Diffusion-Weighted Imaging of the Spinal Cord using SENSE at 3T

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INTRODUCTION

Diffusion-weighted imaging (DWI) is widely used for diagnosis in the brain.[1] However, while of potential clinical value, it is less commonly used in the spinal cord due to motion artifacts and small structure size. In the spine, single-shot EPI can be used to reduce the effects of bulk motion but is limited by long echo times and increased susceptibility artifacts (particularly at 3T). Combining EPI with SENSE allows the reduction of echo time and susceptibility artifacts inherent in single-shot DWI while reducing bulk motion effects inherent in multi-shot EPI.[2]

Our study looks at the feasibility of performing single-shot EPI DWI in the cervical spine at 3T with a standard clinical spine coil and SENSE technology. Both axial and sagittal DWI were evaluated.

METHODS

All imaging was performed on a 3T whole body scanner using the six most superior elements (C-spine) of the SENSE-capable, 12-element, CTL spine coil (Philips Intera, Best, the Netherlands). Axial (3 different resolutions) and sagittal DWI was performed in 3 volunteers. Axial scans were single-shot EPI, TR 3 s, fatsat, b=600 s/mm^2, 6 averages, partial Fourier, in-plane resolution 2.5, 1.25, and 0.96 mm, with TE 78, 84, and 94 ms, SENSE factors 1, 2, and 2, respectively in A/P direction. Axial scan times were each less than 2:12. Because we anticipate DWI in the sagittal plane will be clinically useful, sagittal scans were performed using multi-shot EPI without SENSE, TR 2 heartbeats, partial Fourier, in-plane resolution 1.6 mm, b=400 s/mm^2, TE 13 ms, EPI factor 15, peripheral-pulse gating, and phase-navigator motion correction, averaging 1:50. For all scans, diffusion encoding was performed in phase, measurement, and slice directions. Each exam began with a survey and SENSE reference scan (requiring less than a minute in total).

RESULTS

All three resolutions produced high-quality axial images (Fig 1). Spinal cord boundary is better depicted in the higher resolution scans although signal-to-noise ratio (SNR) is lower. Anisotropy of spinal cord diffusion is readily observed as diffusion-weighting in cranial-caudal direction produces low signal, while L/R and A/P diffusion-weighting produces markedly higher signal. ADC maps were created for axial images at each resolution (Fig 2). Average diffusion coefficient in-plane was 0.4 +/- 0.1 x10^{-3}mm^2/s, and through-plane (cranial-caudal) was 1.70 +/- 0.08 x10^{-3}mm^2/s.

The multi-shot sagittal scans produced high-quality images with minimal susceptibility artifact. Diffusion anisotropy can be observed (Fig 3).

CONCLUSION

High-resolution axial spine DWI with SENSE at 3T appears promising. The higher field strength provides large signal-to-noise and the clinically available spine coil facilitates high-quality SENSE studies. Despite lower SNR, high-resolution images may provide more accurate diffusion mapping as partial-volume effects are reduced. Sagittal multi-shot DWI appears feasible although single-shot DWI utilizing SENSE may ultimately provide better bulk-motion suppression. Future studies include evaluating the potential of SENSE in single-shot sagittal DWI with the CTL coil.

1.) S Warach, et al., Neurology, 42, 1717, 1992.
2.) R Bammer, et al., Magn Reson Med, 46, 548, 2001.

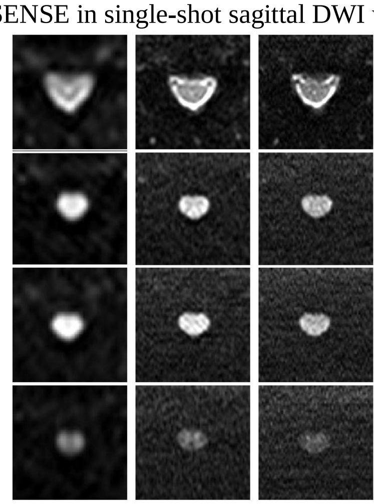

Figure 1. Axial DW images. Top-to-bottom: b0, AP, LR, and FH encoding. Left-to-right: 2.5, 1.25, 0.96 mm in-plane resolution.

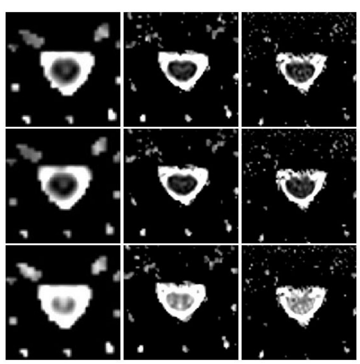

Figure 2. Axial ADC maps. Top-to-bottom: AP, LR, and FH encoding. Left-to-right: 2.5, 1.25, 0.96 mm in-plane resolution.

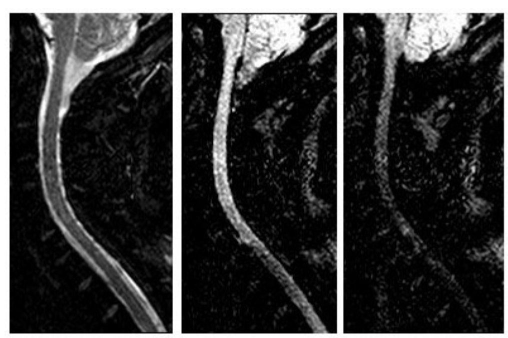

Figure 3. Sagittal DW images: b0, LR, and FH encoding using phase-navigator corrected, multi-shot EPI.