Diffusion weighted EPI vs. MinD SAP-EPI at 7T

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Introduction: Diffusion-weighed imaging (DWI) at standard field strengths such as 1.5T are mostly performed using single-shot EPI (ssEPI) based sequences because of its speed, immunity to shot-to-shot ghosts and motion artifacts. The penalty in terms of distortions, eddy-currents and image blurring is also moderate. One alternative to ssEPI DWI is Short-Axis Propeller EPI (SAP-EPI) (1), which uses reduced readout resolution with rotating "blades" to cover k-space. SAP-EPI allows also multi-shot diffusion-weighted acquisitions for higher resolution, and has been shown (1) to reduce distortions independent of image resolution. At very high field strengths, such as 7T, the gains in SNR are offset by the marked increases in both B_1 and B_0 inhomogeneity. In this work, we explore how SAP-EPI performs with and without diffusion weighting at 7T, where B_0 off-resonances produce marked T2* blurring and susceptibility distortions, rendering ssEPI based DWI unusable.

Materials & Methods: A SAP-EPI sequence was implemented on a GE EXCITE 7T scanner (GEHC, Waukesha, WI), using 40 mT/m gradients on a volunteer using a 16 channel phased-array head coil (NOVA Medical Inc., Boston, MA). A single 5 mm slice was acquired on a volunteer at 128×128 resolution and FOV = 24 cm using three different sequences. 1) Single shot DW-EPI (TE=69 ms, TR=8 s), 2) single-shot DW-SAP-EPI (TE=68 ms, TR=8 s). Each blade had a resolution of 32×128, with 25 half-Fourier blades covering a full 360º over k-space, allowing the use of RGPM distortion correction (2-4). 3) A T2-weighted FSE sequence (TE=70 ms,TR=6s), as an ideal geometric reference to evaluate the distortions in ssEPI and single-shot SAP-EPI.

Results: In Fig. 1, T2-weighted images are shown in the left column, and DWI in the right. The top row depicts single-shot EPI data, while the middle row contains SAP-EPI after RGPM distortion correction applied on each blade-pair. In Fig. 1e, the FSE image is given as a reference. Comparing the shapes of the sulci between a), c), and e), it is evident that the combination of SAP-EPI with RGPM virtually eliminates all serious distortions present in the ssEPI image. Diffusion weighted images show similar improvement, as illustrated by comparing Figs. 1b with 1d. However, it should be pointed out that the residual B1 artifacts due to the dielectric resonance effects at 7T are still visible in all images.

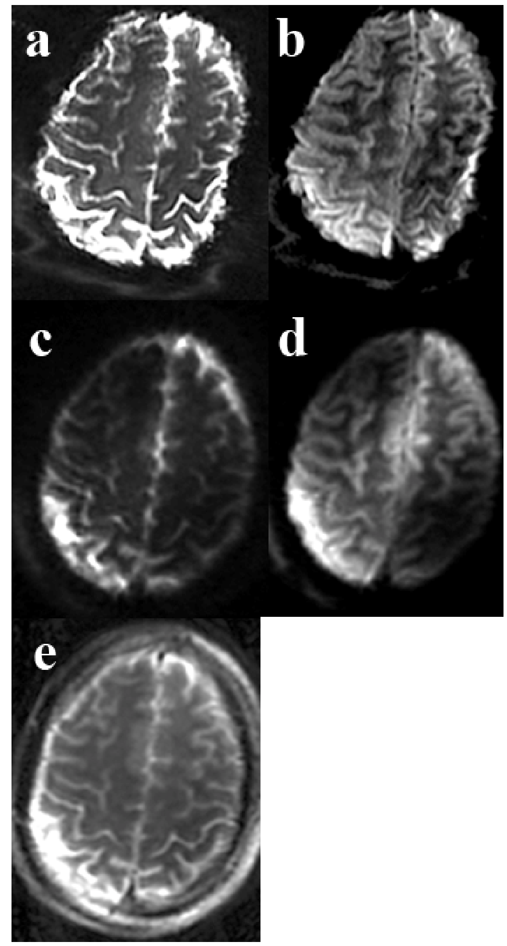

Figure 1: Comparisons of T2w and DW images acquired with single-shot EPI (a-b) and single shot SAP-EPI (c-d). The FSE image is shown in e) for comparison.

Discussion & Conclusion: The low level of image distortion in SAP-EPI is governed by the short-axis readout propeller EPI design. This is an important feature at high field, since any target resolution will only have distortions equivalent to a ssEPI image with resolution equal to the blade width. Furthermore, we can perform RGPM distortion correction as a post-processing step on a blade-pair basis by acquiring pairs of propeller blades, where each pair is oriented 180º from each other. In this pilot study, we have shown that DWI based on SAP-EPI with distortion correction is quite feasible to produce high quality diffusion-weighted images at ultra high fields. Additional distortion reduction is possible with the addition of multi-shot parallel imaging in combination with SAP-EPI and RGPM. The introduction of high reduction factor parallel imaging using the 16 channel array is currently being explored.

References: 1) Skare S *et al.*; 2006; (submitted) ISMRM, Seattle. 2) Chang H, Fitzpatrick JM. IEEE Transactions On Medical Imaging 1992;11(3):319-329. 3) Andersson JL *et al.* Neuroimage 2003;20(2):870-888. 4) Skare S, Andersson JL. Magn Reson Med 2005;54(1):169-181.

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