Quality Assurance for Multi-Center DTI Trial at 3T

Xiaopeng Zhou[1], Ken Sakaie[1], Erik Beall[1], Mark Lowe[1], and Robert Fox[2]
[1]*Imaging Institute, Cleveland Clinic, Cleveland, OH, United States,* [2]*Neurological Institute, Cleveland Clinic, Cleveland, OH, United States*

Target Audience: Researchers using diffusion tensor imaging (DTI) in multi-center trials.

Purpose: To develop a practical quality assurance (QA) protocol for a multi-center 3 tesla MRI trial. NeuroNext[1] is a NINDS-sponsored network of academic medical sites designed to facilitate phase-II trials for neurological diseases. A QA protocol was developed to monitor the stability of the MR hardware across sites. We describe preliminary results from repeated scans on two scanners to demonstrate metrics for testing scanner stability. DTI pushes scanner hardware beyond conditions typically tested by manufacturers' QA protocols. Positioning the phantom accurately is important during the periodic QA procedure to track the performance of the scanner with DTI acquisition. Thus, 2 phantom holders were developed to locate the phantom more accurately for Siemens 3T TIM Trio and Siemens 3T Skyra scanners respectively (Siemens Medical Solutions, Erlangen). The fBIRN phantom[2] was scanned on Trio and Skyra scanners to evaluate the temporal stability of SNR and DTI-derived parameters, such as fractional anisotropy (FA), mean diffusivity (MD), then was used to set up parameters for multi-center DTI study.

Methods

Repeated DTI scans were performed on a Trio and Skyra using the fBIRN phantom filled with doped agar gel[2]. The DTI sequence includes 8 b=0 volumes and 64 diffusion-weighted volumes with b-value of 700 seconds/mm^2 for the diffusion gradient encoding and 2.5mm isotropic voxels. A dedicated phantom holder was constructed with a 3D printer. Sensitivity to positioning of the phantom was tested by examining signal to noise ratio (SNR) from the signal acquired for the phantom placed in 3 different positions in the Trio: accurately position landmarking laser on cross-line marker (C), position landmarking laser on the BIRN phantom "nose" (N) and random positioning (R) on 18 different days. 21 acquisitions on the Skyra were performed with consistent positioning.

Results

The mean of voxel wise measures of SNR, FA, MD across the phantom were calculated using in-house software written in Matlab (MathWorks, Natick, MA, USA). Fig.1 shows three different positions across different days. An F-test shows that the variances of SNR (p=0.93, 0.93), FA (p=0.90, 0.21), and MD (p=0.98, 0.94) do not differ significantly with positioning (positions N and R respectively compared with C). Fig.2 shows the trend in MD associated with the SNR measures shown in Fig.1. SNR change shown in Fig.3 with a series of scans acquired in one day after the Trio underwent repairs but prior to a subsequent failure. Table 1 shows small variance of FA and MD from 3 positions of Trio and Skyra. The variance of SNR is higher on Skyra than Trio. Comparing MD between Trio (position C) and Skyra (position C), p value is 0.86 showing no significant variance between two scanners on MD.

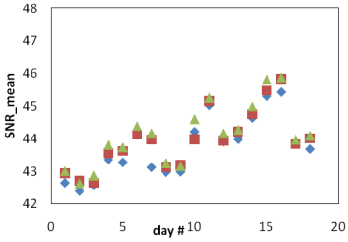

Fig. 1. SNR temporal stability (C blue, N red, R green)

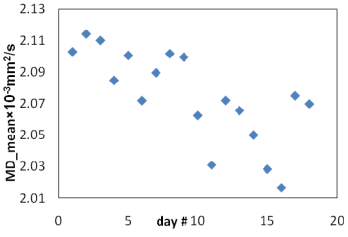

Fig. 2. Opposite trend in MD to SNR (C blue)

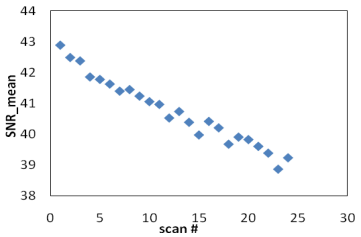

Fig. 3. SNR values change with scans

Table 1. Variance of parameters with time

	Trio C	Trio N	Trio R	Skyra C
SNR	0.86	0.82	0.89	17.21
FA	2.69E-06	2.53E-06	1.45E-06	1.82E-07
MD(×10^{-3}mm^2/s)	0.00084	0.00083	0.00081	0.00078

Discussion In a multi-center trial, it can be difficult to control conditions as carefully as at a single site. We therefore tested the robustness of QA metrics against one possible confound—inconsistent phantom positioning. The insensitivity of measurements to positioning (Fig. 1) with dedicated phantom holder provides confidence that the protocol will be effective across sites. In an ideal situation, a QA protocol with phantom will detect scanner problems (shown in Fig. 3) prior to acquiring human images. Although the variation of tensor parameters is small, it does correlate with SNR (Fig. 2), suggesting that the QA measurements may serve as a valuable covariate for statistical analysis. Tensor parameters also appear consistent across platforms (Table 1). A number of prior studies[3-7] have examined cross-scanner comparability and QA protocols. In this study, we endeavored to develop a QA protocol that is practical and readily performed in a multi-center trial.

Conclusion DTI quality assurance procedure in this study is effective to track the scanner performance and can provide reference parameters to support multi-center DTI clinical trial. Future work will determine the utility of the protocol in practice.

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References

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