

Isotropic resolution in Diffusion Weighted Imaging using 3D multi-slab, multi-echo Echo Planar Imaging

M. Engström^{1,2}, A. Nordell^{1,2}, M. Mårtensson^{1,2}, B. Nordell¹, R. Bammer³, and S. Skare^{2,3}

¹Department of Medical Physics, Karolinska University Hospital, Stockholm, Sweden, ²Karolinska MR Research Center, Karolinska Institute, Stockholm, Sweden,

³Radiology, Stanford University, Stanford, CA, United States

INTRODUCTION

Diffusion weighted Magnetic Resonance Imaging (DWI) is usually performed using a 2D single shot echo planar imaging technique, because it generates good SNR, short scan times and is immune to phase differences between diffusion-encoded excitations. 2D DW-EPI can be acquired with a reasonably high in-plane resolution, especially if parallel imaging is used to reduce the geometric distortions. However, due to non-square RF-pulse profiles and slice cross-talk (especially for thin slices), banding artifacts occurs in the slice direction. These are easily seen when reformatting axial 2D images in for example the sagittal plane. Striving for isotropic resolution, such as often the case in fiber tractography, a 3D technique may therefore be preferred. In this work we propose a new readout strategy that is combined with a 3D multi-slab encoding, with the purpose of achieve sharp and thin slice profiles [1]. Furthermore, we propose a strategy to correct phase differences between diffusion encoded excitations and non-square slab profiles.

METHOD

The sequence consisted of a triple-echo EPI readout following a standard Stejskal-Tanner preparation. First EPI readout was used for slice encoding within the slab, and the third EPI readout was used for phase navigation (currently leaving the second echo unused). Five slab phase encoding steps were performed in five consecutive TRs. The sequence was used on a GE 1.5T Signa Twinspeed (Milwaukee, WI), with the following relevant imaging parameters: $TE_{1,2,3}=77/(122.5)/168\text{ms}$ $TR=8000$ ms $\text{matrix}=128\times 128$, and $b=1000\text{s/mm}^2$.

The slab thickness was 6 mm with no gap between the slabs. To avoid slab excitation imperfections leading to aliasing, the partition encoding covered 10 mm. One slice on each side was discarded and the final voxel size became $2\times 2\times 2$ mm. To further compensate for the slab profile across each sub-volume, the entire volume was imaged three times (i.e. 3 NEX) with a bulk shift of the slabs by 2 mm between each average. Phase correction was performed via comparing the phase-map of the 3rd EPI train between diffusion-encoded excitations.

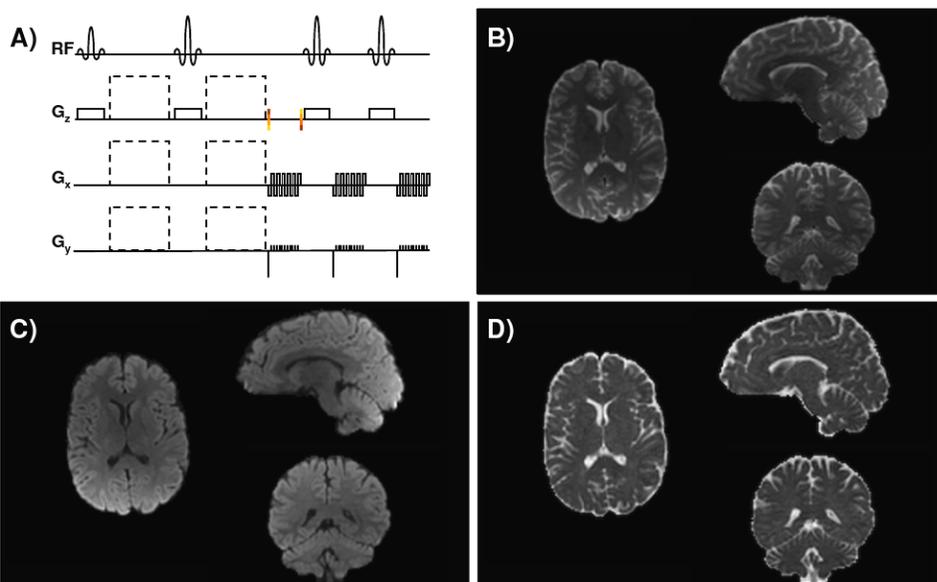


Figure 1: A) Pulse sequence, kz-encoding in color B) T2 (B0) C) ISO-DWI D) ADC

DISCUSSION & CONCLUSION

This paper demonstrates that diffusion weighted 3D multi-slab EPI with phase navigation can yield diffusion weighed data with isotropic resolution without banding artifacts along the slice direction. Currently, only one echo was used to phase encode the slice direction. Next, we will use parallel imaging to shorten the EPI readout time to use the third echo for imaging with a different z-phase encoding. Moreover, we will try to make use of the second EPI readout for the phase navigation. Finally, the number of z-encodes, and RF pulse optimization (to avoid the need for slab edge ‘kiss-offs’) will need to be investigated further.

REFERENCES

[1] Oshio, K., et al. 1991. T2-weighted thin-selection imaging with multislab three-dimensional RARE technique. *J. Magn. Reson. Imaging* 1:695-700