Study of aliasing error with SENSE in body diffusion image using single shot EPI at 3T

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Introduction: Magnetic field inhomogeneity causes artifacts in MRI. For example, in single shot echo planar imaging (EPI), they often appear as severe geometric distortion along the phase encoding direction because of the relatively long readout time (Fig.1). Sensitivity encoding (SENSE) is quite useful to reduce the distortion in EPI since it only acquires partial k-space data using multiple receiver channels and therefore enables to shorten the total readout time. In SENSE, a reference scan usually needs to be performed to create a sensitivity profile of each receiver channel. Gradient echo (GRE) sequences are often used in the reference scan. In diffusion weighted imaging (DWI) using single shot EPI with SENSE, non-negligible aliasing artifacts often remain in the reconstructed images. We suppose that these artifacts result from misregistration between the reference images acquired using GRE sequences and the DW images acquired using EPI. In this study, we have used two types of acquisition methods to create sensitivity profiles: GRE sequences and EPI, and compared the residual artifacts in the reconstructed images.

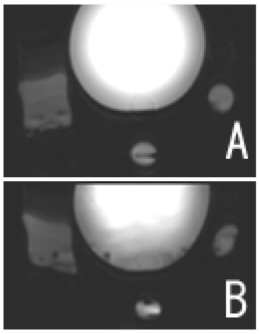
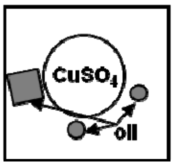


Fig.1. Phantom images of single shot EPI at 3T. Off-resonant frequencies of image B are larger than those of image A.

Methods: We performed all experiments using a 3.0 Tesla Achieva scanners (Philips Medical Systems, Best , The Netherlands). In phantom experiments, a bottle of water doped with $CuSO_4$ with three bottles of oil was scanned. Figure 2 shows the configuration of our phantom. In in-vivo experiments, axial pelvis images were acquired from an asymptomatic volunteer. Six-element phased array surface coil was used in the experiments using 3.0 Tesla scanners, respectively. Two types of sensitivity profiles were created using a GRE and a single shot EPI sequences. In the GRE sequence, TR/TE/FA/slice/FOV were set to 4ms/0.6ms/1deg/54/530mm. In the EPI sequence, TE was set to 6130ms/17ms/50deg/54/530mm. In each of phantom and in-vivo experiments, imaging data were acquired from a DWI sequence using a single shot EPI with SENSE. A reduction factor of SENSE was set to 2 in all the experiments. For each acquired data set, an image was reconstructed using each type of sensitivity profiles described above. In phantom experiments, a turbo spin echo (TSE) sequence was also used to reconstruct a non-distorted image for reference. SENSE was also applied to this TSE sequence with the reduction factor 2. Sensitivity profiles created from the data acquired using the same GRE sequence as described above were used to reconstruct an image.



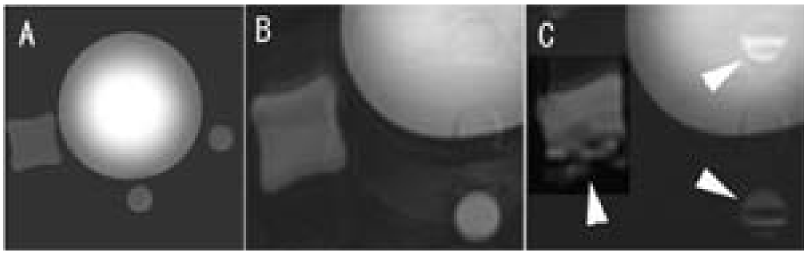


Fig.2. Phantom images.

Result: Figure 2 shows phantom images. Fig.2A is a TSE image. Figs. 2B and C are DW images using EPI with SENSE. Images B and C were reconstructed using sensitivity profiles created from EPI and GRE sequences, respectively. Aliasing artifacts observed in image C are reduced in image B. Figure 3 shows axial pelvis images. Figs. 3A and 3B are DW images using EPI with SENSE reconstructed using sensitivity profiles created from EPI and GRE sequences, respectively. As indicated by arrows, fat signals shifted along the phase encoding direction remain in image B. They are significantly reduced in image A.

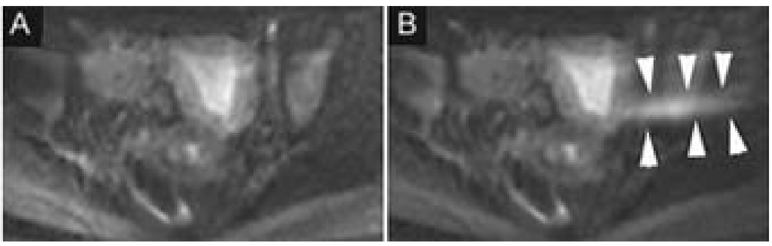


Figure 3. Axial pelvis images.

Conclusion: We used two types of sensitivity profiles when single shot EPI images were reconstructed. The sensitivity profiles were created from the data acquired using GRE and EPI sequences. Artifacts observed when GRE sensitivity profiles were significantly reduced when EPI sensitivity profiles were used. This resulted from the fact that off-resonance effects, e.g. magnetic field inhomogeneity, suscepriblity and chemical shift, often cause severe image distortion in EPI and therefore there is misregistration between images reconstructed from the data acquired using GRE and EPI sequences. Our study suggests that EPI sensitivity profiles be used when imaging data are acquired using a sigle shot EPI with SENSE although GRE sensitivity profiles have often been used in practice.

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