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# DEPENDENCE ON THE B VALUES IN DIFFUSION KURTOSIS CALCULATION

**Yuka Kayaoka BS, Akio Ogura PhD, Tomokazu Takeuchi MS and Daisuke Koyama MS**

Gunma Prefectural College of Health Sciences 323-1 Kamioki-Machi, Maebashi, Gunma 371-0052, Japan.

***Corresponding Author: Akio Ogura PhD**

Gunma Prefectural College of Health Sciences 323-1 Kamioki-Machi, Maebashi, Gunma 371-0052, Japan.

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## ABSTRACT

**Purpose:** The diffusion kurtosis image (DKI) is used for the benign of tumor and malignant differentiation of benign and malignant in tumor, and diagnosis precision improvement of the neurodegenerative disease in a clinic. However, it is pointed out that a mean kurtosis (MK) value depends on the combination of b values to use for calculation. In this study, we examined the dependence of the b values to use for DKI calculation. **Methods:** The normal brains of six people were imaged in DWI of 16 multi-b value from 0 to 4,500s/mm$^2$. The MK value was calculated by the MR signal of each b value. We changed the number of b values and the maximal b value to use for calculation and compared each MK value and the variation index. **Results:** The MK value converged to a constant value as the number of the b value to use for analysis was six or more, and the variation index became small. According to the increase of the maximal b value, the MK value decreased and the variation index became small. **Conclusion:** The number of the b values to use for calculation of DKI was recommended six or more. Moreover, the MK value depends on the maximal b value, but 2,400s/mm$^2$ or more are necessary for the maximal b value in consideration of a variation index.

**KEYWORDS:** Diffusion Kurtosis, B Values, Mean Kurtosis.

## INTRODUCTION

In magnetic resonance imaging, Diffusion weighted imaging(DWI) is the essential imaging method in the detection of the malignant tumor acute ischemic stroke and inflammatory disorder in a clinic now to image the diffusion coefficient of the proton.[1-3]

Aapparent diffusion coefficient (ADC) is analyzed in Gaussian distribution, but a diffusion in the bio-tissue is a limited diffusion of the non-normal distribution which reflected a cell structure. Therfore, in recently, Diffusion Kurtosis Imaging of non-normal distribution is applied at clinical a method of analysis with ametropia distribution.[4-9]

DKI expresses it with an index of the kurtosis of the statistic based on the exponential function approximation to the second clause for the degree that a diffusion not to obey normal distribution deviates from normal distribution in index of the kurtosis (kurtosis) of the statistic based on the exponential function approximation to the second clause.[8]

In other words, three dimensions of degree to become estranged is calculated in a space by a limit diffusion, and it is displayed for a mean of the space direction as Mean Kurtosis (MK) by the exponential function by the free diffusion.

MK is shown for the numerical value that reflected a spatial fine structure of the tissue.

Therefore, recently, it is applied widely even a clinic, and it was reported that the threshold of MK used for diagnosis benign of tumor b and diagnosis precision improvement of the malignant differentiation and neurodegenerative disease is reported now.[5-9]

The benign of tumor using the threshold of MK and malignant differentiation and diagnosis precision improvement of the neurodegenerative disease are reported. The benign of tumor using the threshold of MK and malignant differentiation of the benign and malignant tumor using the threshold of MK, and diagnosis precision improvement of the neurodegenerative disease are reported. However, it is reported that a value of MK depends on the combination of the b values to use for calculation, because kurtosis is demanded from the fitting of the signal value.[7, 9-10]

It is unknown the number of b values and the maximal b value to use for calculation of MK are different between researchers practically it is expected. Actually because it is unknown the number of b values and the maximal b value to use for calculation of MK are different between researchers practically because it is unknown the number of b values and the maximal b value to use for

calculation of MK are different between researchers practically it is expected. expected. Actually.

Therefore, in this study, the number and the maximal b value to use for calculation of DKI simulated it about the dependence for the MK value and examined the b value which was optimal for DKI calculation.

## 2. MATERIAL AND METHODS

### 2-1. The calculation method of Mean Kurtosis (MK)

The kurtosis expressed as a mean of the space direction defines the sharpness of the peak of the distribution on the basis of normal distribution in probability distribution. The peak is sharper with the high kurtosis, and the decrement of the hem is loose. The peak is sharper with the high kurtosis, and the decrement of the hem is loose.

$$S(b) \cong S(0)\exp\left(-bD + \frac{1}{6} \times b^2 \times D^2 \times K\right) \quad \cdots\cdots (1)$$

Where, S(b) is signal value of the diffusion weighted image in any b value. S(0) is a signal value of the diffusion weighted image in b value = 0, and D is a diffusion coefficient.

The DWI signal values for each b values were substituted for expression 1, and D and MK were calculated using MATLAB (MathWorks, Massachusetts, USA).

### 2-2. Scanning parameters

The MR device imaged the head of subjects using Ingenia1.5 T made in Philips company, and the receiver coil used head array coil (15ch).

As for the imaging condition, the imaging parameter was FOV 250*205, TR 4000ms, TE 146ms, number of slices five pieces, slice thickness 10mm, the number of addition twice, BW 23.8Hz, number of the matrices 156*224, EPI factor 41, PI-factor 2, the b valuesl with 16 for 0, 300, 600, 900, 1200, 1500, 1800, 2100, 2400, 2700, 3000, 3300, 3600, 3900, 4200, 4,500s/mm2 using EPI) echo planar imaging of the SE type.

Also, the number of the applying axes of motion probing gradient: was 6 axes.

### 2-3. Imaging subjects

The approval of the Ethical Review Board concerned was obtained beforehand on conducting this study. The imaging subjects were the volunteer of six men and women (age 21-59 years old) that the brain which obtained consent in particular did not have the disease after an open call for participants.

### 2-4. Analytical technique

The signal values of the obtained MR image were measured using image J (v.1.80_112,National Institute of Health, Bethesda, Maryland, USA).

Circular region of interest (ROI) was set in gray matter and white matter in the agreement of three radiologist and neuro surgery physicians, and a signal values were measured.

The size of ROI was 50mm$^2$ or more with the white matter more than 33mm$^2$ with the gray matter (Figure 1). ROI set by five in each of gray matter and the white matter and we set 25 total gray matter, 50 ROI of 25 total white matter in total in six subjects and measured a signal level.

A b level calculated the ratio of the signal level of the diffusion emphasis image of any b level for 0s/mm$^2$ than an obtained signal level, and MK was calculated. ROIs were set in each of gray matter and the white matter by five, and 50 ROIs in total was set to in six subjects, and a each signal values were measured.

## 3. RESULTS

MK of the cephalic gray matter and white matter for the number of MPG at maximal b value = 4,500s/mm$^2$ is shown in Figure 2. The value of MK converged in a constant value for the number of the b level was six or more.

MK of each gray matter and white matter for the number of MPG of maximal b value = 2,100s/mm$^2$ is shown in Figure 3. As for 2,100s/mm$^2$ of maximal b value, MK converged in a constant value for the number of MPG was six or more similar to 4,500s/mm$^2$ of maximal b value = 4500/mm$^2$. Similarly, MK of each gray matter and white matter for the number of MPG at maximal b value = 1,500s/mm$^2$ is shown in Figure 4.

When a maximal b balue was 1,500s/mm$^2$, and the number of the MPG became than four, as for the value of MK, a tendency to converge was found in a constant value.

MKs of each cephalic gray matter and white matter by the different maximal b values are demonstrated in Figure 5.
According to the increase of the maximal b value, MK decreased.

It is shown the coefficient variation index (CV) by six subjects of each gray matter and white matter in the number of MPG varying in 4,500s/mm2 a maximal b value in Figure 6.

CV by six subjects of each gray matter and white matter in each maximal b values are shown in Figure 7.

CV converged in a constant value in six or more the number of MPG. In addition, CV decreased with the increase of the maximal b value.

## 4. CONCLUSION

That a value of MK changes by the combination of b values to use for calculation, because it is demanded from the fitting for the signal value, in clinical MRI. It is noted kurtosis that a value of MK changes by the combination of b values to use for calculation, because it is demanded from the fitting for the signal value, in clinical MRI.[7,10]

When it is used by a clinic, the merit that imaging time has a short is very big, and we are often imaged by the number of MPG where there is few it by an advantage such as being able to reduce an artifact by the body movement, but the dependence of the MK level by the combination of the b level is unknown now. Particularly, the precision is very important when the threshold of the MK value is used for a case to be used for the benign of tumor and malignant differentiation and a diagnosis of the neurodegenerative disease. *I*maging time has a short has very merit, and we are often imaged by the few number of MPG by an advantage of the artifactual reduction by the body movement in using it by a clinic, but the dependence of the MK level by the combination of MPG is unknown now.

From results of this study, for a maximal b value was fixed, and the change of the number of MPG, the MK value converged in a converged in a constant value for the number of MPG was six or more. We thought that a value of MK value decreese, because this reason could not show degree of being structured of the tissue with a decrease in number of MPG definitely.

In addition, the values of the coefficient variation index（CV) increased according to a decrease in number of MPG. BY these results, we consider that the number of MPG to use for analysis of MK should be more than six.

Futhermore, in the change of the maximal b value, the MK value decreased. These results suggested that the MK value depended on a maximal b value and were associated with calculation of DKI. Because the ingredient that the movement of the water molecule was slow was included relatively a lot by setting a maximal b level highly, this thought that an MK level decreased.

Furthermore, the coefficient variation index (CV) by the change of the maximal b value decreased according to the increase of the maximal b value.

Unevenness increased with the small maximal b value. The coefficient variation index (CV) that changed a maximal b value became small as a maximal b level grew big.

Attention was necessary for the setting of the maximal b value, and a maximal b value of about 2,400s/mm$^2$ thought that it was proper from the viewpoint of measurement accuracy from results of this study.

These results are equal to results of this study that a maximal b level of 2000-3000s/mm$^2$ is appropriate in DKI-MRI of the brain. As for the scanning parameters, it is thought about in each device MK converging to a constant value by the number of MPG where there is fewer it about the setting of the number of MPG when we fixed the maximal b level which mentioned above to be different.

Also, we tested it using a device of 1.5T by this experiment, but it is necessary to study it about the setting of the maximal b level of the said article in future because a signal-to-noise ratio is high with the device of 3.0T.

In the calculation of the MK value of DKI, the number of MPG and a maximal b value were examined the dependence for the MK value.

As a result, the number of MPG to use for calculation of DKI was to use six or more, and the tendency that converged was found in a constant value.

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## 6. Figure legends

Figure 1. ROI set to gray matter and white matter.
Figure 2. MK for the number of b values used in the analysis when the maximum b value is 4500 s/mm$^2$.
Figure 3. MK for the number of b values used in the analysis when the maximum b value is 2100 s/mm$^2$.
Figure 4. MK for the number of b values used in the analysis when the maximum b value is 1500 s/mm$^2$.
Figure 5. MK dependence on maximum b value.
Figure 6. Coefficient of variation in the number of b value used in the analysis when the maximum b value is 4500 s/mm$^2$.
Figure 7. The coefficient of variation at each maximum b value.