Diagnostic values and limitations of ADC in patients with prostate cancer.

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Aims and objectives

Prostate cancer is indolent, so presents no signs of clinical growth. Because of that, routine screening is offered for men over 50-years old. Screening consists of serum PSA levels and digital examination. In case of high PSA levels, usually over 4 ng/ml, detailed examination such as MRI will be followed. The Gleason grading system is a grade given to prostate cancer on a scale of 1-5. The higher the GS, the more aggressive the cancer and the more likely it is to spread.

Among MRI sequences, diffusion-weighted images (DWI) and apparent diffusion coefficient (ADC) are useful tools to detect cancers. DWI and ADC depend on the microscopic mobility of water. Generally, cancer tissue tends to have more restricted diffusion due to its hypercellularity. In mammary cancer and lung cancer, correlation of ADC value and aggressiveness of cancer have been indicated(1,2). And also in prostate cancers, correlation of ADC value and its aggressiveness was reported mainly using 1.5-tesla MRI system(3,4,5).

The purpose of this study was to examine the relationship between ADC value and GS of prostate cancer using 3-tesla MRI system, and to evaluate the sensitivity of tumor detection when ADC map is used.
Methods and materials

This study includes 132 lesions of 70 patients who underwent radical prostatectomy containing 7 patients who underwent core biopsy within 1 month prior to MRI examination from 2009 to 2012. The number of lesions with GS of 3+3 is 32, 3+4 47, 4+3 34, 8 or more 19 as shown in table 1.

MRI examination was performed operating at 3-tesla unit. A single-shot echo-planner imaging was used for diffusion imaging with b value of 0 and 1500 sec/mm². ADC values were calculated of ROIs corresponding to the cancer areas retrospectively using the formula; ADC = - ln (S/S0) / b.
Table 1: The sensitivity of prostate cancer using ADC map given by 3-tesla MRI system.

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Results

A typical case of prostate cancer is shown in figure 1. The prostate cancer of this patient exists in right side of peripheral zone as shown in this macro image (Fig. 1a). Prostate cancer shows low signal intensity on T2WI (Fig. 1b) due to fibrosis and loss of normal glands, high signal intensity on DWI (Fig. 1c), and low signal intensity on ADC (Fig. 1d) due to hypercellularity.

First, we checked the relationship between GS and ADC values. The higher Gleason score was, that is, the more aggressive prostate cancer was, the lower minimum ADC value was (Fig. 2). ADC value has a significantly negative correlation with GS.

Next we checked the sensitivity of prostate cancers using ADC map diagnosed by two doctors. Sensitivity of prostate cancer with GS of 3+4 was 83.0%, GS of 4+3, 97.1%, and 8 or more 94.7% (Table 1). This suggests that the sensitivity of high-risk cancers shows a high level. But the sensitivity of low-risk cancers with GS of 6 is low.

Then we analyzed what factors make it difficult to detect cancers. A relationship between GS and the size of tumors was shown in Fig. 3. This suggests that undetected tumors are mainly with low GS (Fig. 3a). And even in the case of GS of 8, the smaller the size was, the more difficult to detect. Moreover, we highlight the lesions with hemorrhage due to core biopsy (Fig. 3b). This suggests that even in larger lesions and higher-risk cancers, hemorrhage makes it difficult to detect cancers.

Difficult cases of detecting prostate cancer using MRI are shown in figure 4 and 5. Figure 4 shows the case of prostate cancer with GS of 3+3. As shown in this macro image (Fig. 4d), the prostate cancers exist in both peripheral and transitional zones. But any lesions corresponding to the macro image could not be detected on the ADC map as well as other sequences (Fig. 4a, b, c). This indicates that it is difficult to detect low-grade cancers despite its size. Figure 5 shows the case of prostate cancer with hemorrhage. As shown in the macro image (Fig. 5d), prostate cancer exists in both sides of peripheral zone. But in the same area, T1WI shows high signal intensity that indicates hemorrhage due to core biopsy (Fig. 5c). Hemorrhage may change an original ADC value of cancers and makes it difficult to detect prostate cancers (Fig. 5b). Small cancer volume and hemorrhage after core biopsy are considered causes of lowering sensitivity of detecting low-risk cancer.
**Fig. 1:** A typical case of prostate cancer using 3-T MRI system. A prostate cancer in peripheral zone is shown in a macro image (a). The signal intensity of prostate cancer is low on T2WI (b) due to its fibrosis and loss of normal gland, high on DWI (c) and low on ADC (d) due to its hypercellularity.

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Fig. 2: A correlation of Gleason scores and ADC value. Referring the location of total 132 lesions of prostate cancer pathologically proven, we put the ROI on ADC map, then get minimal ADC value. Orange bars indicate average of minimum ADC values in each GS.

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Fig. 3: A correlation of Gleason Score and tumor size. Undetected tumors using ADC maps are shown as orange dots(a). Among these undetected lesions, lesions with hemorrhage due to core biopsy are shown as red dots(b).
**Fig. 4:** Difficult case of detecting prostate cancer with Gleason Score of 3+3. Prostate cancers exist in both peripheral and transitional zones as shown in macro image(d). Any lesions corresponding to the macro image could not be detected on T2WI(a), ADC map(b), contrast-enhanced T1WI(c).
**Fig. 5:** Difficult case of detecting prostate cancer with hemorrhage. Prostate cancers exist in both sides of peripheral zone as shown in macro image(d). High signal intensity in T1WI(c) indicates hemorrhage due to core biopsy. Any lesions corresponding to the macro image could not be detected on T2WI(a), ADC map(b).

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Conclusion

ADC value is found to be a strong negative correlation with Gleason Score. ADC is useful for differentiation between low-risk cancer and high-risk cancer, that is, the lower ADC value is, the more aggressive the prostate cancer is.
References


