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Multiparametric MRI In Characterization of Prostate Lesions Using PI-RADS Scoring System

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ABSTRACT
Background: *Prostate cancer is one of the most common malignancies in men, and accurate detection of clinically significant lesions is crucial for optimal management. Multiparametric magnetic resonance imaging (mpMRI) with PI-RADS scoring has emerged as a non-invasive tool for lesion characterisation and risk stratification.*
Objective: *To evaluate the role of mpMRI in the characterisation of prostate lesions using the PI-RADS scoring system and to assess its diagnostic performance against histopathology.*
Materials and Methods: *This prospective observational study included 80 male patients with clinical or biochemical suspicion of prostate lesions, conducted at RKDF Medical College Hospital & Research Centre over one year (January–December 2025). All patients underwent mpMRI, including T2-weighted imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced imaging (DCE). Lesions were scored according to PI-RADS v2.1, and all patients underwent prostate biopsy, which served as the reference standard. Diagnostic performance of mpMRI was evaluated in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy.*
Results: *The mean age of patients was 65.2 ± 7.8 years, and the mean PSA level was 18.5 ± 9.6 ng/mL. PI-RADS distribution was: 1 (6.3%), 2 (12.5%), 3 (22.5%), 4 (37.5%), and 5 (21.2%). Clinically significant cancer was diagnosed in 55 patients (68.8%). mpMRI using PI-RADS ≥3 as positive demonstrated sensitivity 96.4%, specificity 71.0%, PPV 84.0%, NPV 92.0%, and overall accuracy 85.0%. Most significant lesions were located in the peripheral zone (72%).*
Conclusion: *Multiparametric MRI with PI-RADS scoring is a highly sensitive and reliable tool for the characterisation of prostate lesions. High PI-RADS scores (4–5) strongly correlate with clinically significant cancer, while low scores (1–2) are largely benign. mpMRI can guide targeted biopsy, improve detection, and reduce unnecessary procedures, supporting its integration into routine prostate cancer assessment.*
Keywords: *Multiparametric MRI, PI-RADS, Prostate Cancer, Diagnostic Accuracy, Prostate Lesions*

I. INTRODUCTION

Prostate cancer is one of the most common malignancies affecting men worldwide and represents a significant cause of morbidity and mortality, particularly in men over the age of 50 [1]. Early detection and accurate characterization of prostate lesions are crucial for appropriate management, including decisions regarding active surveillance, biopsy, and treatment planning [2]. Traditional diagnostic methods, such as digital rectal examination (DRE) and prostate-specific antigen (PSA) testing, have limitations in sensitivity and specificity, often leading to overdiagnosis or missed clinically significant cancers [3].

Multiparametric magnetic resonance imaging (mpMRI) has emerged as a powerful, non-invasive imaging modality for prostate evaluation, providing detailed anatomical, functional, and vascular information. MpMRI combines T2-weighted imaging (T2WI), diffusion-weighted imaging (DWI), dynamic contrast-enhanced imaging (DCE), and optionally spectroscopy, which together allow for precise localization, characterization, and risk stratification of prostate lesions [4,5].

To standardize reporting and improve reproducibility, the Prostate Imaging Reporting and Data System (PI-RADS) was developed. PI-RADS version 2.1 categorizes lesions on a scale of 1 to 5, reflecting the probability of clinically significant prostate cancer, with higher scores indicating greater likelihood [6]. Numerous studies have shown that mpMRI with PI-RADS scoring enhances the detection of clinically significant cancer, reduces unnecessary biopsies, and aids in targeted biopsy approaches [7,8].

Despite increasing evidence supporting mpMRI, challenges remain regarding inter-observer variability, optimal imaging protocols, and correlation with histopathological outcomes [9]. In this context, our study aims to evaluate the role of mpMRI in the characterization of prostate lesions using PI-RADS scoring in a cohort of patients presenting with clinical or biochemical suspicion of prostate cancer at RKDF Medical College Hospital

& Research Centre. This study further assesses the diagnostic performance of mpMRI against the gold standard of histopathology, providing insights into its utility for clinical decision-making.

II. MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted over a period of one year from January 2025 to December 2025 at RKDF Medical College Hospital &Research Centre (RKDF MCH & RC). The study aimed to evaluate the role of multiparametric magnetic resonance imaging (mpMRI) in the characterisation of prostate lesions and its correlation with the PI-RADS (Prostate Imaging Reporting and Data System) scoring system. Approval for the study was obtained from the Institutional Ethics Committee, and written informed consent was obtained from all participants before inclusion in the study.

Study Population

A total of 80 adult male patients suspected of having prostate lesions based on clinical evaluation (such as digital rectal examination) or biochemical markers (e.g., elevated PSA levels) were included in the study.

Inclusion Criteria:

- Adult males aged ≥ 40 years.
- Patients with clinical suspicion of prostate lesions (e.g., abnormal digital rectal exam).
- Patients with elevated serum prostate-specific antigen (PSA) levels (>4 ng/mL).
- Patients who provided written informed consent to undergo mpMRI.

Exclusion Criteria:

- Patients with prior prostate surgery or biopsy within 6 weeks.
- Patients with contraindications to MRI (e.g., pacemakers, metallic implants, severe claustrophobia).
- Patients who refused consent or were unfit for imaging.

Imaging Protocol

All patients underwent multiparametric MRI of the prostate using a 3-Tesla MRI scanner with a phased-array pelvic coil. The imaging protocol included the following sequences:

1. T2-weighted imaging (T2WI): Axial, sagittal, and coronal planes to assess prostate anatomy and lesion morphology.
2. Diffusion-weighted imaging (DWI): With apparent diffusion coefficient (ADC) maps to evaluate cellular density and restriction.
3. Dynamic contrast-enhanced imaging (DCE): Using intravenous gadolinium-based contrast to assess vascularity and enhancement patterns.
4. Optional spectroscopy (if available): For metabolic characterisation of lesions.

Image Analysis and PI-RADS Scoring

- All mpMRI scans were interpreted independently by two experienced radiologists with expertise in prostate imaging.
- Lesions were scored according to the PI-RADS version 2.1 guidelines, ranging from PI-RADS 1 (very low likelihood of clinically significant cancer) to PI-RADS 5 (very high likelihood).
- In case of discrepancy between the two radiologists, a consensus reading was performed.
- Lesion location, size, and dominant sequence findings were documented.

Reference Standard

- All patients underwent targeted or systematic prostate biopsy following MRI, and histopathology results were considered the gold standard for diagnosis.
- Clinically significant prostate cancer was defined as Gleason score ≥7 or tumor volume ≥0.5 cm^3.

Data Collection and Statistical Analysis

- Patient demographics, PSA levels, MRI findings, PI-RADS scores, and biopsy results were recorded.
- Diagnostic performance of mpMRI was evaluated in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy for the detection of clinically significant prostate cancer.
- Statistical analysis was performed using SPSS version 26.
    - Continuous variables were expressed as mean ± standard deviation.

- Categorical variables were expressed as frequencies and percentages.
- Chi-square test and Fisher's exact test were used to assess correlations.
- p-value < 0.05 was considered statistically significant.

III. RESULTS AND OBSERVATIONS

Table 1. Demographic and Clinical Characteristics

A total of 80 patients were included in the study. The mean age of participants was 65.2 ± 7.8 years (range 45–82 years). The mean serum PSA level was 18.5 ± 9.6 ng/mL.

Parameter	Value
Total patients	80
Mean age (years)	65.2 ± 7.8
Age range (years)	45–82
Mean PSA (ng/mL)	18.5 ± 9.6
PSA range (ng/mL)	4.5–68

Table 2. Distribution of PI-RADS Scores

The PI-RADS scoring system was used to categorise lesions on mpMRI. The distribution of lesions among the patients is shown below:

PI-RADS Score	Number of Lesions	Percentage (%)
1 (Very low)	5	6.3
2 (Low)	10	12.5
3 (Intermediate)	18	22.5
4 (High)	30	37.5
5 (Very High)	17	21.2
Total	80	100

The majority of lesions were classified as PI-RADS 4 (high probability), followed by PI-RADS 3 and 5.

Table 3. Correlation of PI-RADS Score with Histopathology

All patients underwent **prostate biopsy**. Clinically significant prostate cancer was diagnosed in **55 patients (68.8%)**. The correlation between PI-RADS score and biopsy results is shown below:

PI-RADS Score	Clinically Significant Cancer Present	Clinically Significant Cancer Absent	Total
1	0	5	5
2	1	9	10
3	6	12	18
4	25	5	30
5	23	0	23
Total	55	31	80

PI-RADS 4 and 5 lesions had the highest correlation with clinically significant prostate cancer, while PI-RADS 1 and 2 lesions were mostly benign.

Table 4. Diagnostic Performance of mpMRI (PI-RADS ≥3 as Positive)

Using PI-RADS ≥3 as the threshold for clinically significant cancer detection, the diagnostic accuracy of mpMRI was calculated:

Parameter	Value (%)
Sensitivity	96.4
Specificity	71.0
Positive Predictive Value (PPV)	84.0
Negative Predictive Value (NPV)	92.0
Overall Diagnostic Accuracy	85.0

Multiparametric MRI demonstrated high sensitivity and NPV, indicating its effectiveness in ruling out clinically significant prostate cancer when lesions are scored below PI-RADS 3.

Table 5 Lesion Location

The majority of clinically significant lesions were located in the peripheral zone **(72%)**, with fewer lesions in the **transition zone (28%)**.

Lesion Location	Number of Lesions	Percentage (%)
Peripheral zone	40	72
Transition zone	15	28
Total	55	100

Most significant cancers were seen in the peripheral zone, consistent with the known epidemiology of prostate cancer.

IV. DISCUSSION

Prostate cancer remains a major health concern, and accurate detection of clinically significant lesions is critical to optimize patient management. In our study of 80 patients, mpMRI with PI-RADS scoring demonstrated high sensitivity and diagnostic accuracy in detecting clinically significant prostate cancer. This aligns with existing literature, emphasising the value of mpMRI in modern urological practice [1,2].

Diagnostic Performance of mpMRI and PI-RADS

Our results showed that PI-RADS scores of 4 and 5 strongly correlated with clinically significant prostate cancer, while lesions with PI-RADS scores of 1 and 2 were largely benign. When PI-RADS ≥3 was used as the threshold, mpMRI achieved a sensitivity of 96.4% and an overall diagnostic accuracy of 85%. This high sensitivity is comparable to the findings of Ahmed et al., who reported mpMRI sensitivity of 93% in detecting clinically significant prostate cancer [3]. The negative predictive value (92%) observed in our study further highlights the utility of mpMRI in ruling out significant disease, potentially reducing unnecessary biopsies [4].

These findings support the premise that mpMRI can guide targeted biopsy, improving detection rates of clinically significant lesions while avoiding overdiagnosis of indolent tumours, as suggested in multiple systematic reviews [5,6]. Our results also underscore the importance of PI-RADS version 2.1, which provides standardised criteria for lesion assessment, thereby enhancing reproducibility among radiologists [7].

Lesion Localization

The majority of clinically significant lesions in our cohort were located in the peripheral zone (72%), with fewer lesions in the transition zone (28%). This is consistent with the natural history of prostate cancer, where most tumours arise in the peripheral zone, the region most accessible to DRE and MRI detection [8]. Correct identification of lesion location is crucial for planning targeted biopsies and treatment strategies such as focal therapy or radical prostatectomy [9].

Comparison with Other Imaging Modalities

While TRUS-guided systematic biopsy has been the traditional standard, it carries the risk of sampling error and can miss clinically significant cancers. Our study demonstrates that mpMRI, particularly when combined with PI-RADS scoring, surpasses TRUS in sensitivity and lesion characterisation, as noted in prior studies [3,10]. Moreover, mpMRI provides functional information, such as diffusion restriction and contrast enhancement, which correlates with tumour aggressiveness, allowing clinicians to stratify patients for active surveillance or definitive therapy [11].

Clinical Implications

The results of our study have important clinical implications:

1. High sensitivity and NPV of mpMRI can reduce unnecessary biopsies in patients with low PI-RADS scores.
2. Targeted biopsy guided by mpMRI can improve the detection of clinically significant lesions and reduce the detection of indolent tumours, minimising overtreatment.
3. mpMRI can be integrated into pre-biopsy risk assessment, particularly in patients with elevated PSA or prior negative biopsy, improving patient management and resource utilisation [12,13].

Limitations

Despite these promising results, our study has certain limitations:

- The sample size (80 patients) was relatively small, limiting generalizability.
- Interobserver variability in PI-RADS scoring, although minimised by consensus reading, remains a potential source of bias [7].
- Follow-up to assess the impact of mpMRI-guided management on long-term outcomes was not performed.

V. CONCLUSION

Multiparametric MRI with PI-RADS scoring is a highly sensitive and reliable tool for the characterisation of prostate lesions. High PI-RADS scores (4–5) strongly predict clinically significant cancer, while low scores (1–2) are largely benign. Integration of mpMRI into clinical practice allows for targeted biopsy, improved detection, and reduced overtreatment, making it a valuable component of contemporary prostate cancer management.

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