Improving Image Quality by Combining Outer Volume Supression and Parallel Imaging: zoomed EPI with GRAPPA at 7T

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Introduction: Susceptibility effects and T2* relaxation, mainly visible as distortions, dropouts and blurring, can diminish the image quality of EPI acquisitions. Since these effects scale with the field strength, it is essential for high field MRI to find methods to overcome or at least to reduce their influence on image quality. It has been shown that parallel imaging is capable of reducing distortions and blurring in EPI acquisitions [1]. However, parallel imaging is not without its limitations. Parallel imaging methods like GRAPPA [2] can be affected by remaining foldover artifacts due to errors in the reconstruction process. A different method enabling the acquisition of a reduced field of view is the use of outer-volume suppression (OVS) [3]. The zoomed EPI approach however can be affected by imperfect OVS, which leads to foldover artifacts from the remaining signal. The goal of this work is to 'clean' a zoomed image from remaining signals using a combination of the zoomed approach with parallel imaging.

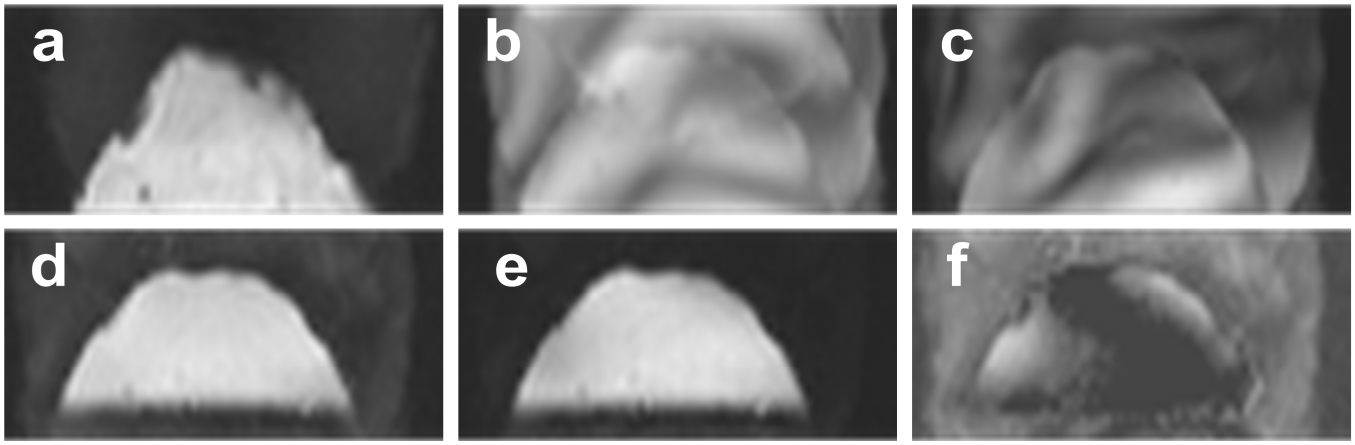

Fig 1: Single-shot EPI phantom study at 7T: (a) 100% FOV (b) 25% FOV (c) 25% FOV with GRAPPA), AF = 4. (d) 25% FOV with zoomed EPI (e) 25% FOV with zoomed EPI and GRAPPA, AF = 4. (f) Corresponding difference image between (d) and (e), scaled to highlight the differences.

Methods: Experiments were performed on a 7T whole body MR scanner (Siemens Medical Solutions, Erlangen, Germany) using an eight channel phased array head coil (RAPID Biomedical, Rimpar, Germany). The in vivo studies were carried out in accordance with the ethics approval from the Max-Planck Society and informed consent was obtained before each study.

Results and Discussion: Fig 1 shows the results of the phantom study. The upper section of the fully encoded full FOV (100% FOV) image is shown in Fig 1a, while Fig 1b shows the undersampled image with a FOV reduced by a factor of 4 (25% FOV). Even though the foldover artifacts are reduced, the GRAPPA reconstruction with an AF = 4 is affected by remaining foldover artifacts (see Fig 1c). The zoomed EPI approach with OVS allows one to reduce the FOV without significant foldover artifacts (Fig 1d). However, due to imperfect OVS foldover artifacts are visible. Applying a GRAPPA reconstruction to the zoomed EPI data cleans up those artifacts (Fig 1e). For comparison a scaled difference image is shown in Fig 1f. The image distortions are clearly visible in the full FOV in vivo image (Fig 2a). The zoomed approach (see Fig 2b) allows one to shorten TE from 142 ms down to 26 ms. The combination of zoomed EPI and GRAPPA (Fig 2d) with an acceleration factor of 4 cleans remaining signal from the imperfect OVS.

Conclusion: Parallel imaging as well as zoomed methods can be used to reduce susceptibility effects and blurring due to T2* relaxation. In both techniques, imperfections of the methods can cause severe losses in image quality. The zoomed approach can be used to suppress potential foldover artifacts in parallel imaging and on the other hand, parallel imaging can be used to clean up the zoomed image from remaining signal. In general, the combination of both methods, zoomed approach and parallel imaging, will lead to improved image quality.

References: [1] Griswold, MRM 2002;47:1202-10; [2] Griswold, MRM 1999;41:1236-45; [3] Pfeuffer, NeuroImage 2002;17:272-86.

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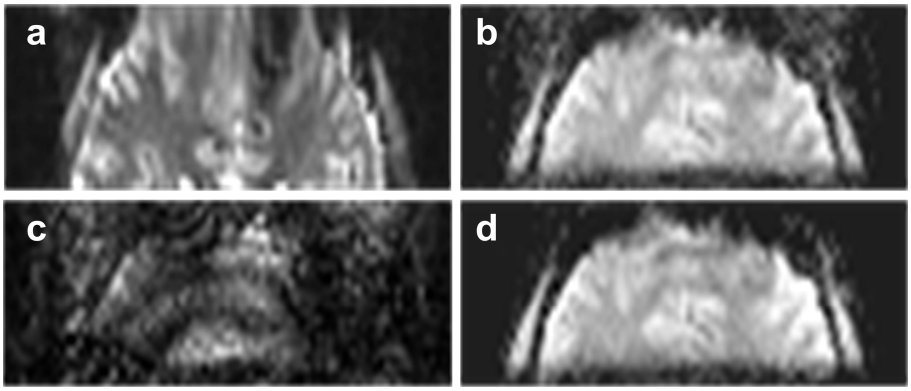

Fig 2: Single-shot EPI in vivo study at 7T: (a) 100% FOV (b) zoomed EPI with 25% FOV (c) difference image between zoomed EPI (b) and zoomed EPI with GRAPPA (d). (d) zoomed EPI and GRAPPA, AF = 4.