

Inter-Vendor Variability in Apparent Diffusion Coefficient Values

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Target Audience

Radiologists or clinicians interested in conducting multicenter MR studies.

Purpose

Magnetic Resonance Imaging (MRI) is used to generate potential biomarkers for challenging neuropathologies. Apparent Diffusion Coefficient (ADC) Maps are frequently used to evaluate stroke and brain tumors. Large multi-site clinical trials often encounter difficulty establishing consistency and minimizing variability in MR data. One of the major potential differences between sites is the vendor of the scanner and console used. Proprietary equipment and software can function as a black box that introduces variability into data that is theoretically equivalent. Here, we compare the variability of cerebrospinal fluid (CSF) ADC values across vendors. CSF, being a relatively homogeneous fluid, introduces less physiological variability than white and gray matter.

Methods

Forty-two patients diagnosed with recurrent glioblastoma were treated with combination cediranib and cilengitide as part of a multicenter Adult Brain Tumor Consortium clinical trial. Fifteen patients participated in a correlative imaging substudy. The substudy was conducted at six different academic centers using three different MRI vendors based on the available scanner at each institution. Platforms include Siemens Tim Trio (3T), Philips Achieva (3T), GE Signa Excite (3T), GE Discovery MR750 (3T), and GE Optima 450w (1.5T). Each patient was scanned on the same scanner for all visits. Raw Diffusion Tensor Imaging data were used to generate ADC maps with in-house scripts that utilize the Diffusion Toolkit [1]. The ventricles were manually outlined on the ADC maps using the 3D Slicer software package. Multiple regression and ANOVA were used to evaluate the association between a variety of parameters including vendor platform, TR/TE, in plane resolution, slice thickness, b-value, number of b0 volumes, number of diffusion directions, and the mean and median ventricular ADC of the subjects.

Results

The only statistically significant association found was between the vendor platform and the ADC. As seen in Figure 1 and Table 1, the ADC values in CSF were statistically different between all three vendors ($p < 0.05$, adjusting for multiple comparison). The mean differences between the scanners, the bounds and the p-values are shown in Table 2. Absolute ADC values in CSF acquired from Siemens scanners were comparable to previously reported values acquired on a Siemens Vision (1.5T) [2]. The intra-vendor variability in ADC value was low, whereas the inter-vendor variability was high (Figure 1). None of the other parameters were statistically significantly associated with the mean or median ADC values. Different scanner models manufactured by the same vendor did not produce statistically different ADC values.

Discussion

We found that ADC values can be influenced by the MRI vendor. Our results support those of a smaller study that examined white and gray matter in healthy subjects, and showed discrepancies between ADC values across different sites and different vendors [3]. These differences in values make comparison of multicenter data challenging and can even confound data from one site with multiple types of MRI scanners. This highlights the need to specify the MRI vendor when reporting absolute threshold values for ADC, as in the designation of discrete regions of change in functional diffusion maps [4]. Patients participating in clinical trials should be scanned on the same vendor platform and preferably the very same scanner over time to minimize intrapatient variability.

Conclusion

When evaluating ADC data across vendors, absolute values may not be directly comparable. Multi-site clinical trials need to use the hardware available at each site, necessitating the comparison of results across vendors. In such cases of multivendor analysis, caution should be exercised to ensure the data are comparable and that comparisons made are just.

References

1. Wang R et al. Diffusion Toolkit: A Software Package for Diffusion Imaging Data Processing and Tractography. *Proc. Intl. Soc. Mag. Reson. Med.* 15 (2007)
2. Pezzullo JA et al. Diffusion-Weighted MR Imaging of Pyogenic Ventriculitis. *American Journal of Roentgenology* 2003 180(1): 71-75.
3. Sasaki M et al. Variability in Absolute Apparent Diffusion Coefficient Values across Different Platforms May Be Substantial: A Multivendor, Multi-institutional Comparison Study. *Radiology* 2008; 249: 624-630.
4. Moffat BA et al. The Functional Diffusion Map: An Imaging Biomarker for the Early Prediction of Cancer Treatment Outcome. *Neoplasia* 2006 8(4): 259-267.

Vendor	Median ADC
Siemens	0.002983321
GE	0.002888737
Phillips	0.002544411

Table 1: Median ADC Across Vendors

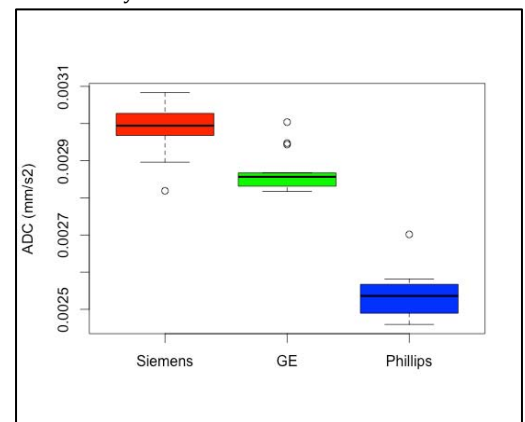


Figure 1: Inter and Intra Vendor Variability
 Siemens: 29 scans, GE: 13 scans, Philips: 7 scans

	Mean Difference	Lower Bound	Upper Bound	p
Phillips-GE	-3.44E-04	-4.19E-04	-2.69E-04	<< 0.05
Siemens-GE	9.46E-05	4.15E-05	1.48E-04	<< 0.05
Siemens-Phillips	4.39E-04	3.70E-04	5.07E-04	<< 0.05

Table 2: Degree of Vendor Separation