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Prostate carcinoma: Accuracy of diagnosis and differentiation with Dynamic Contrast-Enhanced MRI and Diffusion Weighted Imaging

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KEYWORDS
Cancer prostate; DCE-MRI; DWI

Abstract Background: Diffusion weighted image (DWI) and dynamic contrast enhanced MR imaging (DCE-MRI) provide excellent parameters that are useful for differentiating cancer from normal tissue in prostatic cancer patients.

Purpose: To define the diagnostic value of diffusion weighted image (DWI) and dynamic contrast enhanced MR imaging (DCE-MRI) and determine whether the combination of the two techniques provides higher diagnostic accuracy for prostate cancer than each technique alone.

Material and methods: 30 patients suggested to have prostate cancer based on high PSA value underwent MRI examination including axial T2-WI, diffusion weighted image (DWI), apparent diffusion coefficient (ADC) and dynamic contrast enhanced MRI (DCE-MRI). The final diagnosis was confirmed by histopathological study of the TRUS-guided biopsies.

Results: The sensitivity of DCE-MRI, ADC at 1.2 and ADC at 1.4 in detection of prostatic carcinoma was 100%, 84.6% and 100% respectively ($P = 0.000$). The highest validity for cancer prostate is DCE-MRI (Kappa = 0.93) followed by ADC at 1.4 (Kappa = 0.86) then ADC at 1.2 (Kappa = 0.79).

Conclusions: DCE-MRI and DWI have high sensitivity to differentiate cancerous from non-cancerous prostatic tissue, and the combination of both techniques increase the diagnostic accuracy of prostatic cancer than each one alone.

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1. Introduction

Prostate cancer is one of the most common malignancies in elderly men and preoperative identification of localized prostate cancer for early detection and staging are issues of major concern and lead to a complete cure (1). The major goal for prostate cancer imaging in the next decade is more accurate disease characterization through the synthesis of anatomic,
functional, and molecular imaging information (2). MRI has the potential to improve the identification of prostate cancer at an early stage (3).

Addition of dynamic contrast enhancement, spectroscopy, and diffusion weighted imaging to standard T2-weighted sequence is practical, and improves MRI of the prostate (4).

The principles of DCE-MRI are based on tumor angiogenesis, tumors produce factors that promote vessel formation and increase permeability, compared with normal vessels (5). The pattern of enhancement of the malignant prostatic tissue is different from that of normal tissue (6).

Relative peak enhancement is the most accurate perfusion parameter for prostatic cancer detection in both peripheral and central zones (7). Previous studies demonstrated parametric imaging of the wash-in rate was more accurate for the detection of prostate cancer in the peripheral zone; however, there is a significant overlap between the wash-in rate for cancer and that for normal tissue in the transitional zone (8).

Time-signal intensity curves (TIC) from dynamic contrast-enhanced MR imaging were classified into three types based on their shapes (Fig. 1). The X-axis represents the number of series in MRI imaging expressed as (time in seconds) and the Y-axis represents the signal intensity in arbitrary units (relative enhancement) (9). The type A TIC was characterized by an early peak enhancement and a time-to-peak value of no more than 60 s. The type B TIC was characterized by an intermediate early enhancement and a time-to-peak value of no less than 60 s and not greater than 100 s. The type C TIC was characterized by delayed enhancement and no signal peak after a continuous increase in signal intensity for 3 min (9).

DWI is based on the principle of random molecular motion of water in tissues (10). Normal prostate tissue exhibits signal loss, whereas areas of densely packed tumor cells reveal bright on the raw DWI. The use of DWI enables the calculation of the apparent diffusion coefficient (ADC) (11).

1.1. Aim of work

The purpose of this study is to compare the diagnostic utility of DWI (ADC map), DCE-MRI, and a combination of both techniques in the localization and detection of prostatic cancer. This study also assesses the feasibility of using DWI and/or DCEI targeted-biopsy instead of random biopsy.

2. Material and methods

A prospective study of thirty men (age range 36–83 years with mean age = 69.7 years) suggested to have prostate cancer on the basis of high PSA value (greater than 4.0 ng ml 70–1) or abnormal per-rectal examination findings, DWI-MR and dynamic contrast enhancement MRI using a 1.5 T superconducting MR system (Signa Excite HD; GE Healthcare, Milwaukee, USA) with a 8-channel phased array coil, followed by transrectal ultrasound (TRUS) biopsy using endorectal biplane convex 7.5 MHz probe of ultrasound machine (LOGIQ-9 GE Healthcare) to avoid post-biopsy hemorrhage and inflammatory signals that may obstacle accurate interpretation of gland images.

The study started in March 2012 and finished in November 2014. Informed consent was obtained from all cases, and approval for this study was obtained from the ethics review board of our institution.

Exclusion criteria included patients who have contraindication to MRI scanning and patients underwent prior hormonal therapy or if prostatectomy was done following radiotherapy. Histopathological diagnosis of prostate cancer had been proven by TRUS biopsy in all cases.

2.1. Biopsy protocol

Before, the biopsy, the advantage and disadvantage of the biopsy (including pre-procedure, procedure and post-procedure recommendations) were explained to each patient and written informed consent was obtained. We did biopsy for questionable areas detected by MRI under TRUS-guidance using automated spring-loaded 18-gauge biopsy gun (Vitesse biopsy gun. Opti Med.). Using endorectal biplane (convex 7.5 MHz) probe of ultrasound machine, more than two biopsies for the suspected area by MRI were taken. All biopsy specimens were labeled to determine the biopsy location and all specimens were examined by one experienced uropathologist.

2.2. MRI protocol

Conventional MRI consisted from, T2-weighted fast spin-echo sequence were acquired in axial plain using the following parameters {TR:6517, TE:121 /Ef, EC: 1/1 41.7 kHz, FOV:24×24, 4.5 thk/0.5 sp, NEX:4.00 and matrix: 384×320}, axial T1-weighted fast spin-echo sequence using the following parameters {TR:933, TE:11/Ef, EC:1/1 19.2 kHz, FOV:24×24, 5.5 thk/0.5 sp, NEX: 2.00 and matrix:288×256} and sagittal T2-weighted fast spin-echo

Fig. 1 Time-signal intensity curves (TIC) from dynamic contrast-enhanced MR imaging were classified into three types based on their shapes. The onset time (a), the time to peak (b), the wash-in rate (c), represent the velocity of enhancement and defined by d-c/b-a, where (d), represent the maximum (peak) enhancement (9).
sequence using the following parameters (TR:4383, TE:102/EF, EC:1/1 50KHz, FOV:29 × 29, 4.0 thk/1.0sp, NEX:2.00 and matrix:384 × 256). T2-weighted fast spin-echo sequence were acquired in axial plain, axial T1-weighted fast spin-echo sequence and sagittal T2-weighted fast spin-echo sequence.

Axial DWI was obtained by using a single-shot spin-echo-planar imaging sequence (EPI) with the following parameters: 3400/117 and b value of 0 and 1000 s/mm², along all three directions in the axial plane. Full echo information was obtained with a band width of 1220 Hz/pixel and a matrix size of 256 × 156, the field of view was 22 cm, with 4-mm section thickness and no intersection gap, including the entire prostate and seminal vesicle, the orientation and location of these images were identical to the axial T2-weighted images. The use of DWI facilitates the calculation of the apparent diffusion coefficient (ADC), the quantitation analysis of ADC is accomplished retrospectively on a scanner window. The ADC maps were converted to 8-bit gray-scale images with window width (WW) of 121, 971, 1030 and window level (WL) of 485, 515, 605, with this method, regions of low ADC were darker than regions of high ADC, with areas less than or equal to 1 × 10⁻³ mm²/s. being black.

2.3. Dynamic contrast-enhancement MR imaging

Currently no standard MR imaging protocol for dynamic contrast enhancement MR examination has been completely established for prostate imaging (12), but in our institution, we use a modified LAVA technique (liver acquisition with volume acquisition) by performing a 3D-axial T1-weighted fast spoiled gradient-recalled echo LAVA sequences with the following parameters: TR:4.2,TE:2, EC:1/1 62.5 kHz, TI:7, OV:24 × 24, matrix: 256 × 256, 4.0 thk/-2.0 ov, zerofill interpolation process with PI during triphasic acquisition of entire prostate after contrast infusion at arterial, venous and delayed phase of contrast administration, in which 5 identical sequences of 40 slices every 10 s for 14 s. each (acquisition duration), started immediately after administration of contrast agent, gadoteric acid (Dotarem, Guerbet, Roissy Cdg, France) at dose of 0.1 mmol/kg and rate of 3 ml/s via an automatic-injector, followed by 20 ml. flush of saline. Dynamic MR Images were transferred to a diagnostic workstation, and dynamic MR analysis software was used for the evaluation.

The DCE-MRI and DWI were analyzed by commercial software (Functool; GE Healthcare, Milwaukee, USA), for image post-processing, parametric map generation and ROI enhancement measurement, correlation between the initial suspicious DCE-MRI findings and the DWI region of interest (ROI) was performed.

In these maps, the strongly enhanced lesions appear red, intermediate enhanced lesions appear orange or yellow, whereas low enhanced lesions appear green.

Focal regions with large positive enhancement integral values are indicative of tumor involvement. For both the right and left peripheral zones, one slice was selected if there is strongly enhanced lesion in comparison with the surrounding tissue was detected and the region of interest (ROI) was placed and traced on the enhanced lesion on a consensus basis by us. If strongly enhanced lesion was not visible, a slice through the middle of the gland was selected and a ROI was placed over the area encompassing both peripheral zones. For the right and left inner glands, a slice through the middle of the gland was selected and ROIs were placed over the area encompassing both sides of the inner gland because there was inhomogeneous enhancement from coexisting benign prostatic hyperplasia in many cases (9).

2.4. Quantification of enhancement

A time-intensity curve (TIC) for each site was obtained from the dynamic images. TICs were classified into three types based on their shapes (1).

For the peripheral zone sites, we defined type A and B TICs as positive and type C TIC as negative on DCE-MRI. Most normal peripheral zones did not show hypervascularity. As to the inner gland sites, normal inner glands and coexisting BPH often showed moderate vascularity, thus, we defined only type A TIC as positive and type B and C TICs as negative on DCE-MRI.

3. Results

In 30 patients, serum PSA exceeded normal range (PSA was greater than 4.0 ng/ml). Digital rectal examination (DRE) was positive for suspecting malignancy in 4 patients (by palpating hard prostatic mass) and negative for 9 patients (no definite palpable prostatic masses). Patient were comprehensively evaluated for cancer detection, localization and staging with PSA, DRE, Noncontrast enhanced MRI (T2-WL/DWI & ADC maps), DCE-MRI and TRUS MRI-Targeted biopsy, cancer was detected in 13 patients (Figs. 2–4) with Gleason scores ranged from 3 to 10. Prostate cancer was excluded in 17 patients (Fig. 5). DWI was not sensitive in detection of prostatic cancer. The 13 patients diagnosed as cancer prostate underwent surgical intervention.

Central zone (CZ) biopsied in 15 patients, transitional zone (TZ) in 5 patients and peripheral zone (PZ) in 10 patients, biopsies were taken from 2 sites in 11 patients and 3 sites in 19 patients (Table 2). The final diagnosis was adenocarcinoma in 13 cases, benign prostatic hyperplasia in 14 cases, prostatic hyperplasia with prostatitis in 2 cases and nodular prostatic hyperplasia in one case (Table 2).

The sensitivity of DCE-MRI, ADC at 1.2 and ADC at 1.4 in detection of prostatic carcinoma was 100%, 84.6% and 100% respectively (Table 1), while the sensitivity of the PSA was 76.9%. So the highest validity for cancer prostate is DCE-MRI (Kappa = 0.93) followed by ADC (Fig. 6) at 1.4 (Kappa = 0.86) then ADC at 1.2 (Kappa = 0.79). ADC showed the highest agreement with DCE-MRI (Tables 2 and 3).

The accuracy of DCE-MRI in detection of cancer prostate was 96.7%, the accuracy of ADC at 1.2 × 10⁻³ mm²/s and at 1.4 × 10⁻³ mm²/s was 90% and 93.3% respectively. The overall accuracy when adding ADC at 1.4 with DCE-MRI was 96.7%, while the accuracy of PSA was 66.7%.

4. Discussion

T2WI provides high-resolution images that clearly define prostate anatomy. DWI measures the diffusion of water molecules through tissue in the presence of a strong magnetic field and radiofrequency pulses. Prostate cancer exhibits a
Fig. 2  Biopsy-proved adenocarcinoma in a 75-year-old man (a) Axial T2-weighted image shows an area of low signal intensity (arrow) in the left peripheral zone. (b) Axial diffusion-weighted image shows high signal intensity in the same area (arrow). (c) ADC maps show a low signal and ADC value in the same area (arrow). (d) Wash-in MR image shows a higher wash-in rate in the same area (arrow) than in other areas. (e) Wash-out MR image shows a higher washout rate in the same area (arrow) than in other areas. (f) Time-signal intensity curve from dynamic contrast-enhanced MR imaging shows faster and stronger enhancement and post-initial plateau curve.
Fig. 3  Biopsy-proved adenocarcinoma in 70-year-old man (a) Axial T2-weighted image shows an area of low signal intensity (arrow) in the center of peripheral zone. (b) Axial diffusion-weighted image shows high signal intensity in the same area (arrow). (c) ADC maps show a low signal and ADC value in the same area (arrow). (d) Wash-in MR image shows a higher wash-in rate in the same area (arrow) than in other areas. (e) Wash-out MR image shows a higher washout rate in the same area (arrow) than in other areas. (f) Time-signal intensity curve from dynamic contrast-enhanced MR imaging shows faster and stronger enhancement and post-initial rapid washout curve.
Fig. 4  Biopsy-proved adenocarcinoma in a 82-year-old man (a) Axial T2-weighted image shows an area of low signal intensity (arrows) in the left central and both peripheral zones, it infiltrates the posterior capsule with bulge beyond prostatic margin and lateral recto-prostatic angle effacement (arrow heads) caused by peripheral zone tumor. (b) Axial diffusion-weighted image shows high signal intensity in the same area (arrow). (c) ADC maps shows a low signal and ADC value in the same areas (arrow), moreover, diffusion shows area of restriction diffusion in the left pubic ramus. (d) Wash-in MR image shows a higher wash-in rate in the same areas (arrow) than in other areas. (e) Wash-out MR image shows a higher washout rate in the same area(arrow) than in other areas. (f) Time-signal intensity curve from dynamic contrast-enhanced MR imaging shows faster and stronger enhancement and post-initial rapid wash-out curve, the abnormal area at diffusion shows rapid strong wash-in with post-initial plateau curve of metastatic deposit.
Fig. 5  Biopsy-proved nodular prostatic hyperplasia in 83-year-old man (a) Axial T2-weighted image shows suspicious area of low signal intensity (arrow) in the left PZ. (b) Axial diffusion-weighted image shows high signal intensity in the same area (arrow). (c) ADC maps show a low signal and high ADC value in the same area (arrow). (d) Wash-in MR image shows a higher wash-in rate in the same area (arrow) than in other areas. (e) Wash-out MR image shows similar washout rate in the same area (arrow) as other areas. (f) Time-signal intensity curve from dynamic contrast-enhanced MR imaging shows faster and stronger enhancement and post-initial persistent rising curve.
reduced diffusion of water compared to normal prostate tissue due to its tightly packed cells with a relative decrease in water content (13).

The glandular-ductal tissues have lower peak enhancement (PE) and higher (ADC) than the stromal-low ductal tissues (14).

In our study, benign prostatic lesions were more common than malignant lesions, benign lesions were diagnosed in 17 cases; 10 cases of them were in the central zone, 4 cases were in the peripheral zone and 3 cases were in the transitional zone, while malignant lesions (cancer prostate) were diagnosed in 13 cases which were more common in the peripheral zone (6 cases) followed by central zone (5 cases) then the transitional zone (2 cases) and these results agreed with that of Manenti et al. (15).

Our study showed that prostatic cancer detected by T1-WI, DCE-MRI and ADC maps is more accurate than that detected by DWI and T2-WI all over the whole different prostatic zones with sensitivity and specificity reach 100% and 94% respectively at DCE-MRI and at lower ADC value ($1.4 \times 10^{-3} \text{ cm}^2/\text{s}$) the sensitivity and specificity reach

### Table 1  Validity of DWI, DCE, ADC and PSA in diagnosis of cancer prostate.

<table>
<thead>
<tr>
<th></th>
<th>Positive for malignancy (13 cases)</th>
<th>Negative for malignancy (17 cases)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Kappa</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCE-MRI</td>
<td>13</td>
<td>16</td>
<td>100.0</td>
<td>94.1</td>
<td>92.9</td>
<td>100.0</td>
<td>0.93</td>
<td>0.000</td>
</tr>
<tr>
<td>ADC at $1.2 \times 10^{-3} \text{ mm}^2/\text{s}$</td>
<td>11</td>
<td>16</td>
<td>84.6</td>
<td>94.1</td>
<td>91.7</td>
<td>88.9</td>
<td>0.79</td>
<td>0.000</td>
</tr>
<tr>
<td>ADC at $1.4 \times 10^{-3} \text{ mm}^2/\text{s}$</td>
<td>13</td>
<td>15</td>
<td>100.0</td>
<td>88.2</td>
<td>86.7</td>
<td>100</td>
<td>0.86</td>
<td>0.000</td>
</tr>
<tr>
<td>PSA at 1.6</td>
<td>10</td>
<td>10</td>
<td>76.9</td>
<td>58.5</td>
<td>58.8</td>
<td>76.9</td>
<td>0.34</td>
<td>0.05</td>
</tr>
</tbody>
</table>

DWI: diffusion weighted image ($\times 10^{-3} \text{ mm}^2/\text{s}$) & ADC: Apparent Diffusion Coefficient & PPV: positive predictive value & NPV: Negative predictive value & DCE: Dynamic contrast enhancement & PSA: prostatic surface antigen.

### Table 2  Validity of DWI, DCE, biopsy in diagnosis of cancer prostate.

<table>
<thead>
<tr>
<th></th>
<th>Total number (30)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td><strong>DWI</strong></td>
<td></td>
</tr>
<tr>
<td>Hyperintense</td>
<td>20</td>
</tr>
<tr>
<td>Hypointense</td>
<td>10</td>
</tr>
<tr>
<td><strong>DCE</strong></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>14</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>9</td>
</tr>
<tr>
<td><strong>Biopsy</strong></td>
<td></td>
</tr>
<tr>
<td>2 sites</td>
<td>11</td>
</tr>
<tr>
<td>3 sites</td>
<td>19</td>
</tr>
<tr>
<td><strong>Site of biopsy</strong></td>
<td></td>
</tr>
<tr>
<td>CZ (central zone)</td>
<td>15</td>
</tr>
<tr>
<td>TZ (transitional zone)</td>
<td>5</td>
</tr>
<tr>
<td>PZ (peripheral zone)</td>
<td>10</td>
</tr>
<tr>
<td><strong>Final diagnosis</strong></td>
<td></td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>13</td>
</tr>
<tr>
<td>Benign prostatic hyperplasia</td>
<td>14</td>
</tr>
<tr>
<td>Prostatic hyperplasia with prostatitis</td>
<td>2</td>
</tr>
<tr>
<td>Nodular prostatic hyperplasia</td>
<td>1</td>
</tr>
</tbody>
</table>

**Fig. 6** ROC curve showing validity of ADC value in diagnosis of cancer prostate.

### Table 3  Agreement between DCE and ADC (at 1.2), ADC (at 1.4) and PSA.

<table>
<thead>
<tr>
<th></th>
<th>DCE (dynamic contrast enhancement)</th>
<th>Kappa</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A ($N = 14$)</td>
<td>B &amp; C ($N = 16$)</td>
<td></td>
</tr>
<tr>
<td>ADC $1.2 \times 10^{-3} \text{ mm}^2/\text{s}$</td>
<td>Abnormal 11</td>
<td>1</td>
<td>0.73</td>
</tr>
<tr>
<td>Normal</td>
<td>3</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>ADC $1.4 \times 10^{-3} \text{ mm}^2/\text{s}$</td>
<td>Abnormal 14</td>
<td>1</td>
<td>0.93</td>
</tr>
<tr>
<td>Normal</td>
<td>0</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>PSA</td>
<td>Abnormal 10</td>
<td>7</td>
<td>0.27</td>
</tr>
<tr>
<td>Normal</td>
<td>4</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

ADC showed the highest agreement with DCE-MRI one case overestimated as malignant by DCE-MRI. (DCE: Dynamic contrast enhancement & DWI: diffusion weighted image & ADC: apparent diffusion coefficient & PSA: prostatic surface antigen).
100% and 88% respectively, by this way our results may add a new idea than before which mentioned that DWI should be combined with T2WI. It has shown that DWI combined with T2WI has superior diagnostic accuracy to T2WI alone, with sensitivity and specificity of 85–90% and ROC-AUC of 0.80–0.90 when compared to radical prostatectomy findings (7,16,17).

At the same time our results are complementary to results obtained by AbdelMaboud et al. (18), who stated that prostatic cancers had lower ADC value than that of the healthy prostate, it was \(1.484 \pm 0.289 \times 10^{-3} \text{mm}^2/\text{s}\) for the histopathologically proven benign peripheral zone, and \(0.737 \pm 0.154 \times 10^{-3} \text{mm}^2/\text{s}\) for the histopathologically proven cancer prostate.

In our study the demonstration of prostate cancer arising from inner gland is difficult than in peripheral gland in which, in the peripheral zone the sensitivity of DCE and ADC maps was similar but the specificity and accuracy of DCE were greater than DCE-MRI, however ADC maps were good in excluding cancer in which four positive sites on DCE-MRI (giving rise to type B TIC) were negative on ADC maps among the histopathologically confirmed benign sites and our findings are compatible with those of Emad-Eldin et al. (19) who stated that the CZ and PZ of normal prostate were easily discriminated on diffusion and ADC images. (The signal intensity of BPH nodule was non-homogeneous and lower than that of PZ on ADC map.) Prostatic cancer showed high signal intensity on DWI and low signal intensity on ADC map.

The mean ADC value of prostate carcinoma was significantly lower than that of normal CZ, PZ, and BPH nodule \((P < 0.05)\). The PZ tissue had a significantly higher ADC value than CZ \((P < 0.05)\). The ADC value of BPH lesions was significantly lower than that of CZ \((P < 0.05)\).

Thus, hypervascularity denoted by type B TICs at peripheral zone may not be judged as positive for cancer in contrast to type A TICs; however these results approximate the results obtained by Kozlowski et al. (20) that stated that the sensitivity and specificity values were 54% and 100% respectively for the ADC data, and 59% and 74% respectively for DCE-MRI data. But evaluation of this result with larger number of patients with prostate cancer or hypervascular lesions will be necessary.

According to our study, type A dynamic enhanced curve in kinetic evaluation of prostatic lesion was detected in all PC at different zones and one benign case at peripheral zone and type C curve was detected in all benign cases at central and transitional zone and type B curve at all benign cases of peripheral zone as mentioned before in addition to some cases at central zones which is compatible with other results stated that DCE-MRI is less operator dependent, and high-temporal resolution DCE-MRI can be used to detect the first-pass of a contrast agent providing quantitative modeling parameters. Turnbull et al. (21) successfully differentiated prostate cancer from BPH using a two-compartment simplex minimization technique, in which the concentration of Gd-DTPA is assumed to be proportional to the relative increase in FSPGR signal.

Engelbrecht et al. (7) evaluated methods that were shown to provide more accurate estimations of pharmacokinetic parameters. Quantitative DCE-MRI might therefore have the capacity to visualize the focus of cancer within the inner gland of the prostate.

In central and transitional zones the sensitivity, specificity and accuracy of DCE-MRI were greater than ADC maps, particularly when type A TIC was defined as positive, in which three positive sites on DCE-MRI were negative on ADC maps among histopathologically confirmed cancer sites and this result is in agreement with those by Ito et al. (9) who stated the visualization of prostate cancers arising from the inner gland is difficult because coexisting BPH may produce a signal similar to that of cancer nodules with marked vascularity and when type A and B TICs were defined as positive sensitivity improved but specificity was substantially reduced.

Therefore, we suggest that the ADC map is helpful as a supplement to DCE-MRI images rather than as a substitute for DCE-MRI images and this is agreed with the results obtained by Lim et al. (22).

Based on our current results, unenhanced MRI (comprised of DWI, ADC maps and T2-WI) cannot be replaced by DCE-MRI for accurate detection of prostatic, although the accuracy and sensitivity of both imaging techniques were not significantly different and however our results are disagreeing with that obtained by Iwazawa et al. (23) who stated that detection of central-gland cancer by DCE-MRI alone and by DWI alone was nearly equal. On the other hand the detection of central gland cancer by T2-WI or DCE-MRI is often difficult because of zonal T2 contrast between cancer and normal tissue is relatively low, in addition, central gland tissue is more susceptible to enhancement with gadolinium resulting in insufficient contrast between cancer tissue and normal tissue, our explanation for this difference is that we use dynamic, kinetic evaluation of benign and malignant tissues which agreed with recent authors, such as Delongchamps et al. (24) who stated that with the usage of DCE-MRI is able to assess tissue vascularization via the acquisition of contrast-enhanced T1-weighted sequences measuring specific parameters, such as time to peak enhancement and time to wash-out.

In this respect, DCE-MRI is superior to other imaging modalities but could not replace them due to the need of specific benefit of each of them. In addition we found that T1-WI DCE-MRI was the only sequence that can detect extra-glandular extension and as a result played critical role in staging of disease as well as plane strategy of treatment which agreed with the results from different studies including Villers et al. (3) showed that DCE-MRI is one of the tools that help in pre-operative identification of these anterior cancers. It was also confirmed by Akin et al. (25).

In our study, we depend on all MR sequence acquisition analysis to guide prostatic biopsy and this agreed with Vargas and Hricak (26) who mentioned that multiple MRI sequences were used to guide prostate biopsies is important to clarify the interpretability of the results decrease the probability of inconsistent or incompatible results due to differences in targeting approaches.

Our results showed that MRI-targeted biopsy is an accurate technique for detecting and quantifying intra-capsular tumor as well as benign lesions with a sensitivity approached 100%, which agreed with the result obtained by Tanimoto et al. (27), in which forty-four prostate cancers were detected by biopsy in a series of 83 patients who had pre-biopsy DWI, DCE-MRI in combination with T2-WI. The sensitivity for the detection of the prostate cancer was 95% and also, we agreed with the meta-analysis obtained by Moore et al. (28) who found that while MRI-targeted and standard biopsy
approaches detected cancer at similar rates, the MRI-targeted approach decreased the diagnosis of clinically insignificant cancers and reduced the percentage of men with abnormal prostate-specific antigen or digital rectal examination findings that required biopsy.

In our study we used 8-channel pelvic phased-array coil (PPA) as it is better than endorectal coil in providing excellent image quality in prostate MRI because of high spatial resolution, which agreed with other author like Husband et al. (29).

One interesting thing in this study is that we use modified LAVA (liver acquisition with volume acquisition) technique consists of 3-D T1-weighted gradient echo-sequence with optimized fat sat fulfills at last the need to acquire dynamic image during arterial and venous phases after injection with high in-plane and through-plane spatial resolution which agreed with other authors like Verma and Rajesh (12), who mentioned that, there is currently no standard protocol for DCE-MRI of the prostate, but DCE-MR of the prostate is usually performed using a fast imaging sequence. Three-dimensional gradient-echo sequences enable the entire prostate to be imaged in a few seconds.

Conflict of interest

The authors declare that there are no conflict of interest.

References

