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Original Article

Radiology Section

Diffusion Weighted Imaging on a 3 Tesla Magnetic Resonance Scanner as a Diagnostic Tool in Early Detection of Prostate Cancer

RUCHIRA DAS[1], ARCHANA SINGH[2], SUDIPTA SAHA[3], SHUBHAM SAHA[4], DILIP KUMAR PAL[5], UTPALENDU DAS[6], MADAN KARMAKAR[7]

ABSTRACT

Introduction: Multiparametric Magnetic Resonance Imaging (MRI) of prostate including Diffusion Weighted Imaging (DWI) is greatly evolving as a diagnostic tool in prostate cancer. Incidence of prostate cancer in India is on rise with most of the cases been diagnosed in late stages. In this scenario, DWI imaging can pick up the cases at an earlier stage causing a significant impact in the patient management.

Aim: To assess the role of DW-MRI as a non invasive initial investigation tool in prostate carcinoma prior to biopsy.

Materials and Methods: The study was a prospective observational study conducted during April 2014 to March 2015 in the Department of Radiodiagnosis in collaboration with Department of Urology in a hospital in Kolkata. A total of 34 patients with a clinical suspicion of prostate cancer underwent prostate DWI-MRI by a 3T scanner before Transrectal Ultrasound (TRUS)-guided biopsies. IBM Statistical Package for Social sciences (SPSS) version 17.0 was used for statistical analysis and the sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were determined.

Results: All patients (100%) with biopsy proven adenocarcinoma showed diffusion restriction. A total of 95.8% were PI-RADS 5. False positive results were found in two patients. The sensitivity, specificity, PPV and NPV were 100% (95% CI=85.75% to 100.00%), 80% (95% CI=44.39% to 97.48%), 92.31% (95% CI=74.87% to 99.05%) and 100% (95% CI=63.06% to 100.00%)

Conclusion: From the present study, it was noted that sensitivity of DWI is very high (100%). DWI also has a high specificity and positive predictive value. Hence, DWI is one of the most effective adjunct non invasive tools for initial investigation in prostate carcinoma which improves the diagnostic performance and helps in performing targeted biopsies from the suspicious prostatic lesion.

Keywords: Biopsy, Diagnostic imaging, Magnetic resonance imaging, Prostate carcinoma

INTRODUCTION

Despite advances in prostate cancer detection and treatment, it remains the second leading cause of cancer deaths among males in Europe. The incidence rate of prostate cancer is 3.9 per 100,000 men in India and it causes 9% of all cancer-related mortality [1,2].

Prostate MRI particularly DWI, has evolved in a big way for early diagnosis of prostate carcinoma and its staging [3-6]. MRI not only helps in tumour detection, localisation, staging, but also in restaging and follow-up. It also provides information about tumour aggressiveness which correlates well with Gleason score and DWI effectively assesses the tumour volume for subsequent radiotherapy [7]. The DWI component of MRI scan has far stronger correlations with both cancer grade and volume than T2 and Dyanamic Contrast Enhancement (DCE) [7]. This superior performance of DWI relates to the direct dependence of image contrast on differences in the rate of diffusion of water molecules due to tissue microstructure changes. Cancer-associated changes significantly alter the water diffusion behaviour [8].

The objective of this study was to assess the role of DW-MRI of the prostate in detection of the prostatic carcinoma in a male population with elevated Prostate-Specific Antigen (PSA) and abnormal Digital Rectal Examination (DRE) or normal PSA and abnormal DRE as an initial investigation modality prior to TRUS guided biopsy.

MATERIALS AND METHODS

This is a prospective observational study conducted between April 2014-March 2015, in the Department of Radiodiagnosis in collaboration with the Department of Urology of IPGME and R-SSKM Hospital, Kolkata, West Bengal, India. The study was approved by the Institutional Ethical Committee (Inst/IEC/533) and informed consent was obtained from patients in their own language. The study was conducted on 34 patients who underwent MRI and prostate biopsy.

Inclusion criteria: Patients with elevated PSA (>4 ng/mL) and DRE suspicious of prostate cancer, Patients with normal PSA but DRE suspicious of prostate cancer and previously negative TRUS biopsy patients with elevated PSA were included in the study.

Exclusion criteria: The known patients of prostate cancer were excluded from the study.

For prostate MRI, 3.0 Tesla MRI machine, with 16 channel Body coil 3T Torso Array was used. The sequences evaluated in this study were axial DWI and ADC (Apparent Diffusion Co-efficient). Axial DWI images were taken using TR/TE 4217/257 ms, number of excitations (average) 6, matrix size 176×176, slice thickness 3 mm, interslice gap 0.5 mm and acquisition time 10 minutes with free breath. DWI was obtained by using diffusion gradients with three b-values (0, 800, and 1000 s/mm^2). ADC map was generated from the system using 'Functool'.

A 12 core biopsy was used as the gold standard for this study. A 5.0 to 7.5 mHz transducer was used for transrectal imaging of the prostate. An 18-gauge Bard biopsy needle loaded in a spring-action automatic biopsy device was used to procure specimens. Cores were taken from the base, midzone and apex.

Prostate Imaging Reporting and Data System (PI- RADS) scoring was used to diagnose Ca Prostate [7]. Ranging from 1 (most likely not cancer) to 5 (very suspicious):

PI- RADS 1 - Very Low

PI- RADS 2 - Low

PI- RADS 3 - Intermediate

PI- RADS 4 - High

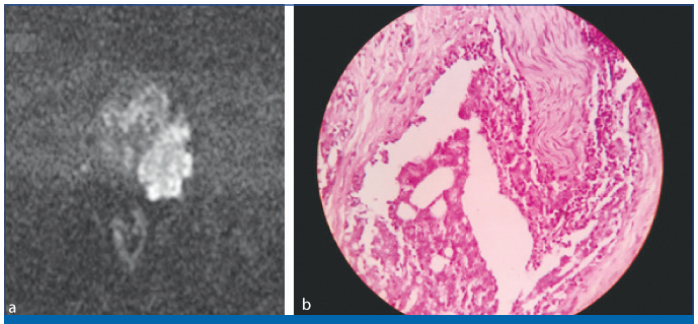
PI- RADS 5 - Very High

STATISTICAL ANALYSIS

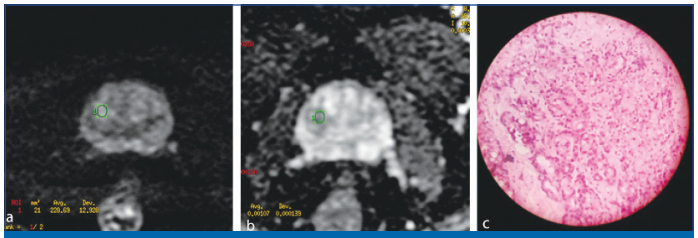
The results were compiled and analysed using computer software, IBM SPSS statistics version 17.0. Descriptive statistical data, including sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) were determined.

RESULTS

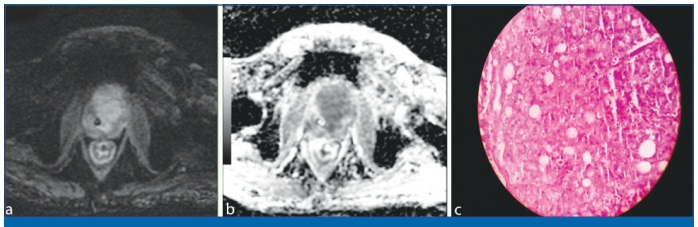
Data from 34 patients was analysed. All patients (100%) with biopsy proven adenocarcinoma showed diffusion restriction [Table/Fig-1-6]. However, we found false positive results in two patients. Histopathologically, one was diagnosed as chronic prostatitis and the other as benign prostatic hyperplasia [Table/Fig-7,8]. The sensitivity, specificity, PPV and NPV was 100% (95% CI= 85.75% to 100%), 80% (95% CI=44.39% to 97.48%), 92.31% (95% CI=74.87% to 99.05%) and 100% (95% CI=63.06% to 100%) [Table/Fig-9].



[Table/Fig-1]: a) Showing diffusion restriction at b =800; b) Histopathology showed Gleasonn score 7 adenocarcinoma with perineural involvement [H&E:X100].



[Table/Fig-2]: a,b) DWI image and corresponding ADC showing diffusion restriction in b=800; c) Biopsy showed Gleason score 8 adenocarcinoma [H&E:X100].

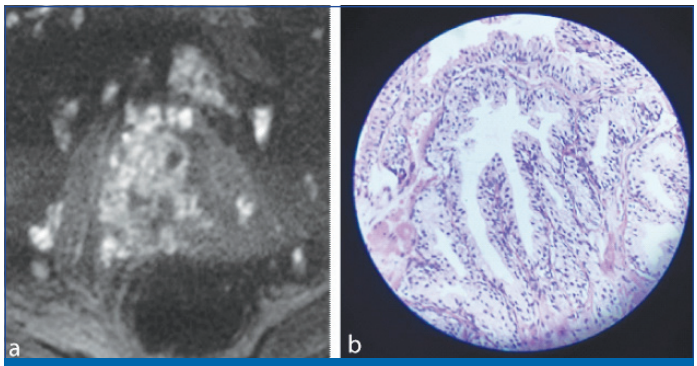


[Table/Fig-3]: a,b) Showing hyperintense mass on DWI involving anterior and central gland, peripheral zone and periprostatic area; ADC shows corresponding hypointensity; c) Biopsy revealed Gleason grade (5+4=9) (H&E:X400) prostatic adenocarcinoma with periprostatic spread.

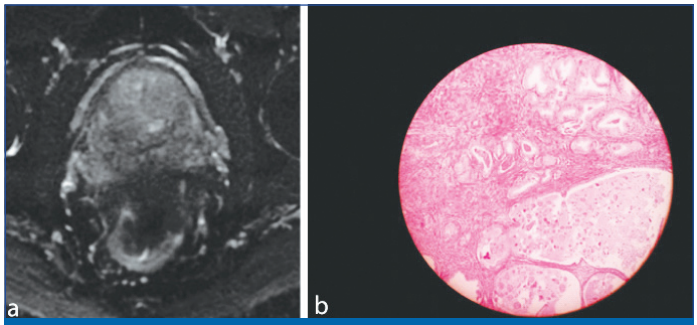
Therefore, it is noted that sensitivity of DWI is very high (100%). DWI also has very high specificity and PPV.

DISCUSSION

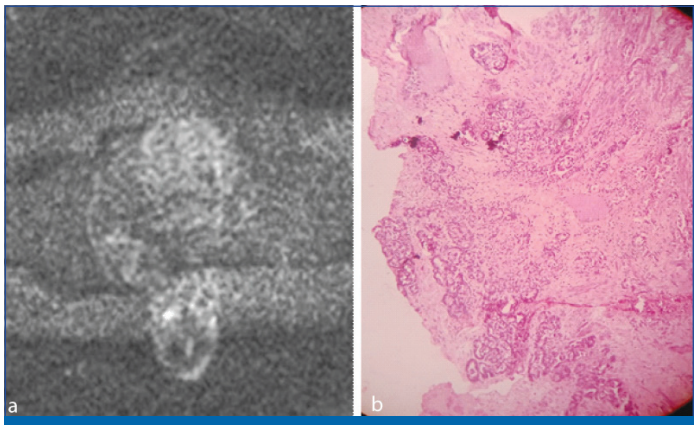
Diffusion-Weighted Imaging (DWI) measures the diffusion of water molecules occurring as a result of Brownian motion, with the measured signal in tissue sensitive to the presence of microstructures that can impede diffusion or flow thus, DWI can be useful in assessing or comparing pathologies such as cancer, where structural changes, including changes in cellular density



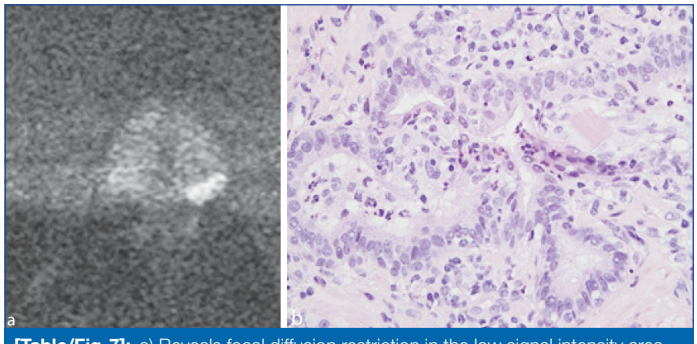
[Table/Fig-4]: a) Does not show any diffusion restriction. MRI prostate features are in keeping with benign prostatic hyperplasia; b) Histopathology showing the same-benign prostatic hyperplasia [H&E:X100].



[Table/Fig-5]: a) Shows DWI does not show any evidence of increased signal intensity or reduced signal in ADC (not shown here); b) Biopsy revealed nodular hyperplasia of prostate (H&E:X100).

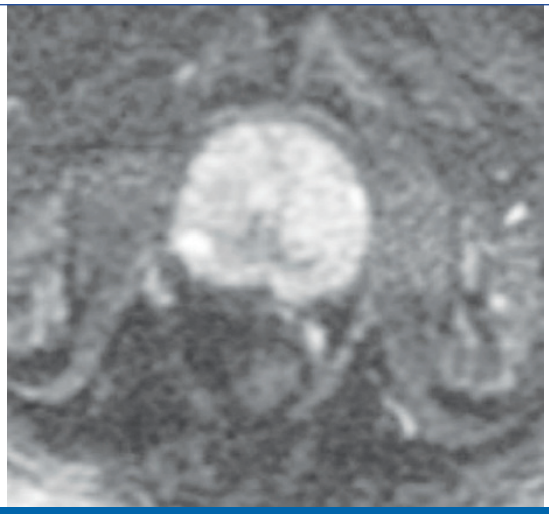


[Table/Fig-6]: a) Hyperintensity noted in b=800 in the anterior mass. Another isointense nodule seen in right posterolateral aspect; b) Photomicrograph revealed Gleason (4+3=7) (H&E 100x) adenocarcinoma with areas of benign prostatic hyperplasia.



[Table/Fig-7]: a) Reveals focal diffusion restriction in the low signal intensity area at b=800. It was reported as likely to be malignant; b) Biopsy and whole mount histopathology revealed chronic prostatitis [H&E:X400].

or extracellular space, are expected [9,10]. In DWI, proton diffusion properties are used to obtain image contrast. In clinical routine, two to three b-values (usually between 0 to 1000) are applied to get different images of the same values with different signal intensities. ADC maps which can be generated from the work station are commonly displayed in grey scale. Comparing the signals between different b-values and between DWI and ADC can help in qualitative analysis for suspicious lesions. Quantitative estimation can be done



[Table/Fig-8]: Showing focal diffusion restriction at b=800. It was reported as likely to be malignant. Biopsy showed benign prostatic hyperplasia, thus proving to be a false positive.

DWI	Value (%)	95% CI
Sensitivity	100.00	85.75% to 100.00%
Specificity	80.00	44.39% to 97.48%
PPV	92.31	74.87% to 99.05%
NPV	100.00	63.06% to 100.00%

[Table/Fig-9]: Sensitivity, Specificity, PPV, NPV of DWI.
PPV: Positive predictive value; NPV: Negative predictive value; DWI: difusion weighted imaging, CI: Confidence interval

by plotting a curve using signal intensity for each b-value which is generally displayed in a logarithmic scale. From this curve, by applying a specific formula, it is possible to calculate the ADC of water molecules.

In prostate cancer, ADC is significantly lower compared to the value in surrounding normal peripheral zone tissue. Concurrent review of ADC maps with T2-weighted endorectal MRI has led to an improvement in tumour localisation [11]. The change in ADC with prostate cancer has been attributed to an increase in cellular density and disruption of ductal architecture in the peripheral zone [12,13]. As a measure of water diffusion, ADC measured using similar parameters (i.e., consistent b-values) should relate to the underlying tissue characteristics. However, there is still an appreciable overlap seen in ADC values for prostate cancer versus normal peripheral zone within single studies, despite the fact that the direction of relative (intra-patient) differences is consistent [14,15]. This suggests that cellular microstructure likely varies between patients, which could potentially impact the characterisation of lesions with DWI. As Gleason grades are related to gland morphology changes in ADC, value might be expected to relate to Gleason grade or scores. Nevertheless, although some studies report a significant correlation between ADC and Gleason, these findings have not been consistent [16,17].

As mortality rate of prostate carcinoma is high, early diagnosis, localisation of tumour and early treatment is essential. DWI helps in three ways. First, DWI helps in improvement of tumour detection, especially if tumour is located in the peripheral zone [18]. Second, TRUS guided biopsy alone has low sensitivity of around 60% and a high false negative rate of 15-30% [19]. In this scenario, DWI will play a significant role by helping in localisation of the tumour in patients, and thereby helping in performing targeted biopsies in new patients as well as patients in whom previous attempts of biopsies were unsuccessful. So, it has a potential to improve the success rate of TRUS guided biopsy. Lastly, DWI also helps in treatment by helping in radiotherapy planning.

Limitation(s)

First, a large cohort is required to validate the results. Second, in DWI particular problems faced are increased noise and image distortion, and susceptibity artifacts specially at high b-values. Therefore, it cannot be used in morphologic assessment. Third, lack of standardisation is a major challenge. As not many studies have been done in India earlier about the role of diffusion in Prostate MRI imaging, so there may be a variation of consensus about the correct b-value.

CONCLUSION(S)

Diffusion is a very much useful tool which is non invasive, that can provide important information about tumour biology and its cellularity in prostate cancer. Also, it can help in targeted biopsy making a positive impact and thus avoiding repetitive blind biopsy and help in patients with previous negative results also.

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PARTICULARS OF CONTRIBUTORS:
1. Consultant Radiologist, Department of Radiodiagnosis, Warrington and Halton Teaching Hospitals, NHS Foundation Trust, Warrington, United Kingdom.
2. Associate Professor, Department of Radiodiagnosis, IPGME&R, Kolkata, West Bengal, India.
3. Assistant Professor, Department of Radiodiagnosis, IPGME&R, Kolkata, West Bengal, India.
4. Junior Resident, Department of Radiodiagnosis, IPGME&R, Kolkata, West Bengal, India.
5. Professor, Department of Urology, IPGME&R, Kolkata, West Bengal, India.
6. Professor, Department of Radiodiagnosis, IPGME&R, Kolkata, West Bengal, India.
7. Professor, Department of Radiodiagnosis, IPGME&R, Kolkata, West Bengal, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Archana Singh,
Associate Professor, Department of Radiodiagnosis, IPGME&R and SSKM Hospital,
244, AJC Bose Road, Kolkata, West Bengal, India.
E-mail: asinghrd@gmail.com

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