Preliminary Experience of Diffusion Kurtosis Imaging for the Prostatic Gland

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Introduction

Diffusion kurtosis imaging (DKI) is a non-Gaussian diffusion-weighted imaging (DWI) method that can better reflect the complexity of tissue structures than conventional monoexponential model. The parameter *K*, which can be obtained from DKI, can reflect deviations from normal distribution in restricted water diffusion. The purpose of this study was to clarify the differences in parameters between prostate cancer (PC), benign prostatic hyperplasia (BPH), and the benign peripheral zone (PZ) using DKI.

Materials and Methods

Seventeen patients who were histologically proven to have PC and had undergone total prostatectomy after MRI (mean age, 65.9 ± 6.4 years) were investigated in this study. The mean preoperative prostate-specific antigen (PSA) level was 8.68 ± 5.4 ng/mL. Imaging was performed using a 3-T MRI scanner (Achieva, Philips Healthcare, Eindhoven, the Netherlands) using a 6-channel phased-array coil. DWI was performed using 11 b-values (0, 10, 20, 30, 50, 80, 100, 200, 400, 1000, and 1500 s/mm^2). Other parameters were as follows: TR/TE, 5000/49; 3.5-mm slice thickness with 0.1-mm gap; FOV, 240 × 240 mm; and matrix size, 256 × 256. DWI data were analyzed using the PRIDE software (Phillips Healthcare) that fits signal intensities (*S*) as a function of b-value using the equation $S = S_0 \cdot \exp(-b \cdot D + b^2 \cdot D^2 \cdot K/6)$, and the parameters *D* and *K* were obtained (Fig. 1). *K* represents non-Gaussian diffusion behavior, and *D* is a corrected apparent diffusion coefficient (ADC) that accounts for the non-Gaussianity. The software also calculated the standard ADC using a conventional monoexponential fit with the equation $S = S_0 \cdot \exp(-b \cdot ADC)$. Regions of interest (ROIs) were placed within PC, BPH, and benign PZ on the basis of MRI and pathologic findings by the consensus of 2 radiologists. BPH was classified as BPH-low, BPH-mix, or BPH-high depending on the signal intensity of the T2-weighted image. Independent sample *t*-tests and receiver operating characteristic (ROC) analyses were performed to assess the statistical significance, with *P* values less than .05 considered significant.

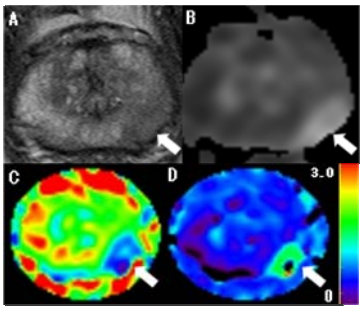

Fig 1: A 73-year-old man (PSA level, 12.1 ng/mL) with PC (solid arrows). A: T2-weighted image, B: ADC-map, C: *D*-map, D: *K*-map. Compared to healthy tissue, tissue with PC showed higher *K* and lower ADC and *D*.

Results and Discussion

Figure 1 shows the DKI parametric map for a typical patient. Compared to healthy tissue, tissues with PC showed higher *K* and lower *D*. Table 1 shows the results of *D*, *K*, and ADC. *D* was significantly lower in PC and higher in BPH-high than in benign PZ. *K* was significantly higher in PC and BPH-low than in benign PZ. Comparing these parameters between PC and various types of BPH, *D* was significantly lower and *K* was significantly higher in PC than in BPH-mix and BPH-high. Although there was no significant difference, *K* trended toward being higher in PC than in BPH-low (*P* = 0.06). ADC was significantly lower in PC than in all types of BPH. Table 2 and Figure 2 demonstrate the results of the ROC analyses for discriminating PC from benign PZ. There was no significant difference in the area under the curve (AUC) between the 3 parameters. However, *K* showed a greater sensitivity than *D* and ADC.

Although it was difficult to distinguish between PC and BPH, especially BPH-low, *K* was significantly higher in PC than in BPH-mix and BPH-high, trending toward being higher in PC than in BPH-low. We used 11 b-values and a maximum b-value of 1500 s/mm^2 in this study. The appropriate number and maximum b-value for DKI has not been established and should be clarified in the future.

Table 1: Results of the Parameters *D*, *K*, and ADC

Parameter	PC	Benign PZ	BPH-low	BPH-mix	BPH-high
D (×10^{-3} mm^2/sec)	1.39 ± 0.30*	1.83 ± 0.34	1.59± 0.36	1.89 ± 0.14**	2.15 ± 0.20*, **
K	1.20 ± 0.25*	0.66 ± 0.23	1.01 ± 0.30*	0.78 ± 0.14**	0.61 ± 0.14**
ADC(×10^{-3} mm^2/sec)	0.94 ± 0.23*	1.50 ± 0.31	1.16 ± 0.28*, **	1.46 ± 0.16**	1.79 ± 0.26*, **

means ± standard deviation

*Significantly different in comparison with benign PZ. **Significantly different in comparison with PC.

Table 2: Results of ROC Analyses for Discriminating PC from Benign PZ

Parameter	AUC	Threshold	Sensitivity (%)	Specificity (%)
D	0.854	≤1.61(×10^{-3} mm^2/sec)	80.95	82.35
K	0.947	>0.842	95.24	88.24
ADC	0.920	≤1.065(×10^{-3} mm^2/sec)	66.67	100.00

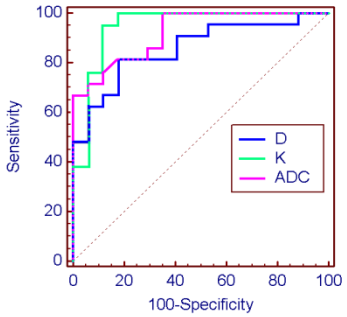

Fig 2: Comparison of ROC curves for discriminating PC from benign PZ. There was no significant difference in the AUC between the 3 parameters.

Conclusion:

We have shown the differences in parameters among PC, BPH, and benign PZ using DKI. The parameter *K* obtained from DKI was significantly higher in PC than in benign PZ, BPH-mix, and BPH-high and trended toward being higher in PC than in BPH-low. DKI may contribute to the diagnosis of PC, especially in the differential diagnosis of PC and BPH.

References:

1) Rosenkrantz AB, et al. Prostate cancer: feasibility and preliminary experience of a diffusional kurtosis model for detection and assessment of aggressiveness of peripheral zone cancer. Radiology 2012; 264(1): 126-35. 2) Lemke A, et al. Diffusion kurtosis imaging in prostate cancer. Proc. Intl. Soc. Mag. Reson. Med. 2011; 19: 45. 3) Oto A, et al. Prostate cancer: differentiation of central gland cancer from benign prostatic hyperplasia by using diffusion-weighted and dynamic contrast-enhanced MR imaging. Radiology 2010; 257(3): 715-23.