Multi-Center Reliability of Diffusion Tensor Imaging

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Introduction

Diffusion tensor imaging is seeing increasing utilization for studying white matter changes in the brain. This imaging technique is sensitive to white matter structure allowing the integrity of the white matter to be probed. There have been a relatively small number of studies that have reported reliability data for multi-vendor and multi-site studies. There have been three prior studies that evaluated diffusion tensor imaging across multiple scanners. However, these were relatively small studies that employed only two or three scanners. The purpose of this study was to evaluate the reliability and reproducibility of diffusion tensor imaging across sequences, sites, and vendors.

Table 1. Sites and Scanners Used

Site	Vendor	Model
Iowa	Siemens	3T Trio
Minnesota (CMRR)	Siemens	3T Trio
UC Irvine	Siemens	3T Trio
Cleveland Clinic	Siemens	3T Trio
Johns Hopkins (Kennedy Krieger)	Philips	3T Achieva
Dartmouth	Philips	3T Achieva
Washington	Philips	3T Achieva

Methods

Seven sites participated in this multi-center imaging study to evaluate diffusion tensor imaging across multiple centers and vendors (Table 1). The sites involved in this study had either a Siemens 3T TIM Trio scanner or Philips 3T Achieva scanner. Five normal control subjects were recruited into this multi-center imaging study after informed consent was obtained in accordance with the Institutional Review Board at each of the imaging sites. All five subjects were imaged at the seven sites within a 30 day period. Two diffusion tensor imaging protocols were evaluated. The first imaging protocol used a vendor provided diffusion tensor imaging sequence and gradient directions. This sequence consisted of 30 gradient directions for the Siemens scanners and 32 directions for the Philips scanners. A single b=0 image was collected with this sequence and a b-value of 1000 seconds/mm^2 was used for the diffusion gradient encoding. Standard product diffusion encoding schemes were used for each vendor. The second sequence collected the same 71 directions across both the Siemens and Philips scanners using a custom gradient direction encoding scheme designed using electrostatic repulsion. In this sequence, eight b=0 images were acquired on all scanners. For the diffusion tensor sequence, the same field of view (256x256mm) and matrix size (128x128) was used across all of the sites and protocols. The scanners employed slight variations in the imaging sequences. The Philips scanners used a Stejskal-Tanner sequence while for the Siemens scanners employed a dual spin-echo technique. In addition to the diffusion tensor sequences that were acquired, anatomical images were collected using three-dimensional (3D) T1 weighted (MP-RAGE) and T2 (SPACE) sequences were acquired at each center.

The anatomical images collected at the University of Iowa were processed using the BRAINS automated image analysis pipeline. The diffusion tensor images were processed using the GTRACT image analysis suite. The DTI images were co-registered to the anatomical images and regional measures of fractional anisotropy (FA) and mean diffusivity (MD) within the white matter were obtained. Regional measures of FA and MD were compared across all of the sites and vendors. All data were manually reviewed for image artifacts and quality of the registration with the anatomical image. Data with image artifacts were eliminated from this study. The coefficient of variation was determined for each of the measured regions, within subject, within vendor, and across vendors. To determine the magnitude of the variation across scans the percentage difference was also computed.

Results

For the coefficient of variation measurements, the expected stepwise increase in variation existed from within site, within vendor and across vendors (Figure 1). For the FA measurements, the average CV within a site for the cerebrum ranged from 0.37-1.4%. This increased to 0.86-2.7% within a vendor, and ranged from 2.2-3.1% across vendors. Regional measures divided into frontal temporal, parietal, and occipital regions showed slightly larger variations. Similar results were found for mean diffusivity, axial, and radial diffusivity. The CV for these rotationally invariant scalars was similar in size.

Conclusions

Relatively consistent rotationally invariant scalar measures can be obtained from diffusion tensor imaging can be obtained from a single scanner (~1%). This increases when moving across sites within a single vendor and across vendors. The maximum CV that was found in this study was 3.1% when comparing measurements across all vendors and sequences. This information should help multi-center studies employing diffusion tensor imaging to appropriately power their studies.

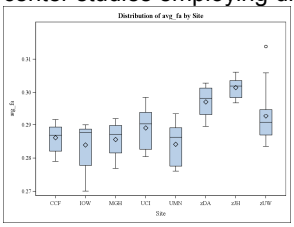

Figure 1. FA values by site

References

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