

Diffusion Tractography at 0.5T: Comparison to 1.5T

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Synopsis

The feasibility of generating diffusion tractography from data obtained on a head-only 0.5T system is demonstrated and results are compared qualitatively to tractography generated from clinical 1.5T data. DTI data from 0.5T compares favorably in quantitative (FA, ADC) measures to literature values, and qualitative (segmented white matter tracts) measures to 1.5T.

Introduction

Diffusion tensor imaging (DTI) is emerging as an important tool for the pre-operative planning of surgical treatment for many neurosurgical pathologies [1]. There is growing interest in increased accessibility to MR including locating systems closer to the point-of-care [2]. Lower field scanners with high-performance gradients have advantages in this context including less restrictive siting requirements, improved spatial fidelity through reduced geometric distortions, and diffusion imaging performance that can be comparable to 1.5T [3]. In this work we compare DTI imaging on a head-only 0.5T system designed for improved accessibility to standard clinical 1.5T imaging.

Methods

Imaging was performed on two healthy volunteers with informed consent in compliance with health and safety protocols. Isotropic 3D T1-weighted images and DTI images were acquired on a head-only 0.5T system and compared to previously acquired data from a 1.5T system (Philips Achieva, Best, Netherlands). Images were then processed using a commercially available whole brain tractography and surgical planning software (Modus Plan™, Synaptive Medical, Toronto). Acquisition parameters were as follows. 1.5T: 2.4 x 2.4 x 3mm resolution, 32 diffusion directions, scan time 9:56; 0.5T: 2.4 x 2.4 x 3.0mm resolution, 60 diffusion directions, scan time 10:19.

Quantitative FA and ADC images were available at 0.5T and following the method of Hakulinen et al [4] mean FA and ADC values were computed in ROIs placed in the genu of the corpus callosum, the anterior corona radiata and the basal pons and compared to literature values.

Whole brain DTI results were compared qualitatively for the definition of major white matter tracts, applicability for automatic white matter segmentation and appropriate definition of key white matter bundles in automatically segmented results.

Results

Mean FA and ADC values at 0.5T were similar to values reported in the literature for regions in various locations in the brain (Table 1). Qualitatively, FA, ADC and RGB maps obtained at 0.5T compared favorably to those obtained at 1.5T in the clear identification and directionality of major white matter tracts, and in the similarity of ADC maps (Figure 1). Note that due to reduced chemical shift effects, fat saturation was not applied at 0.5T.

Tractography from both 0.5T and 1.5T were able to visualize major white matter tracts throughout the brain including numerous branching tracts. DTI data from both volunteers at both field strengths was of sufficient quality for successful automatic white matter segmentation (Figure 2).

Qualitative comparisons between tractography results from 0.5T and 1.5T of the corticospinal tract, and the fornix demonstrated reasonable identification of these key fiber bundles, and good agreement in the characteristic of the bundles (Figure 3).

Discussion

Quantitative computed FA and ADC values are in close agreement with literature values.

Processed RGB and FA maps and whole brain tractography had similar appearance between 0.5T and 1.5T compared to historical scans of the same volunteers from 2016. Due to the presence of fat in the 0.5T images, FA, ADC and RGB images contain structure in the subcutaneous fat of the scalp which can be addressed in the future with the use of fat suppression. Despite the significantly lower SNR associated with 0.5T compared to 1.5T, DTI results were similar. There is some apparent reduction in tract density at 0.5T. Regardless, these results demonstrate a significant improvement in both image quality and scan time over previously reported DTI performed at 0.5T [5].

Automatic white matter segmentation was successful on all studies. Fiber tracts which are good indicators of DTI fidelity include the fornix, and corticospinal tract due to their complex paths and deep brain locations. There is good qualitative agreement in the shape, location and extent of those structures.

Conclusion

This work has demonstrated that whole brain DTI at 0.5T (1) provides qualitatively similar segmented volumes and processed DTI images as 1.5T and (2) is of sufficient quality for automatic white matter segmentation.

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References

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Figures

Region	Measurement	Volunteer 1	Volunteer 2	Hakulinen et al*
Corpus Callosum	FA	0.52 +/- 0.10	0.89 +/- 0.04	0.83 +/- 0.04
	ADC	711 +/- 124	742 +/- 37	758 +/- 67
Genu	FA	0.66 +/- 0.13	0.62 +/- 0.08	0.55 +/- 0.07
	ADC	767 +/- 19	750 +/- 19	742 +/- 27
Anterior Corona Radiata	FA	0.79 +/- 0.05	0.74 +/- 0.12	0.65 +/- 0.07
	ADC	700 +/- 31	750 +/- 77	710 +/- 50

Table 1: Quantitative comparison of mean pixel values in computed FA and ADC images in the genu of the corpus callosum, the anterior corona radiata and the basal pons from DTI data acquired at 0.5T and literature reported values.

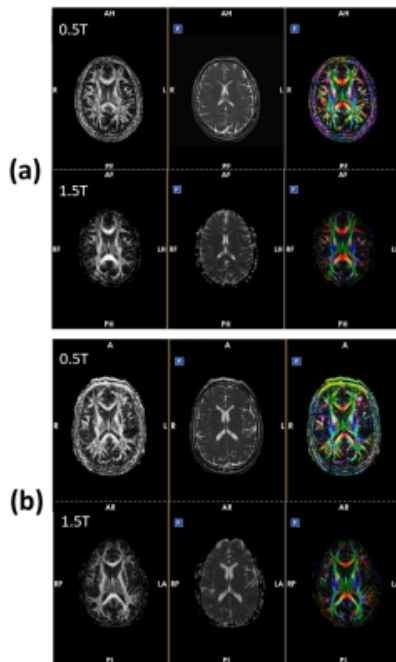


Figure 1: (a) Representative processed FA (left), ADC (middle), and RGB (right) images from volunteer #1 obtained at 0.5T (top) and 1.5T (bottom). (b) Analogous images from volunteer #2.

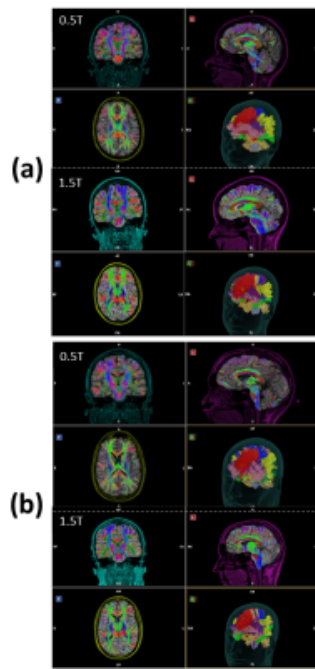


Figure 2: (a) Representative whole brain tractography demonstrated in 3 orthogonal imaging planes and whole brain automatic white matter segmentation results from volunteer #1 obtained at 0.5T (top) and 1.5T (bottom). (b) Analogous tractography images obtained from volunteer #2.

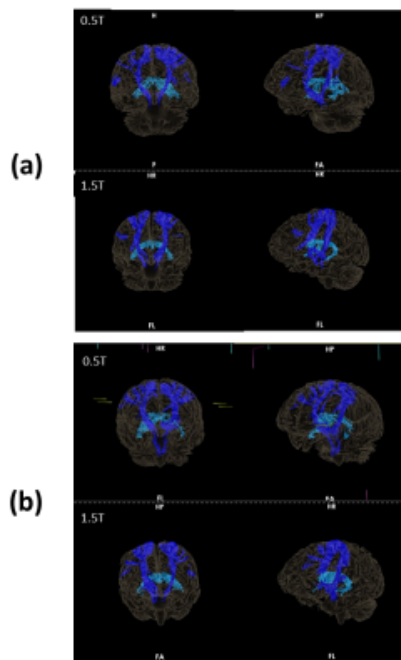


Figure 3: (a) Two separate views of automatically segmented tract bundles of the corticospinal tract (blue), and fornix (cyan) obtained from volunteer #1 at 0.5T (top) and 1.5T (bottom). (b) Analogous automatically segmented white matter bundles from volunteer #2.