The clinical value of ADC maps in the detection of prostate cancer

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Introduction: MR imaging (MRI) has been used for the delineation of the extent of cancer, or for post-therapeutic check-up [1]. Recently the clinical value of diffusion-weighted imaging (DWI) and dynamic MRI in combination with T2-weighted imaging (T2W) has been reported for the screening of prostate cancer in patients with elevated PSA levels [2]. To determine whether the ADC (apparent diffusion coefficient) map generated from DWI can help to detect prostate cancer, we compared ADC maps with step sections from prostatectomy specimens.

Methods: Sixteen male patients who had undergone radical prostatectomy after both an MRI and a subsequent systematic transrectal prostate biopsy were included in this study. Patients underwent MRI (Signa Excite IX; 1.5 T, GE Healthcare) consisting of axial T2W-FSE (TR/TE=5000/87.9), DWI-EPI with parallel imaging (3600/72.6, b-values= 0 and 1000 s/mm^2), and dynamic MRI (fat-suppressed FSPGR: 130/2.0/90^o). The slice thickness/interslice gap was 5 mm/0.5 mm for all sequences.

Visual inspection of ADC maps: The ADC and eADC [exponential ADC: eADC= 1/exp(-b x ADC)] maps were simultaneously prepared on a workstation (AW ver. 4.1; GE Healthcare) from DWI. On the eADC, the color shades used on the ADC map were inverted. If the lesion showed an apparently cold color (blue) on the ADC map or a warm color (red) on the eADC map, it was considered a malignant focus. The fusion images of both T2W images and eADC maps were also prepared to refer to anatomical detail in image interpretation (Figure 1). Two experienced radiologists observed ADC/eADC maps plus fusion images, and recorded any regions suspicious of cancer on axial cross-sectional schemas of the prostate under consensus. A pathologist enclosed the cancerous region with red pen on H&E stain sections from pathological specimens. Both sessions were independently performed, and the correspondence of regions pointed out on the schemas and H&E stain sections were carefully reviewed. To measure the ADC of each tissue, accurate placement of the region of interest (ROI) circle on the ADC maps was ensured at the regions corresponding to the cancerous tissues and noncancerous peripheral zone (PZ) and inner gland (IG; central and transition zone) tissues in the pathological sections. For cancerous tissue, the ROI circle was placed in the cancerous area (≥ 5 mm) as large as possible, with referring to the pathological sections. To avoid any other tissues in ROI, we referred to T2W images. For the accurate ADC measurement, ROI circle was put on PZ or IG as large as possible, with excluding any true and/or false positives. The type of hyperplasia in IG was not considered in putting ROI.

Results: From the step sections of 16 prostate specimens, 66 cancerous foci (32 foci were 5 mm and over, and 34 were below 5 mm in maximum diameter) were pathologically proved. The sensitivity of ADC maps was 78% (25 of 32 lesions; 85% for PZ cancer and 67% for IG cancer) for ≥ 5 mm lesions, and 32% (11 of 34 lesions; 39% for PZ cancer and 18% for IG cancer) for < 5 mm lesions, respectively (Table). There were 43 false positives (FP); six were ≥ 5 mm and 37 were < 5 mm in size. All FP were noted only in IG (Figure 2). The positive predictive values (PPV) were 100% for PZ (100% [≥ 5 mm] and 100% [< 5 mm]) and 19% for IG (57% [≥ 5 mm] and 5% [< 5 mm]). T2W failed to delineate FP from cancerous tissue of IG. On a patient-to-patient basis, 15 of 16 patients were correctly diagnosed to have cancer by the ADC/eADC map alone. The mean ADC (x 10-3 mm2/s) was 0.95±0.11 for the cancerous tissue, 1.83±0.18 for the noncancerous PZ tissue, and 1.40±0.09 for the noncancerous IG tissue. The cancerous tissues showed significantly lower ADC values than those of noncancerous PZ or IG tissues ($p < 0.001$), but no difference was found between the ADC of cancerous tissue and that of FP (0.97±0.07).

Discussion: Recent studies have indicated that DWI can distinguish prostate cancer tissues from benign tissues because of the differences in the ADC values [3-4]. The use of ADC/eADC maps together with DWI would be recommended, because areas with low ADC were more easily recognized on color ADC maps than on DWI alone. Although the ADC/eADC maps are very useful to detect cancerous tissue in PZ, a considerable number of false positives in IG may still bring up an important question in prostate tissue characterization by DWI. Further studies will be necessary to investigate the significance of ADC/eADCmaps using different scanning parameters of DWI [5].

References:

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Table

		≥ 5 mm	< 5 mm	Total
sensitivity	PZ cancer	17/20 (85%)	9/23 (39%)	26/43 (60%)
	IG cancer	8/12 (67%)	2/11 (18%)	10/23 (43%)
	subtotal	25/32 (78%)	11/34 (32%)	36/66 (55%)
PPV	PZ cancer	17/17 (100%)	9/9 (100%)	26/26 (100%)
	IG cancer	8/14 (57%)	2/39 (5%)	10/53 (19%)
	subtotal	25/31 (81%)	11/48 (23%)	36/79 (46%)

Figure 1 Serial ADC-T2W fusion images. A malignant focus is noted in theright IG (white arrow). T2W failed to detect the cancer.

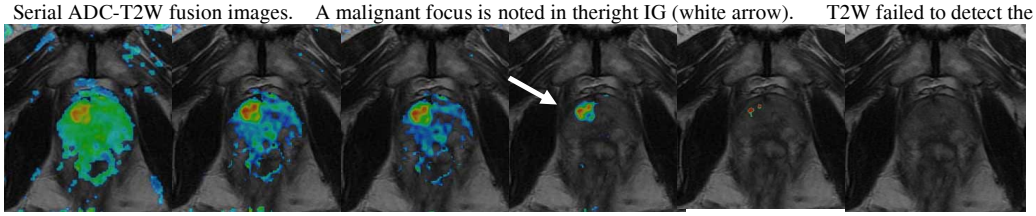

Figure 2 A small cancer (4 mm) is noted in PZ (arrow). A false positive is also seen on the eADC map (white arrow).

eADC H&E section T2W (T2W failed to detect the cancer.)