Quantitative Evaluation of Eddy Current Distortion as Part of Quality Assurance Protocol for Multicenter DTI Trial at 3T

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Target Audience: Researchers using high angular resolution diffusion imaging (HARDI) in multicenter clinical trials.

Purpose: To develop a practical quantitative evaluation of eddy current artifact as part of the quality assurance (QA) procedure for a multicenter HARDI trial at 3T. The large diffusion-weighting gradients of HARDI pulse sequences tend to provoke eddy current distortions. Such distortions can pose problems when, for example, transforming images to a common space. As the eddy current distortions can vary across scanners, it is important to quantify the extent of distortion to control for systematic differences in data acquired at different sites in a multicenter trial.

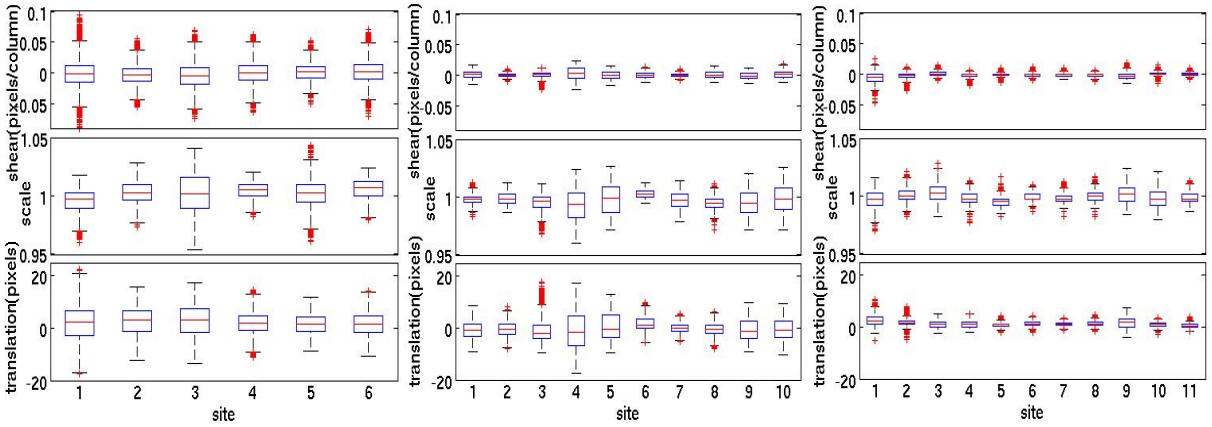

Fig. 1. Distortion parameters among Skyra(left), GE(middle), Trio(right) scanners

Table 1. Comparison between range of parameters from distorted and corrected images

	GE	GE_c	Trio	Trio_c	Skyra	Skyra_c
shear	[-0.024 0.024]	[-0.0057 0.0041]	[-0.047 0.026]	[-0.0071 0.0088]	[-0.097 0.093]	[-0.013 0.012]
scale	[0.96 1.03]	[0.98 1.01]	[0.97 1.03]	[0.98 1.01]	[0.95 1.04]	[-0.98 1.02]
translation	[-17.44 17.82]	[-2.68 4.25]	[-5.04 10.65]	[-1.21 3.02]	[-17.52 22.30]	[-1.77 3.75]

Regular quantification of eddy current distortion may also detect increased severity of artifact, provoking a service call in order to prevent corrupted scans.

Methods: DTI scans were performed using the fBIRN phantom[1] on 3T MRI scanners at 27 clinical sites within the NeuroNext network (www.neuronext.org). Scanners were manufactured by two major companies: Siemens (Siemens Medical Solutions, Erlangen, Germany) and GE (GE Healthcare, Milwaukee, WI), and are different models: TIM Trio, Skyra, Signa EXCITE, Signa HDxt, DISCOVERY MR750 and DISCOVERY MR750w and with different software levels (VB17, VD13 of Siemens, and 12x, 15x, 16x, 23x, 24x of GE). HARDI sequences were matched across all scanners in terms of spatial resolution and diffusion weighting (2.5 mm isotropic voxels, 8 b=0 volumes and 64 diffusion-weighted volumes with b-value of 700 seconds/mm^2). One GE scanner was limited to only 55 diffusion-weighted volumes. Trio scanners employed a twice-refocused spin-echo[2]. Skyra scanners employed a monopolar plus sequence[3]. GE Scanners employed Stejskal-Tanner pulse sequence[4]. All used single-shot EPI readout. To quantify the eddy current induced artifacts, an algorithm proposed by Haselgrove and Moore[5] was used to determine the scale, translation and shear of diffusion-weighted images compared with non-diffusion-weighted image. The eddy current distortion parameters were calculated for each slice and gradient using software developed in-house written in Matlab (MathWorks, Natick, MA, USA). To check whether this method is effective, the corrected images were processed with this method to see how much those parameters were improved.

Results: Trio scanners showed the least distortion among all scanners (Fig.1). All GE scanners showed less eddy current distortion than Skyra, but GE scanner 4 showed worse distortion than other GE scanners. Skyra showed the most distortion. Skyra scanner 1 showed more translation and shear than other Skyra scanners. Skyra scanner 3 and 5 showed bigger scale than other Skyra scanners. There was much less distortion from those corrected images than distorted images (Table1), especially for Skyra.

Discussion and Conclusion: A quantitative evaluation of eddy current method as part of QA protocol was developed and applied to 27 scanners. Those derived parameters are physically meaningful and related to certain gradients of the MR hardware. These parameters will be monitored on a monthly basis and are expected to be a useful tool for assuring data quality for the duration of the trial. This approach of quantifying well-understood artifact should be important in HARDI studies in general and multicenter trials in particular.

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References

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