QIBA Diffusion-Weighted MRI Biomarker Committee: 2018 Status Update

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Quantitative Imaging Biomarkers Alliance RSNA

SUMMARY AND GOALS OF THE DW-MRI BIOMARKER COMMITTEE

Overview:
The QIBA Diffusion-Weighted MRI Biomarker Committee (DWI BC), formerly the QIBA DWI Task Force, has developed a Profile around the apparent diffusion coefficient (ADC), seeking to standardize image acquisition protocols, analysis routines, and QA/QC procedures.

The DWI BC has performed an extensive literature search, developed physical phantoms and digital reference objects, and has generated software to analyze DWI data in a standardized and consistent fashion.

Current Profile Status:
After a Public Comment release of the DWI Profile, the BC focused on addressing feedback to achieve QIBA Stage 2, Consensus. It is the BC's hope that Stage 3, Technical Confirmation, can be achieved for the existing Profile claims in short order.

Our initial DWI Profile addresses ADC in <u>brain, liver, and prostate</u>. Utilizing new test-retest data, the BC hopes to include claim statements and associated imaging protocols for breast ADC in 2019.

Conformance Procedures:
The BC has developed checklists for each Actor involved in Profile activities to demonstrate conformance, and which are part of the Profile itself. The BC groundwork projects described below are integral components of the Profile, and facilitate its adoption by sites.

Where to Find the DWI Profile:
https://qibawiki.rsna.org/index.php/Profiles

Contact us at qiba@rsna.org for more information!

Quantitative Imaging Biomarkers Alliance (QIBA) Recommendations for Improved Precision of DWI and DCE-MRI Derived Biomarkers in Multicenter Oncology Trials:
Members of the DWI BC, led by Amita Shukla-Dave and other QIBA members, wrote a review (in press, JMRI) providing recommendations for improving the reproducibility of QIBs, e.g., the need for more test-retest studies, which are critical for generating claim statements, and how to conduct them. Additional test-retest studies, that by themselves or in conjunction with other studies have $N \geq 35$, should allow for more precise claim statements improving the utility of ADC as a QIB. Table 1 shows the steps necessary to obtain wCV for a given study dataset.

Table 1: Steps for calculating the within-subject coefficient of variation

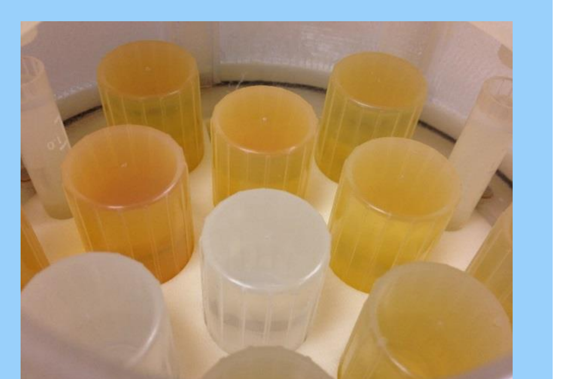
Steps	Method for calculating within-subject coefficient of variation (wCV)
1	Calculate the variance and mean for each of N subjects from their replicate measurements.
2	Calculate the wCV^2 for each of the N subjects by dividing their variance by their squared mean.
3	Take the mean of the wCV^2 over the N subjects.
4	Take the square root of the value in step 3 to get an estimate of the wCV.

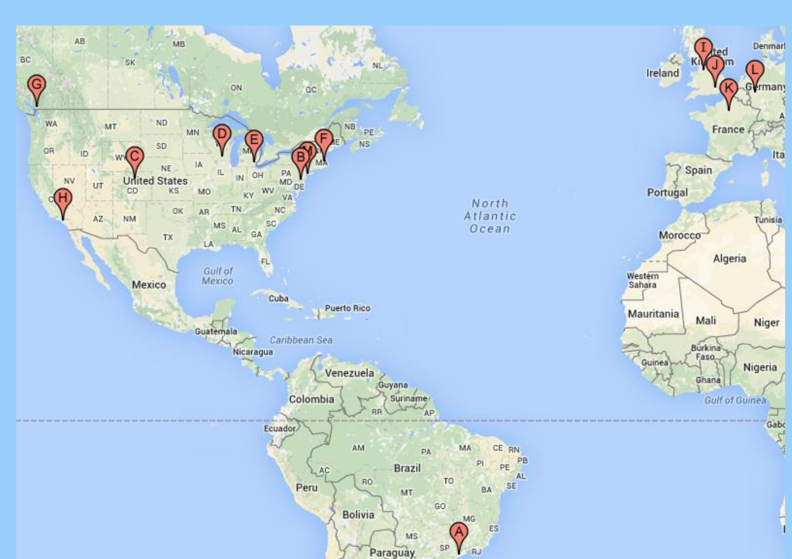
GROUNDWORK PROJECTS

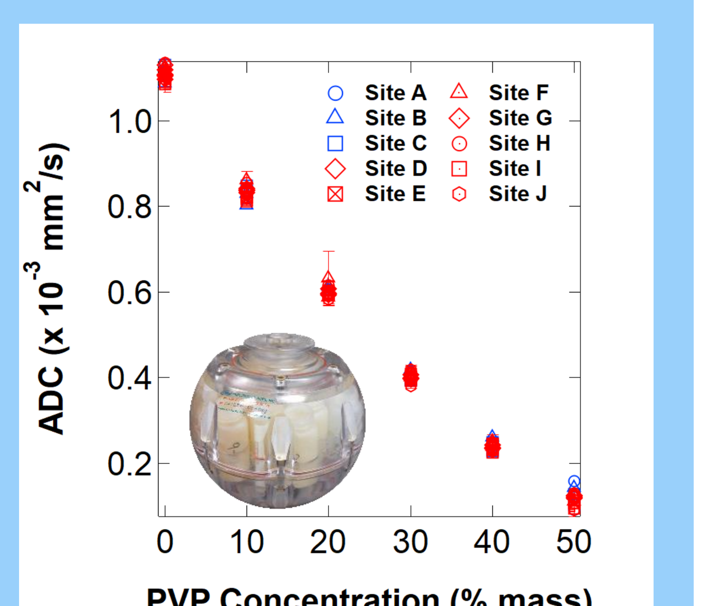
The DWI BC has produced 3 groundwork project deliverables: an isotropic diffusion phantom, associated analysis software (QIBAPhan), and a DWI DRO.

QIBA/NIST/NCI Isotropic Diffusion Phantom (PI: Michael Boss)

- Uses polyvinylpyrrolidone to tune water diffusion, provide physiological range of ADC values
- Ice-water bath enables temperature control across time and sites
- Compatible with wide range of head coils
- Round-robin results indicate excellent reproducibility across time and sites, CoV<4.1 % for ADC>0.4 x 10^{-3} mm^2/s

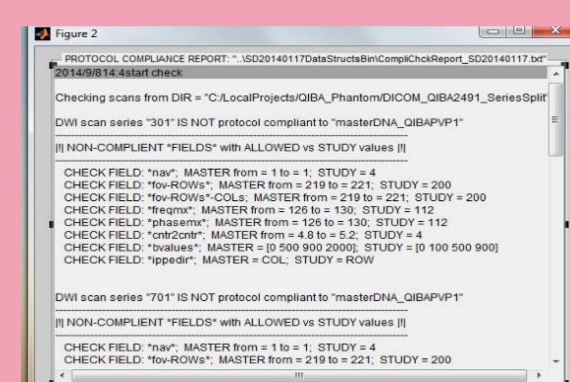


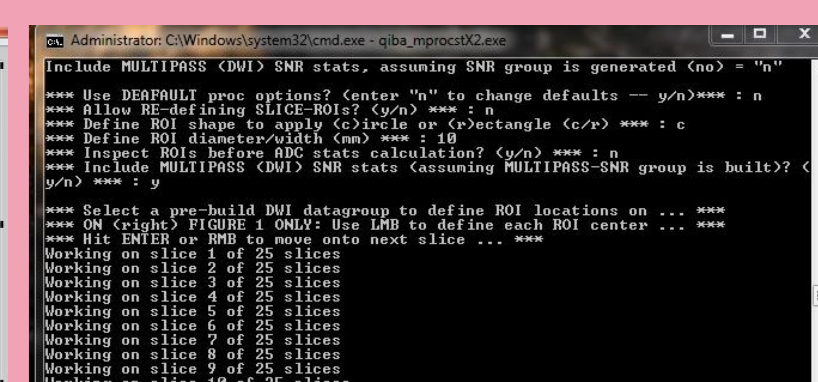


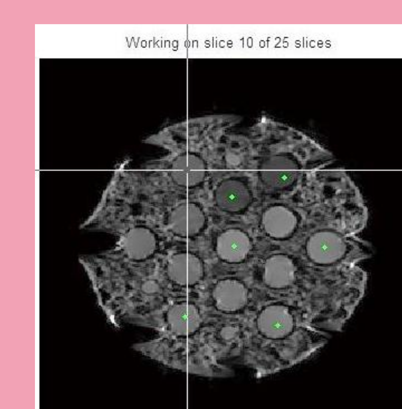


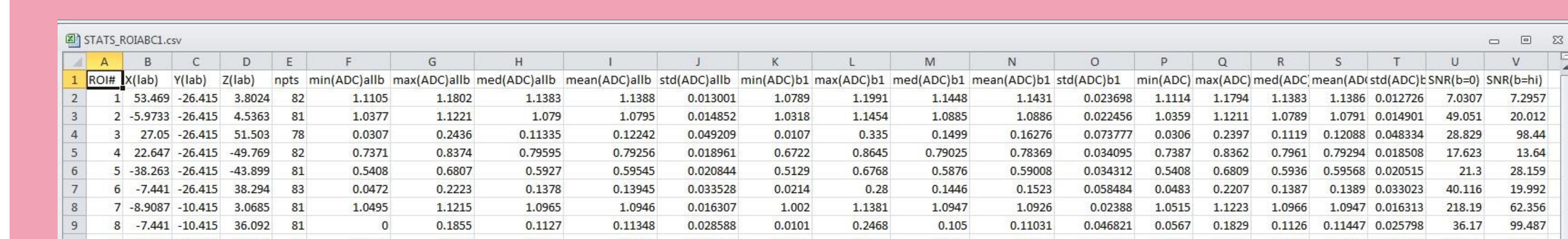
QIBAPhan Software (PI: Thomas Chenevert)

- Reads DW-MRI multi-vendor, multi b-value classic DICOM images of the isotropic diffusion phantom
- Output scan series catalogue, checks acquisition protocol compliance
- Displays DWI and derived ADC maps for user-supervised ROI placement
- Generates ROI summary statistics for ADC, DWI and SNR for individual b-values and repeat scans



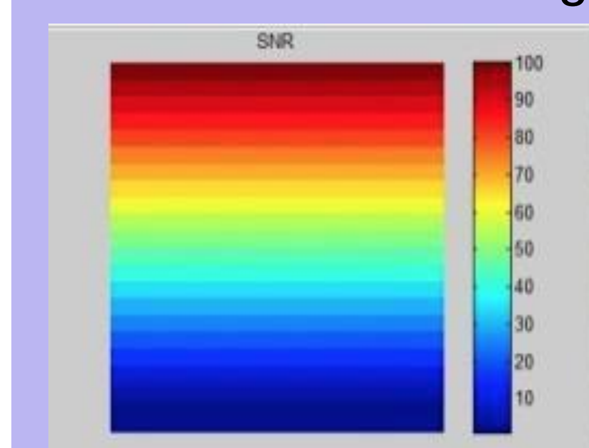


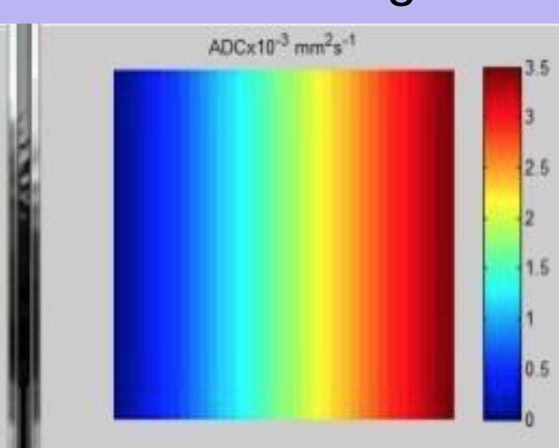


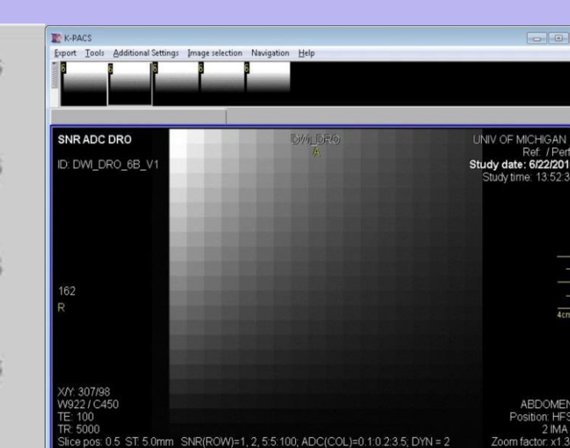


DWI DRO (PI: Dariya Malyarenko)

- Consists of five single-frame DWI DICOM series (with six images for six *b*-values) that differ by generated random noise samples and number of pseudo-averages per *b*-value
- Each DRO image contains 16x20 pixel blocks of magnitude DWI intensities for input SNR (22-horizontal) and ADC (18-vertical) parameter pairs simulated using mono-exponential decay model with a specific *b*-value
- Rician noise is modeled by (pseudo) quadrature acquisition with independent random noise samples using geometric mean of three-direction magnitude DWI images







PUBLICATIONS

1. EM Palacios, AJ Martin, MA Boss, et al. *Towards Precision and Reproducibility of Diffusion Tensor Imaging: A Multicenter Diffusion Phantom and Traveling Volunteer Study*, AJNR **38**:537-545; **https://doi.org/10.3174/ajnr.A5025**
2. SJ Hectors, M Wagner, I Corcuera-Solano, et al. *Comparison Between 3-Scan Trace and Diagonal Body Diffusion-Weighted Imaging Acquisitions: A Phantom and Volunteer Study*; Tomography **2**:411-420; **https://dx.doi.org/10.18383/j.tom.2016.00229**
3. D Malyarenko et al. *Toward uniform implementation of parametric map DICOM in multi-site quantitative diffusion imaging studies*; J Med Imag **6**:011006; **https://doi.org/10.1117/1.JMI.5.1.011006**
4. DC Newitt, D Malyarenko, TL Chenevert, et al. *Multi-site concordance of apparent diffusion coefficient measurements across the NCI Quantitative Imaging Network*; J Med Imag **5**:011003; **https://doi.org/10.1117/1.JMI.5.1.011003**

QIBA Projects and activities have been funded in whole or in part with Federal funds from the National Institute of Biomedical Imaging and Bioengineering, National Institutes of Health, Department of Health and Human Services, under Contract Nos. **HHSN268201000050C**, **HHSN268201300071C**, and **HHSN268201500021C.**