Optimization of Reduced Field of View (rFoV) Quantitative Diffusion MRI in Thoracic Spine

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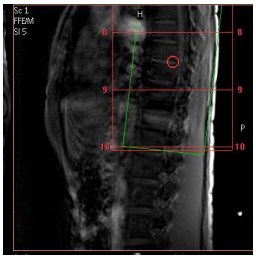
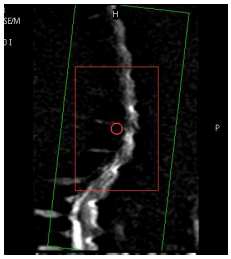
Introduction: While axial spine diffusion-weighted imaging (DWI) with single-shot EPI (ss-EPI) can be used for quantitative evaluations at 1.5T [1,2], sagittal thoracic spine is less amenable to acceptable results due to susceptability induced distortions and low signal to noise ratios (SNR) due to large FoV and distance from coil elements. Higher field strength magnets with newer spine array coils address SNR limitations and reduced-FOV (rFOV) methods have recently been implemented to overcome distortion challenges [3,4]. In this work, we optimized a rFoV technique; compared this with standard ss EPI; and report quantitative measures for a normal healthy population in thoracic spine.

Materials and Methods: Six healthy volunteers were imaged under an IRB approved protocol for the optimization of the thoracic spine imaging techniques. Both local and array coils were evaluated with the standard ssEPI and rFOV technique to determine imaging parameters that provide SNR suitable for post processing. The ss EPI design is a standard spin echo EPI technique with SPAIR fat suppression. The reduced-FOV method uses outer volume suppression as well as a 90 deg slice-selective pulse followed by an non-coplaner 180 deg refocusing RF pulse which defines a reduced inner volume; this allows fewer phase encoding steps for equivalent voxel resolution without aliasing.
Both 1.5Tesla and 3.0T Philips Achieva MR scanners (Best, The Netherlands) with Nova Dual or Dual Quasar 80 mT/m gradients with 200 mT/m/ms slew rates were used with surface coils or an 8-channel CTL coil. We used 3 b-values 0,50,500; 16 diffusion directions; and 2 averages. The sagittal ssEPI technique consisted of 11, 3 mm slices with TR/TE of 2500/73 msec at a 1.4 by 1.4 mm reconstructed voxel size over a 200 mm FoV for an imaging time of 11:60min. The rFOV technique consisted of 6, 3 mm slices with TR/TE of 4000/63 msec at a 1.4 by 1.4 mm reconstructed voxel size over a 100 mm FoV for an imaging time of 12:24 min. Images were processed on the Philips Workstation (EWS) using the fibre tract options: minimum FA 0.15, max angle 27 deg, minimum fibre length 10 mm. We drew two regions of interest covering one thoracic vertebrae and tract fibres running between these regions. Using this process we assess tract based FA and ADC values as well as number of tracts and average tract length.

Results and Discussion: At 1.5 Tesla and optimized coil configurations, there wasn't sufficient SNR within the 12 min acquisition time window to have sufficient reproducibility to support clinically acceptable procedures. At 3T with the CTL array coil elements focused on the specific area of interest there was sufficient SNR (greater than 10 for all b values) if the TR was increased to 4000 msec. Figure 1a shows a scout view with the position of the ssEPI acquisition, 1b is the b0 with the expected distortions and the position of the rFoV acquisition. Figure 1c shows the b500 iso data with significantly reduced distortion. Figure 2a shows the fibre tract of the ssEPI acquisition and figure 2b the rFoV. Using the standard ssEPI the ADC for the tracts was 1.020 +/- 0.490 10-3 mm2/secwhile the rFoV was 0.838 +/- 0.438 and the FA was 0.491 +/- 0.187 and 0.605 +/- 0.224 respectively. For fibre statistics the ssEPI had 168 tracts covering 442 voxels at an average length of 53 +/- 5.23 mm while the rFoV had 616 tracts covering 305 voxels at an average length of 31 +/- 6.03 mm. Using the rFoV technique we obtained quantitative results consistent with previously reported data and clinical expectations. With this technique we obtain sagittal results that are better than ssEPI and maybe useful for clinical assessment of spinal cord pathologies.





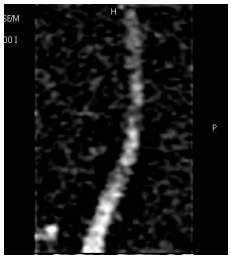
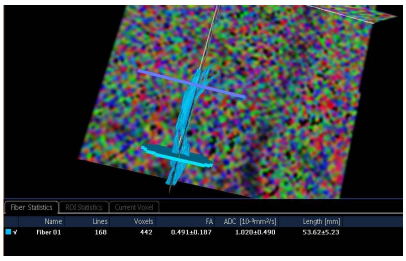


Figure 1) a) volunteer scout view showing position of ssEPI scanning volume b) ssEPI B0 image showing expected distortions and inner volume used for rFoV scan. c) B500 isotropic diffusion weighted image of the rFoV scan.



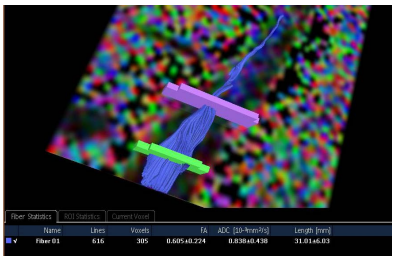


Figure 2) a) fibre tract of ssEPI scan showing reduced number of fibres. b) fibre tract of rFoV scan with greater number of fibres in a more coordinated orientation.

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