Reduced FOV Diffusion-Weighted 3D-EPI

Mathias Engström[1,2] and Stefan Skare[1,2]

[1]*Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Stockholm, Sweden,* [2]*Department of Neuroradiology, Karolinska University Hospital, Stockholm, Stockholm, Sweden*

Introduction

DW 3D Multi-Slab EPI (1) has been presented as an alternative for isotropic high-resolution (~1.5 mm^3) diffusion weighted imaging. The sequence makes use of multiple 3D encoded slabs, which combined, generate a full final volume. In this work we present, a single slab/volume, reduced FOV (2) version of the sequence, applicable for imaging of the spine and areas prone to susceptibility distortion artifacts. By applying the excitation slab selection gradient on the in-plane phase encoding gradient, inner volume imaging (IVI) is achieved, effectively limiting the FOV in the in-plane phase encoding direction without aliasing. By combining IVI with parallel imaging (PI) we are able reduce the off-resonance sensitivity of the sequence to a level corresponding to R = 6-8, where 3-4 is due to IVI and 2 from PI (3).

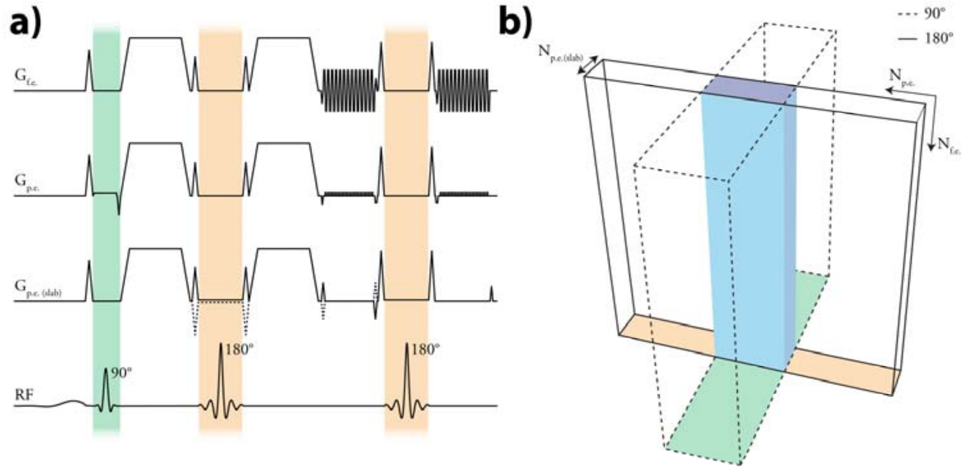

Figure 1. a) The reduced FOV DW 3D-EPI sequence. b) Spatial positioning of the excitation pulse (green) and the refocusing pulses (orange). The blue area outlines the imaging volume.

Material & Methods

A healthy volunteer was scanned, with pulse gating (RR = 2), using an 8-channel head coil (Invivo Hi-Res Head Coil, Gainsville) at a 3T MRI system (GE DVMR750, GE Healthcare, Milwaukee). The following scan parameters were used; TR = ~2300 ms, $TE_{100/33/25\%}$ = 87/71/65 ms, $FOV_{100/33/25\%}$ = 240x(240/80/60)x27 mm, matrix $size_{100/33/25\%}$ = 162x(162/54/40)x18, $R_{100/33/25\%}$ = 3/2/2 (GRAPPA), acquisition time = ~41 s/volume, and a final nominal resolution of ~1.5 mm^3. 6 b0 volumes and 16 non-collinear diffusion encoded directions with b = 1000 s/mm^2 ('b1000') we acquired.

The volunteer was instructed to stay as still as possible, and soft padding was positioned between the headphones and the coil wall. The pulse sequence and spatial position of the excitation and refocusing pulses are shown in Fig. 1a-b, respectively.

Results

Figure 2 shows reconstructed data, b0 and 6 diffusion directions, using the three phase FOVs of 100-33-25% (a-c). As can be seen in Fig 2b-c the distortions are reduced if inspecting the pons and the spine at the expense of some reduction in SNR due to the smaller phase encoding FOV, SNR ~ $\sqrt{FOV_{Phase}}$.

Discussion & Conclusion

We have shown that IVI and PI is possible to combine with 3D-EPI for targeted diffusion weighted imaging. Compared to full FOV 3D-EPI (Fig. 2a) we see reduced distortions, e.g. if inspecting the area around the pons. The lowered SNR is due to the smaller imaging volume and the reduced readout time. What distinguishes our approach from the work of e.g. Jeong (2), Heidemann (3), and Saritas (4) is the use of 3D Fourier encoding to create isotropic resolution, well suited for imaging of small structures, such as the cervical spine. Two reduction levels, 33% (Fig. 2b) and 25% (Fig. 2c), were investigated to test the sequence performance and show that PI is possible for large FOV reductions. Further work includes evaluating optimal coil choices and sequence parameters for an increased performance.

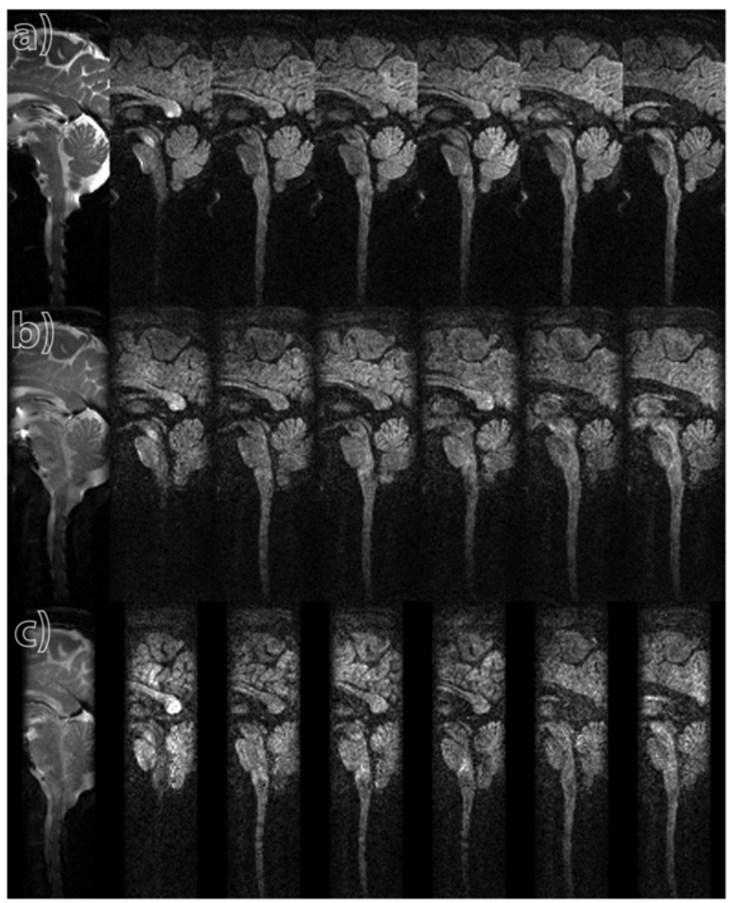

Figure 2. Sagittal 3D-EPI scans with different phase encoding FOV and acceleration factors. a) 100%, R=3. b) 33%, R=2, c) 25%, R=2

References

[1] Engström et al., ISMRM 2012 p. 3519; [2] Jeong EK., et.al. High-Resolution DTI with 2D Interleaved Multislice Reduced FOV Single-Shot Diffusion-Weighted EPI (2D ss-rFOV-DWEPI). *Magn. Reson. Med.* 2005;54:1575-79. [3] Heidemann RM, et.al. k-space and q-space: combining ultra-high spatial and angular resolution in diffusion imaging using ZOOPPA at 7 T. Neuroimage 2012;60(2):967-978 [4] Saritas E., et.al. DWI of the spinal chord with Reduced FOV Single-Shot EPI. *Magn. Reson. Med.* 2008;60:468-73