Twice Refocused Inner Volume EPI DTI of the Spinal Cord: Initial Findings

F. B. Laun[1], B. Stieltjes[2], L. Schad[1]

[1]Medizinische Physik in der Radiologie, Deutsches Krebsforschungszentrum, Heidelberg, Baden-Württemberg, Germany, [2]Abt. Radiologie, Deutsches Krebsforschungszentrum, Heidelberg, Baden-Württemberg, Germany

Introduction

Diffusion tensor imaging of the spinal cord is challenging due to the required high resolution, the susceptibility differences of the involved tissues and the pulsation of the surrounding CSF. Single shot Echo-Planar Imaging (EPI) is the method of choice, but has the drawback of being sensitive to local gradients when long readout trains are used. The readout train can be shorten by using inner volume (IV) techniques [1]. The disadvantage of IV techniques is their low time efficiency because of the inability of multislice acquisitions. Jeong et al. [2] propose to apply a second refocusing 180° pulse in phase direction after the EPI readout train to recover the magnetization in the not measured slices. The second 180° inversion pulse can already be applied in the diffusion preparation when using a twice refocused spin echo (TRSE) preparation. In this work such a sequence is used to measure fractional anisotropy (FA) and mean diffusity (ADC) values using a probabilistic voxel classification approach [3].

Methods

Diffusion weighted images of the healthy spinal cord were acquired on a 1.5T system (Avanto, Siemens Medical Solutions, Erlangen, Germany) with a twice refocused, cardiac gated, inner volume EPI sequence. (Fig. 1) Parameters: Field of View = 200*40mm², Resolution=160*32, TE=85ms, Slice thickness=5mm, 5 complex averages, b=0,600 s/mm², 12 diffusion directions, TR=4 heart beats, fat saturation. FA and ADC values were calculated for each pixel (Fig. 2a, b). A recently introduced method for ROI-analysis based on probabilistic voxel classification [3] for a user independent analysis of DTI-derived parameters was used. The voxels in a region of interest (ROI, blue in Fig 2c) were classified into tissue voxels (yellow in Fig 2d), partial volume voxels (blue) and other voxels (green) depending on their FA and ADC values. Then the mean FA and ADC of the ROI were calculated for the tissue voxels.

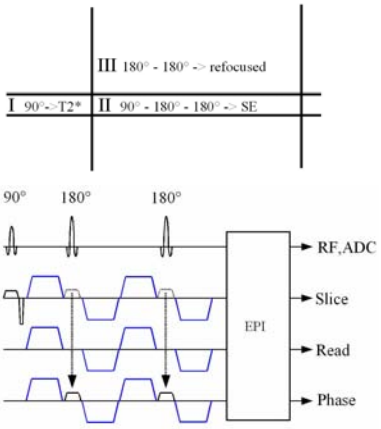

Fig 1. Timing table of the TRSE multislice capable IV diffusion weighted sequence.

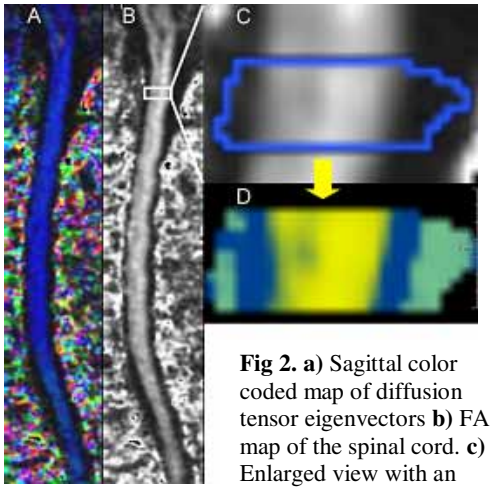

Fig 2. a) Sagittal color coded map of diffusion tensor eigenvectors **b)** FA map of the spinal cord. **c)** Enlarged view with an arbitrary ROI **d)** Different voxel classes of the ROI

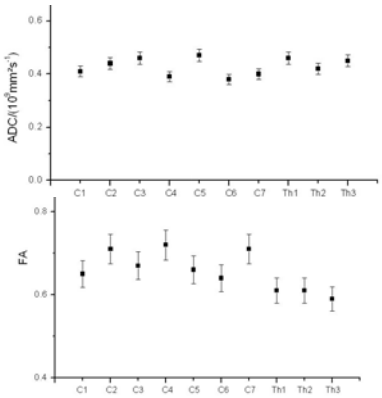

Fig 3. Mean FA and ADC plotted versus position on the spinal cord. Error bars indicate the variance found by different investigators

Results

The sequence yielded good image quality of the cervical and upper thoracic spinal cord as can be seen in Fig. 2a (colormap) and 2b (FA). In the colormaps the predominant cranio-caudal direction is represented in blue. The calculated FA and ADC values varied about 10% over the cervical spinal cord (Fig 3). FA was found to be approximately 0.75, ADC about $0.45*10^{-9}$mm²/s. Repeated ROI placement showed a user-induced variation of ±5% of FA and ADC values as indicated by the error bars in Fig. 3.

Conclusion

Using the probabilistic voxel classification approach, the calculated FA and ADC values are resistant to variations of ROI placment. Previous investigators found consistently lower FA values (about 10%) and higher ADC values (40%) [2, 4] when compared with our initial findings. This can be explained by the elimination of the partial volume voxels in our quantification method. In this investigation, we measured one, mid-sagittal slice. The use of two 180° pulses in phase direction allows the acquisition of more than one slice per TR. Future work will focus on increasing the imaging efficiency and increase of spinal cord coverage.

References

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