TOWARDS PRECISION NEUROIMAGING: STANDARDIZATION OF DTI OF A MULTICENTER TRAUMATIC BRAIN INJURY STUDY

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HIGHLIGHTS

TRACK-TBI is an NIH-funded study with the goal to create a large, high quality neuroimaging and clinical database. A critical need for a multicenter imaging study is to minimize the inter-site variability. Initial results suggest the feasibility of standardizing DTI across 3T scanners in a large-scale neuroimaging research study

Introduction

Each year, an estimated 1.7 million Americans sustain traumatic brain injury (TBI), often resulting in devastating neurological disabilities. Transforming Research and Clinical Knowledge in TBI (TRACK-TBI) is an NIH-funded study that began in 2014 with the goal of enrolling 3000 patients at 11 sites to create a large, high quality database that integrates clinical, imaging, proteomic, genomic, and outcome biomarkers to establish more precise methods for TBI diagnosis and prognosis. Diffusion tensor imaging (DTI) has shown promise in prior single-center studies and a major objective of TRACK-TBI is to validate its utility. A critical need for a multicenter imaging study is to minimize the inter-site variability of quantitative biomarkers, which is especially important to detect subtle microstructural changes following concussion using metrics such as fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AD) and radial diffusivity (RD). To our knowledge, DTI standardization has not previously been attempted across this number of sites and across all three major MR vendor platforms. In this work, we present our approach to and initial results from harmonization of a high angular resolution 3T DTI protocol across 13 scanners at 11 academic medical centers using a novel diffusion phantom as well as a traveling human volunteer.

Methods

Diffusion MRI was acquired from a prototype 3D-printed isotropic diffusion phantom developed at the National Institute of Standards and Technology (NIST) and from the brain of a travelling volunteer on thirteen 3T MR scanners representing all three major vendors (4 GE, 2 Phillips, and 7 Siemens) at 11 different sites using 8- or 12-channel head coils. The diffusion phantom was scanned at b=0, 500 and 900 s/mm^2 with 1.1mm in-plane resolution and 5mm slices, using 3 orthogonal directions. Human brain DTI was performed with b=1300 s/mm^2 in 64 directions at 2.7-mm isotropic resolution, with 8 b0 volumes. DTI analysis was performed in FSL, including brain extraction, motion and eddy current correction and calculation of FA, MD, AD and RD. Tract-Based Spatial Statistics (TBSS) was used to register the white matter skeletons across scans. Means and the coefficient of variation (CoV) across scanners were calculated for each DTI metric from 15 major white matter tracts in the JHU DTI-81 atlas.

Results

For the NIST diffusion phantom, the CoV of MD across the 13 canners was less than 3.5% for a range of diffusivities from 0.4-1.1x10^{-6} mm^2/s (Fig1).

For the volunteer, the CoVs across scanners of the 4 DTI metrics, each averaged over the entire white matter skeleton, were all less than 5%. In individual white matter tracts, large central pathways such as the corpus callosum, the cingulum, corona radiata, and the superior longitudinal fasciculus also showed good reproducibility with the CoV consistently below 5%. However, other tracts showed more variability with the CoV of some DTI metrics ranging up to 10% (Fig2).

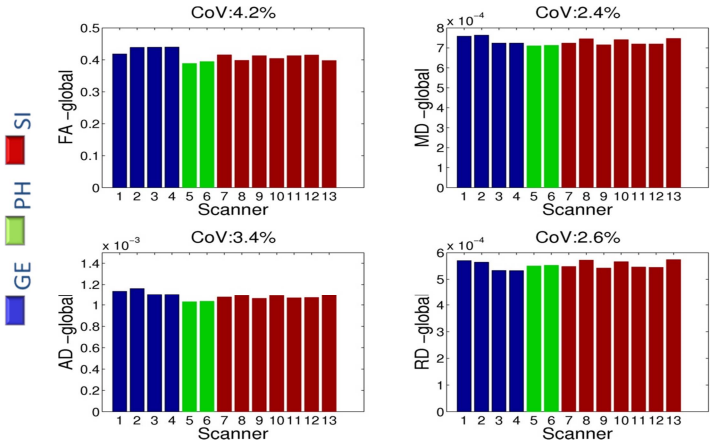
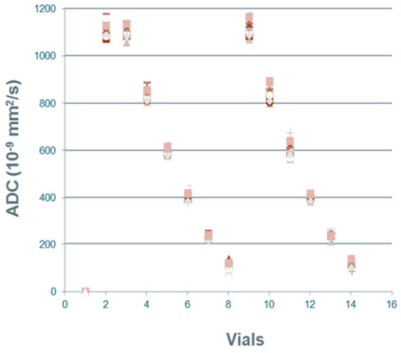


Fig2. Results for the Human travelling Volunteer. The CoV for the main DTI metrics: FA, MD, AD, RD was less than 5% showing a good reproducibility.



Mean ADC (10^{-9} mm^2/s)	Coefficient of Variance
1109	2.2%
839	2.9%
602	3.4%
404	3.5%
237	4.5%
115	11.9%

Fig1. Result for the phantom diffusivity analysis. Each vial at different concentrations of PVP is plotted. The higher the concentration of PVP, the higher the diffusivity measure.

Conclusions

Initial results suggest the feasibility of standardizing DTI across 3T scanners from all three major MR vendors in a large-scale neuroimaging research study. Further technical development is needed to improve reproducibility in certain white matter tracts.