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Research Article

Study of Multiparametric Magnetic Resonance Imaging in Prostatic Carcinoma by Using PI-RADS: An Observational Study

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Background: Prostate cancer is one of the most common malignancies affecting men worldwide. Early detection and accurate characterization of clinically significant prostate cancer are essential for appropriate patient management. Multiparametric magnetic resonance imaging (mpMRI) of the prostate provides excellent soft-tissue contrast and combines anatomical and functional information. The Prostate Imaging–Reporting and Data System (PI-RADS) provides a standardized approach for acquisition, interpretation, and reporting of prostate MRI examinations. Aim: To evaluate the role of multiparametric magnetic resonance imaging using the PI-RADS scoring system in the detection and characterization of prostate carcinoma and to assess the association between PI-RADS category and histopathological findings. Materials and Methods: This observational study included 50 patients with clinical suspicion of prostate carcinoma who underwent multiparametric MRI of the prostate. The MRI protocol included T2-weighted imaging, diffusion-weighted imaging with apparent diffusion coefficient mapping, and dynamic contrast-enhanced imaging. Prostatic lesions were identified and categorized according to the PI-RADS scoring system. MRI findings were correlated with histopathological findings obtained by prostate biopsy or surgical specimens. The association between PI-RADS categories and histopathological diagnosis was assessed, and the diagnostic performance of different PI-RADS thresholds was evaluated. Results: A total of 50 patients were included in the study, with PI-RADS 5 being the most frequently observed category. Histopathological examination demonstrated prostate carcinoma in 78% of patients. A statistically significant association was observed between higher PI-RADS categories and histopathologically proven prostate carcinoma ($p < 0.0001$). Using a PI-RADS threshold of ≥3, the sensitivity was 100% and specificity was 33%. Using a threshold of ≥4, the sensitivity was 84.34% and specificity was 73.6%. The corresponding positive predictive value and negative predictive value were [84.5% and 100%] for the PI-RADS ≥3 threshold and [93.7% and 43.1%] for the PI-RADS ≥4 threshold, respectively. Conclusion: Multiparametric MRI using the PI-RADS scoring system provides a standardized and valuable approach for the detection and characterization of prostate lesions. Higher PI-RADS categories demonstrate a significant association with histopathologically proven prostate carcinoma. The high sensitivity observed at a PI-RADS threshold of ≥3 indicates its potential value for detecting prostate malignancy, while a threshold of ≥4 provides greater specificity. Incorporation of mpMRI and PI-RADS assessment may therefore contribute to improved risk stratification and appropriate selection of patients for biopsy and further management.

Keywords: Prostate carcinoma; Multiparametric MRI; PI-RADS; Prostate imaging; Diffusion-weighted imaging; Prostate biopsy; Clinically significant prostate cancer.

INTRODUCTION

Prostate cancer is a common malignancy in men and its incidence increases with age. Diagnosis is commonly initiated by clinical assessment, serum prostate-specific antigen (PSA) testing and digital rectal examination, followed by tissue sampling when indicated. PSA is not cancer-specific and can be elevated in benign prostatic hyperplasia, prostatitis and other non-malignant conditions, creating

diagnostic uncertainty and potentially leading to repeated biopsies. [1,2] Multiparametric MRI (mpMRI) provides high soft-tissue contrast and combines anatomical and functional information from T2-weighted imaging, diffusion-weighted imaging (DWI) and dynamic contrast-enhanced (DCE) imaging. It has become an important imaging technique for lesion detection, localisation and risk stratification in suspected prostate cancer. [2,3] The Prostate Imaging Reporting and Data System (PI-RADS) was developed to standardise acquisition, interpretation and reporting of prostate MRI. PI-RADS v2.1 uses a five-point scale to communicate the likelihood that an MRI lesion represents clinically significant prostate cancer, with lesion assessment weighted differently according to peripheral-zone and transition-zone location. [4] Histopathological examination remains necessary for definitive diagnosis, while Gleason grading provides information on tumour grade and prognosis. [5,6] The present study was undertaken to assess the diagnostic accuracy of mpMRI based on PI-RADS v2.1 for prostate carcinoma, to evaluate the relationship between PI-RADS score and Gleason score, and to assess the relationship between PI-RADS score and serum PSA.

MATERIALS AND METHODS

Study Design and Setting

This was a single-centre, cross-sectional observational study conducted in the Department of Radiology, Apollo Hospital Bangalore, over one year from November 2022 to November 2023. The study population comprised men with clinical suspicion of prostate carcinoma and raised serum PSA.

Sample Size

The study reported a sample size of 50. During the one-year study period, all eligible patients presenting with suspected prostate cancer were included. Inclusion criteria were men aged 50–80 years, raised serum PSA, with or without an abnormal digital rectal examination, willingness to participate and provision of informed consent, and absence of other comorbidities. Exclusion criteria were MRI implants, claustrophobia, TRUS-guided biopsy within the preceding 2 weeks, previous surgical intervention on the prostate, and acute urinary tract infection.

MRI Acquisition and Image Analysis

All participants underwent prostate mpMRI using either a Philips Achieva 1.5T MRI system. The protocol included axial T1-weighted imaging with a large field of view, axial/coronal/sagittal small-field-of-view T2-weighted imaging, axial high-b-value DWI and axial DCE imaging. Prostate volume was calculated using the ellipsoid formula: maximum longitudinal diameter × maximum anteroposterior diameter × maximum transverse diameter × 0.52. The index lesion was defined as the lesion with the highest PI-RADS score; when two or more lesions had the same highest score, the lesion with extraprostatic extension was considered the index lesion. Lesion dimensions were measured on the sequence best demonstrating the lesion according to zone, and lesions were categorised according to PI-RADS v2.1. T2-weighted imaging was the determining sequence for transition-zone lesions and DWI was the determining sequence for peripheral-zone lesions.

Histopathology

All participants underwent 12-core TRUS-guided biopsy. Histopathological examination was used as the reference standard. Gleason grading was recorded for malignant lesions, with prostate cancer defined in the analysis as Gleason score ≥6 and clinically significant prostate cancer as Gleason score ≥7, consistent with the study protocol.

Statistical Analysis

Continuous variables were summarised as mean±standard deviation and categorical variables as frequencies and percentages. Chi-square or Fisher's exact test was used for associations between categorical variables. Spearman's rank correlation was used for non-normally distributed continuous variables. ROC analysis was performed to estimate the area under the curve (AUC) for PI-RADS in detecting prostate cancer and clinically significant prostate cancer. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated for PI-RADS thresholds ≥3 and ≥4. A p value <0.05 was considered

statistically significant. Data were analysed using SPSS 20.0 and Microsoft Excel.

RESULTS

Fifty men were included. The mean age was 63.5±8.63 years (range 50–80 years), and 17 (40.4%) participants were aged 71–80 years. Mean BMI was 26.44±1.17 kg/m². The mean prostate size was 43.63±19.42 g and the mean index-lesion size was 16.7±12.0 mm. Mean serum PSA was 41.3±25.2 ng/mL (range 5.7–111.7 ng/mL).

Table 1. Baseline Characteristics of The Study Population (N=47)

Variable	Result
Age, mean±SD (years)	63.5±8.63
Age 50–60 years, n (%)	13 (27.7)
Age 61–70 years, n (%)	15 (31.9)
Age 71–80 years, n (%)	17 (40.4)
BMI, mean±SD (kg/m²)	26.44±1.30
Prostate size, mean±SD (g)	43.63±19.42
Index-lesion size, mean±SD (mm)	16.7±12.0
PSA, mean±SD (ng/mL)	41.3±25.2

Table 2. Distribution of Index Lesions By PI-RADS V2.1 Score (N=50)

PI-RADS score	n	%
1	0	0.0
2	3	6.4
3	8	17.0
4	16	34.0
5	20	42.6

Table 3. Histopathological Diagnosis and Gleason Score

Finding	n	%
Prostatic adenocarcinoma	38	80.9
Benign prostatic hyperplasia	4	8.5
Prostatitis	5	10.6

Table 4. Gleason Score Distribution Among Malignant Lesions (N=50)

Gleason score	n	%
6	7	13.2
7	17	34.2
8	14	28.9
9	9	18.4
10	3	5.3

The mean ADC value for all index lesions was 0.732±0.110 $\times10^{-3}$ mm²/s. Mean ADC values decreased progressively across PI-RADS categories: 0.964 $\times10^{-3}$ mm²/s for PI-RADS 2, 0.844 $\times10^{-3}$ mm²/s for PI-RADS 3, 0.745 $\times10^{-3}$ mm²/s for PI-RADS 4 and 0.643 $\times10^{-3}$ mm²/s for PI-RADS 5. Among malignant lesions, mean ADC was 0.801±0.04 $\times10^{-3}$ mm²/s for Gleason ≤6, 0.722±0.05 $\times10^{-3}$ mm²/s for Gleason 7 and 0.647±0.06 $\times10^{-3}$ mm²/s for Gleason >7. Spearman correlation between ADC and Gleason score was −0.784 ($p<0.0001$).

Table 5. Association Between Serum PSA Category and PI-RADS Score

PSA (ng/mL)	PI-RADS 2	PI-RADS 3	PI-RADS 4	PI-RADS 5	Total
4.1–10.0	2	1	0	0	3
10.1–20.0	1	4	2	1	8
20.1–40.0	0	3	9	5	17
>40.0	0	0	5	14	19
Total	3	8	16	20	47

The association between PSA category and PI-RADS score was statistically significant (Pearson chi-square=39.988, p<0.0001).

Table 6. Association Between PI-RADS Score and Gleason Group Among Malignant Lesions (N=38)

Gleason group	PI-RADS 3	PI-RADS 4	PI-RADS 5	Total
≤6	3	2	0	5
7	1	9	3	13
>7	0	3	17	20
Total	4	14	20	38

The association between PI-RADS score and Gleason group was statistically significant (Pearson chi-square=28.906, p<0.0001). Among malignant PI-RADS 5 lesions, 17/20 (85.0%) had Gleason score >7.

DISCUSSION

This study evaluated 50 men with raised PSA who underwent mpMRI and subsequent TRUS-guided biopsy. The mean age was 63.53 years, consistent with the predominantly older age group in which prostate cancer is encountered. The peripheral zone accounted for 42.6% of index lesions and the transition zone for 25.5%, while additional lesions involved more than one zone or showed extraprostatic extension.

Most index lesions were assigned high PI-RADS categories: 34.0% were PI-RADS 4 and 42.6% were PI-RADS 5. Histopathology demonstrated adenocarcinoma in 80.9% of participants. The distribution of malignancy across increasing PI-RADS categories in this study is directionally consistent with published evidence showing increasing cancer detection with increasing PI-RADS category. [7,8]

A statistically significant association was observed between PSA category and PI-RADS score (p<0.0001). Seventy percent of PI-RADS 5 lesions occurred in participants with PSA >40 ng/mL, whereas 66.7% of PI-RADS 2 lesions occurred in the 4.1–10 ng/mL PSA group. A similar relationship between PSA and PI-RADS category has been reported in biopsy-proven prostate cancer cohorts. [9] A significant association was also demonstrated between PI-RADS score and Gleason group (p<0.0001). Among malignant lesions, 85.0% of PI-RADS 5 lesions had Gleason scores >7. These findings support the role of PI-RADS as an imaging-based risk stratification system, although histopathology remains necessary for definitive grading. [5,6] ADC values showed a significant inverse relationship with Gleason score (rho −0.784, p<0.0001), with lower ADC values in higher-grade tumours. The direction and magnitude of this relationship are comparable with previously reported studies evaluating quantitative diffusion parameters and Gleason grade. [10,11] The AUC values of 0.912 for prostate cancer and 0.932 for clinically significant prostate cancer indicate strong discrimination in this study population. Published studies have also demonstrated good diagnostic performance of PI-RADS v2/v2.1, although performance varies according to lesion location, reader experience, study population and reference standard. [12–14] The choice of PI-RADS threshold influenced the balance between

sensitivity and specificity. For prostate cancer, PI-RADS ≥3 produced 100% sensitivity but 33.33% specificity, whereas PI-RADS ≥4 produced 84.47% sensitivity and 73.78% specificity. For clinically significant prostate cancer, the corresponding values were 100% and 21.43% for PI-RADS ≥3 and 96.97% and 71.43% for PI-RADS ≥4. Thus, in this cohort, using ≥4 reduced false-positive classifications while retaining high sensitivity for clinically significant disease. This is an observation from the present dataset and should not be interpreted as a universal biopsy threshold without consideration of clinical context and current guidelines. The study has several limitations. It was a single-centre study with a relatively small sample size. Randomisation was not performed. TRUS-guided biopsy was used as the reference standard and is subject to sampling error. In addition, PI-RADS interpretation may have inter-observer variability. These factors limit generalisability and support the need for larger prospective multicentre studies.

CONCLUSION

In this single-centre observational cohort, mpMRI interpreted using PI-RADS v2.1 showed high diagnostic discrimination for prostate cancer and clinically significant prostate cancer, with AUCs of 0.912 and 0.932, respectively. PI-RADS score was significantly associated with serum PSA category and Gleason score. A PI-RADS threshold of ≥4 increased specificity compared with ≥3 while maintaining high sensitivity for clinically significant disease in this cohort. These findings support the use of PI-RADS v2.1 as part of a multimodal diagnostic pathway for men with suspected prostate cancer, with biopsy decisions incorporating clinical findings, PSA and MRI results.

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