Effects of computation methods, median filtering and Rician noise removal on diffusional kurtosis and tensor imaging metrics in vivo

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Target audience: Researchers and clinicians who investigate the brain and its pathologic conditions by using diffusion-weighted imaging and diffusion metrics.

Purpose: In clinical practice, high spatial resolution diffusional kurtosis imaging (DKI)[1] and diffusion tensor imaging (DTI) can be achieved, using multi-band echo-planar imaging (EPI)[2] in a commercially available 3T MR scanner. Diffusion metrics derived from DKI and DTI data, such as the fractional anisotropy (FA), apparent diffusion coefficient (ADC), mean diffusional kurtosis (MK), and axial or radial diffusional kurtosis (Ka or Kr), are used for quantitative evaluation of normal and pathological brains. However, these metrics may change with different post-processing methods. The purpose of this exhibit is to characterize, particularly for clinical use, the effects of different computation methods, median filtering and Rician noise removal on DKI and DTI in normal white matter and brain tumors.

Outline of contents: The DKI data, which consist of 1.5 mm iso-voxels covering the entire brain, were acquired in a commercially available 3T MR scanner (Siemens Skyra, Siemens AG, Erlanger, Germany) with a 32-channel head coil, by using the following parameters: b values of 0, 1000, and 2000 s/mm^2; 30 motion-probing gradient directions; and a multi-band factor of 3. We present clinical case examples that illustrate differences in the diffusion metrics of normal white matter and brain tumors, between data computed 1) with Jensen's kurtosis[1] method and the Neighbor sampling addition method[3], 2) with and without median filtering, and 3) with and without Rician noise removal (representative data are shown in Table 1 and Figure 1).

Table 1 Various diffusion metrics in normal corticospinal tract

	Jensen's kurtosis		Neighbor sampling addition method	
	Without median filtering	With median filtering	Without median filtering	With median filtering
FA	0.54 ± 0.16	0.50 ± 0.16	0.54 ± 0.16	0.50 ± 0.16
ADC	0.67 ± 0.17	0.63 ± 0.16	0.67 ± 0.17	0.63 ± 0.16
MK	1.18 ± 0.24	1.21 ± 0.22	1.21 ± 0.17	1.24 ± 0.16
Ka	1.43 ± 0.67	1.47 ± 0.51	1.42 ± 0.62	1.46 ± 0.49
Kr	1.42 ± 1.35	1.56 ± 0.94	1.67 ± 1.37	1.69 ± 0.90

Values represent mean ± SD. Unit for ADC is μm^2/ms, whereas FA, MK, Ka, and Kr are dimensionless.
Note that FA and ADC were calculated based on a monoexponential model using the data with b values of 0 and 1000 s/mm^2.

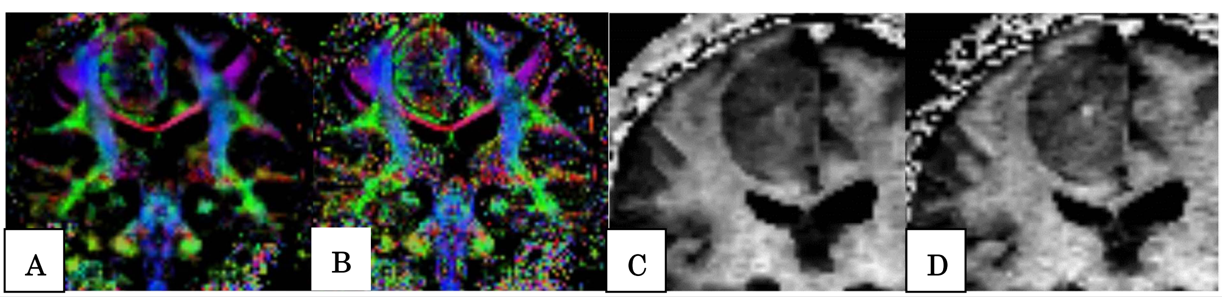

Figure 1. Comparisons of color-coded FA maps and MK maps in coronal view with (A, C) and without (B, D) median filtering in patients with meningioma.

Summary: This exhibit will demonstrate the effects of two computation methods, median filter and Rician noise removal on DTI and DKI in normal white matter and brain pathology in vivo. Median filtering is an important factor that affects quantitative diffusion metrics; for example, it produces a 10% change in FA values. Differences of two computation methods were less influential because the data including small numbers of b-values (0, 1000, and 2000 s/mm^2) in this presentation and results may be different under condition of more than 3 b-values. Rician noise removal was also less influential in changing diffusion metrics, presumably because the signal-to-noise ratio of the data was sufficient for calculation. Selection of post-processing methods (i.e., use of median filtering) should be clarified in research and clinical use.

References: 1. Jensen JH, Helpern JA, Ramani A, et al. Diffusional kurtosis imaging: the quantification of non-Gaussian water diffusion by means of magnetic resonance imaging. Magn Reson Med. 2005;53(6):1432–1440. **2.** Moeller S, Yacoub E, Olman CA, et al. Multiband multislice GE-EPI at 7 tesla, with 16-fold acceleration using partial parallel imaging with application to high spatial and temporal whole-brain fMRI. Magn Reson Med, 2010; 63(5): 1144–1153. **3.** Masutani Y and Aoki S. Fast and Robust Estimation of DKI Parameters by General Closed-Form Expressions and their Extensions. Magn Reson Med Sci. 2012 (submitted).