconstruction parameters (**a**). Fully Fourier-encoded image (matrix 128 x 256) using spin tagging (**b**). Image generated from a single echo using conventional SEA reconstruction (**c**). Image generated from the same single echo using the GRAPPA-Operator (**d**) and the modified deconvolution approach (**e**).

Results and Discussion: Fig 2 demonstrates the resolution enhancement using both approaches. Single-echo images from the rotating phantom are presented in Fig 3. Compared to the standard SEA reconstruction approach the images generated with the GRAPPA-Operator show an improved quality. Although both methods result in improved image quality for SEA experiments, their performance is limited. The deconvolution method requires high resolution coil sensitivity maps. Because of the small size of the individual coil elements it is not trivial to extract the sensitivity maps with sufficient accuracy. In contrast, the GRAPPA-Operator approach is limited since noise and errors will propagate from one k-space line to the next. The error propagation strongly depends on the encoding capabilities of the coil array which could be quantified by a principle component analysis, for example [4]. However, both methods introduced here have shown improved image quality for actual single-echo experiments, even in moving objects.

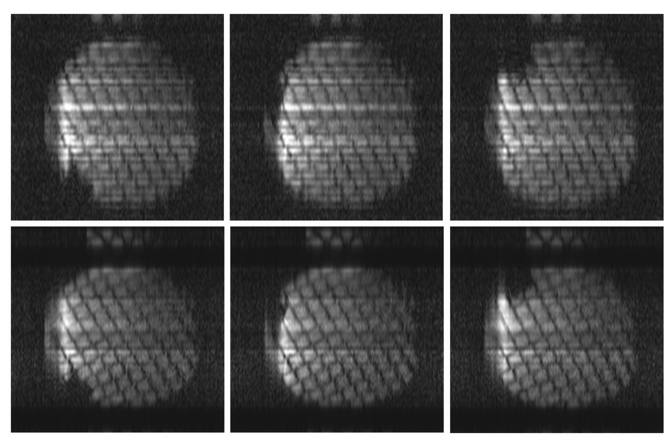

Fig 3: Single-echo images from a rotating phantom generated with a standard SEA reconstruction (top row) and the GRAPPA-Operator approach (bottom row).

References:

[1] McDougall MP, Wright SM. MRM 54:386–392 (2005). [2] Ji JX, et al. Proc ISMRM, Seattle, WA, USA (2006): Abstract 288. [3] Griswold MA, et al. MRM 54:1553–1556 (2005). [4] Breuer F, et al. Proc ISMRM, Miami, FL, USA (2005): Abstract 2668.