Influences of b-value on the reproducibility and accuracy of diffusion kurtosis imaging

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Introduction

Diffusion kurtosis imaging (DKI) was demonstrated to successfully estimate the non-Gaussian distribution of water diffusion *in vivo* and has been applied in many clinical applications. Similar to diffusion tensor imaging, b-value is an important factor in the measurement of DKI indices and may have influential effects on them. More b-values are always preferable to have better fitting accuracy, but the concomitant lengthening of scan time may hinder its clinical applications. Rapid DKI with three b-values was proposed to obtain DKI indices in clinically acceptable time [1], but the results may be affected by the choice of b-value. Hence, the purpose of this study was to investigate the effects of b-value on the reproducibility and accuracy of DKI indices.

Materials and methods

The DKI data were acquired from a 20 year-old healthy male subject with six high b-values (500, 750, 1000, 1500, 2000, 3000 s/mm^2) in 30 non-collinear directions, and were repeated three times for reproducibility measurement. Other imaging parameters were: TR/TE = 6500/99 ms, FOV = 240x240 mm^2, matrix size = 80x80, slice thickness = 3 mm (isotropic), # slice = 25, ASSET factor = 2, total acquisition time = 1h10m. The full datasets were combined as the gold standard dataset and were further decomposed into twelve rapid DKI datasets for comparisons, including (b0, b1, b2) = (0, 500, 1500), (0, 500, 2000), (0, 500, 3000), (0, 750, 1500), (0, 750, 2000), (0, 750, 3000), (0, 1000, 1500), (0, 1000, 2000), (0, 1000, 3000), (0, 1500, 2000), (0, 1500, 3000), (0, 2000, 3000) s/mm^2. The DKI data were motion corrected by 12-parameter affine registration, and the resultant rotation matrices were utilized to compensate gradient table in DKI. This study performed a global DKI fitting approach to robustly estimate DKI indices, which parameterized six diffusion tensor elements and fifteen kurtosis tensor elements with homogeneous polynomials and imposed positive semi-definite constraints to the generalized tensor imaging [2]. Such an approach has been demonstrated to have lower fitting errors than those without constraints, and hence was employed in this study. After DKI indices were obtained, the reproducibility and accuracy of DKI indices were assessed by calculating the coefficient of variation and the biases from the gold standard values respectively.

Results

Figure 1 shows ΔMK maps of twelve rapid DKI datasets. As compared with gold standard DKI, the MK values were underestimated in rapid DKI as b2 > 2000 s/mm^2, but were overestimated as b1 ≤ 1000 s/mm^2 and b2 ≤ 2000 s/mm^2. Besides, the white matter tissues with highly anisotropic diffusion, such as splenium of corpus callosum, exhibited larger MK biases than those with less anisotropy. Figure 2 shows the CV(MK) of twelve rapid DKI datasets. In general, the CV(MK) was found to decrease with b2 but increase with b1 in both gray and white matter tissues, and larger separations of b1 and b2 helped reduce the variations of MK values.

Figure 1

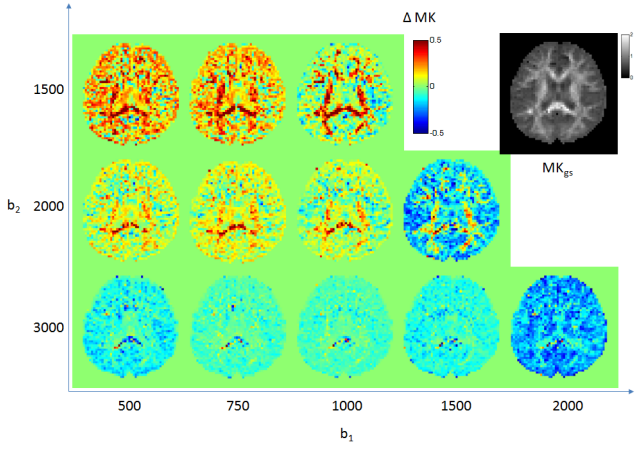
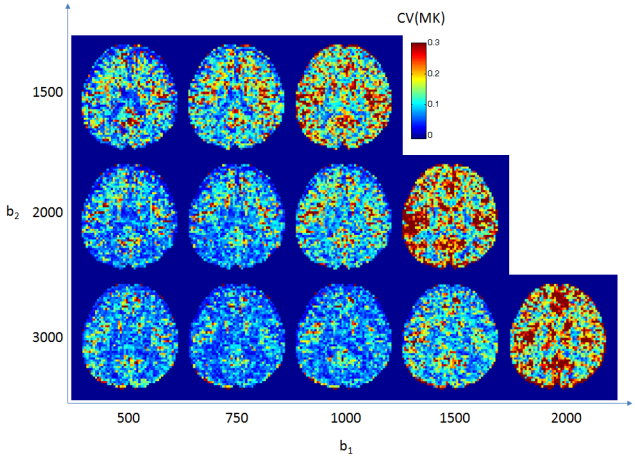


Figure 2



Discussion

Previous studies have shown that DKI model exhibited less dependency on b-values and more accurate estimation of FA and MD values than those estimated with DTI model [3-5]. This study performed human brain DKI experiments which acquired six high b-value DWIs to construct a gold standard DKI dataset and separated those b-values to generate twelve rapid DKI datasets. The results showed that the reproducibility and accuracy of MK were dependent on b-values in rapid DKI datasets, suggesting that the b-value significantly impacted the measurements of DKI-derived MK value. As many studies performed DKI measurement to detect white matter alterations, it is necessary to take b-value into account when comparing DKI results with those acquired with different b-values.

References

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