RESEARCH PAPER

Assessment of Role of Multi Parametric Magnetic Resonance Imaging in Diagnosing Prostate Cancer

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Received: 15th Feb, 2026; **Revised:** 27th Feb, 2026; **Accepted:** 20th Mar, 2026; **Available Online:** 5th Apr, 2026

ABSTRACT

Background

Traditional diagnostic methods for prostate cancer, such as PSA testing, digital rectal evaluation, and TRUS-guided biopsy, exhibit restricted accuracy. Multiparametric MRI has become a dependable, non-invasive modality with enhanced sensitivity and specificity for the early diagnosis, localisation, and characterisation of prostate lesions.

Methods

The study was conducted over a duration of 18 months among clinically suspected prostate cancer patients who were investigated by MRI on PHILIPS ACHIEVA 1.5 Tesla MRI machine. Multiphasic scanning with T1W, T2W, diffusion weighted imaging and Dynamic contrast image acquisition was done. Histopathology correlation was done in all the cases.

Results

PI-RADS v2.1 demonstrated 85.7% sensitivity (95% CI: 73.8–93.0), detecting most clinically significant prostate cancers. Specificity reached 100% (95% CI: 59.0–100), with no false positives. Positive predictive value (PPV) was 100% (95% CI: 91.6–100), indicating all PI-RADS ≥ 4 lesions with biopsy confirmation were clinically significant. Negative predictive value (NPV) was also good at 73% (95% CI: 63.7–81.3); this indicated good negative predictive accuracy as well. Overall diagnostic accuracy was 87.5% (95% CI: 75.9–94.8).

Conclusion

The findings validated the utility of multiparametric MRI (mpMRI) and PI-RADS v2.1 as effective tools for detecting prostate cancer, highlighting their contribution to enhanced diagnostic precision and informed clinical decision-making. The study demonstrated a robust correlation between imaging-based classifications and histopathological results, confirming mpMRI as a dependable, non-invasive method for assessing prostate lesions.

Keywords: Histopathological examination, Multiparametric MRI, PI-RADS v2, Prostate cancer

How to cite this article: Ambady GB, Jayaraj AC, Mathew B, Anand R, Jegan M. Assessment of Role of Multi Parametric Magnetic Resonance Imaging in Diagnosing Prostate Cancer. Int J Drug Deliv Technol. 2026;16(4): 177-183. DOI: 10.25258/ijddt.16.4.19

Source of support: Nil.

Conflict of interest: None

Introduction:

Prostate cancer (PCa) is the second most common cancer in men worldwide, making up about 15% of all male cancer diagnoses[1,2]. The epidemiological landscape of prostate cancer is shaped by genetic, environmental, and lifestyle factors, which collectively result in disparities in incidence and mortality across different regions[3].

Clinically, prostate cancer exerts a profound impact on patient quality of life and imposes a substantial economic burden on healthcare systems due to long-term treatment and management costs[4]. Conventional diagnostic tools include the digital rectal examination (DRE), transrectal ultrasound (TRUS)-guided biopsy, and serum prostate-specific antigen (PSA) testing[5]. However, PSA testing, though widely used, suffers from limited specificity, often resulting in overdiagnosis and overtreatment, which expose patients to unnecessary interventions and related morbidities[6,7].

DRE also presents notable limitations, including low sensitivity and high inter-observer variability, making it unreliable as a primary diagnostic approach[8]. The current gold standard, TRUS-guided biopsy, has been shown to miss up to 45% of clinically significant cancers, reflecting a significant diagnostic gap[9]. These limitations underscore the crucial requirement for more specific and non-invasive diagnostic alternatives.

Multiparametric MRI (mpMRI) has emerged as a powerful tool that combines anatomical and functional imaging to offer detailed visualization of prostate morphology and tumor characteristics. It has demonstrated that it is possible to decrease unnecessary biopsies while elevating the finding of clinically significant cancers[10,11]. Introduction of the Prostate Imaging Reporting and Data System (PI-RADS) Version 2.1 has further enhanced diagnostic accuracy by standardizing mpMRI interpretation and improving interobserver consistency among radiologists[12,13].

Recent research also suggests that mpMRI findings may correlate with tumor biology, showing that mpMRI-detected moderate-risk cancers often behave similarly to low-risk ones, whereas mpMRI-invisible low-risk cancers may display unexpectedly aggressive features[14,15]. These insights reinforce the clinical importance of accurate imaging for risk stratification, treatment planning, and personalized patient management.

The evolving landscape of prostate cancer diagnosis increasingly recognizes mpMRI as a cornerstone tool, marking a significant transition toward reliable, non-invasive, and patient-centered diagnostic strategies. This study therefore aims to evaluate the diagnostic performance of mpMRI using the PI-RADS v2.1 framework, with emphasis on its role in enhancing detection, classification, and management of clinically significant prostate cancer.

Materials and methods:

Study design and Sample Size Estimation

This prospective observational research was carried out over 18 months at a tertiary care hospital.

The sample size was determined using the prevalence taken from existing literature[16] and applying those values in the subsequent formula:

$$N = \frac{Z\alpha^2 pq}{d^2}$$

Sample size = 56

$n = Z\alpha^2 \times [\text{Specificity} \times (1 - \text{Specificity})] / [e^2 \times (1 - \text{Prevalence})]$ where $Z\alpha$ at a 95% confidence interval = 1.96, Prevalence (p) = 16%, Specificity (q) = 84%, allowable error (d) is set at = 10%.

Inclusion Criteria

The patients, either with obstructive LUTS or the clinically suspected cases of carcinoma prostate, based upon raised levels of prostate-specific antigen, abnormal findings of digital rectal, or other clinical indices, were selected for the investigation.

Exclusion Criteria

Patients with a known history of carcinoma prostate who had previously undergone surgical resection or radiotherapy, biopsy, patients with general contraindications to MRI, such as metallic implants, pacemakers, or claustrophobia were excluded.

Ethical approval and methods of data collection

The institution's Ethical Board provided the ethical clearance. After obtaining consent from the patient, individuals who fulfilled the inclusion criteria underwent multiparametric MRI, which encompassed T1, T2, DWI, and DCE scans. Qualified radiologists reviewed each patient's MRI scans separately and provided them a PI-RADS assessment. Individuals with a score of three or more; were given biopsy for histopathological confirmation. The overall score on the PI-RADS was also worked out and compared with histopathology.

Equipment used

Multiparametric MRI was conducted via a 1.5 Tesla or 3 Tesla MRI scanner, fitted using a pelvic phased-array coil.

Statistical Analysis

Collected data was analyzed using IBM SPSS software version 26. Continuous data was expressed as mean and standard deviation and discrete data as frequency and percentages. Association between the groups was done using chi-square and fisher exact test, where p<0.05 was considered significant. Diagnostic performance was evaluated by regression analysis.

Results:

A total of **56 participants** were recruited for the study.

Table 1: Demographic and baseline characteristics

Characteristic	Category/Subgroup	Frequency	(%)	p-value
Age Group	**51–60**	13	23.2	<0.001*
	61–70	18	32.1	
	71–80	23	41.1	
	81–90	2	3.6	
Clinical Symptoms (SYM)	**Prostatism**	38	67.9	0.0075*
	Haematuria	18	32.1	
PI-RADS Scores	**PI-RADS 3**	14	25	0.156
	PI-RADS 4	18	32.1	
	PI-RADS 5	24	42.9	
Distribution of Lesion Characteristics and Associated Invasions	**Presence of Lesion**	56	100	<0.001*
	Extra-capsular Extension (ECE)	8	14.3	
	Urinary Bladder/ Rectal Invasion	5	8.9	
	Neurovascular Invasion (NVB)	5	8.9	
	Metastasis (METS)	16	28.6	
DRE Findings	**Soft to Firm**	4	7.1	<0.001*
	Hard	25	44.6	
	Nodular	27	48.2	
Prostate Volume Across PIRADS Scores	**PI-RADS 3 (Mean ± SD)**	51.9 ± 24.1 cc		0.42
	PI-RADS 4 (Mean ± SD)	53.5 ± 22.6 cc		
	PI-RADS 5 (Mean ± SD)	69.2 ± 36.0 cc		

*p-value<0.05 – Statistically significant

Among the 56 patients studied, the majority (73.2%) were aged between 61 and 80 years, showing a statistically significant variation in age distribution (p < 0.001) (Table 1).

Table 2: Distribution of zone of lesion according to the PIRADS score

PI-RADS Score	TZ	PZ	TZ+PZ
"3"	1 (7.1%)	4 (22.2%)	0 (0)
"4"	5 (27.8%)	6 (33.33%)	0 (0)
"5"	5 (20.8%)	8 (44.44%)	10 (41.7%)
p-value	0.307	0.913	0.007*

*p-value<0.05 – Statistically significant
TZ-transition zone, PZ-peripheral zone

Based on PI-RADS classification, the highest percentage of patients were considered as PI-RADS 5 (42.9%). Extra-capsular extension and seminal vesicle invasion were each observed in 14.3% of patients, while neurovascular bundle invasion was seen in 8.9% and metastasis in 28.6%.

Analysis of prostate volume across PI-RADS categories showed the highest mean volume in PIRADS 5 (69.2 ± 36.0 cc), though the difference was statistically insignificant (p = 0.42).

Lesion distribution varied across zones; transition zone lesions were rare in PI-RADS 3 (7.1%) and showed moderate frequency in PI-RADS 4 (27.8%) and 5 (20.8%) (p = 0.307). Peripheral zone lesions had similar distribution across scores; 28.6% in PI-RADS 3, 33.3% in PI-RADS 4, and 33.3% in PI-RADS 5 (p = 0.913). Combined transition and peripheral zone lesions were absent in PI-RADS 3 and PI-RADS 4, while it was 41.7% in PI-RADS 5 (p = 0.007). There was a significant difference noted in the distribution of lesions in the combined zone across the PIRADS scores (Table 2).

Table 3: Association between MRI sequence and PI-RADS score

MRI sequence	PI-RADS Score						p-value
	"3"		"4"		"5"		
	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	
T2	14 (100)	0 (0)	18 (100)	0 (0)	24 (100)	0 (0)	NA
DCE	0 (0)	14 (100)	18 (100)	0 (0)	24 (100)	0 (0)	0.247
DR/ADC	10 (71.4)	4 (28.6)	18 (100)	0 (0)	24 (100)	0 (0)	0.013*

*p-value<0.05 – Statistically significant
P-present, A-absent

T2-weighted imaging showed consistent detection across all scores; 100% of lesions in PI-RADS 3, 4, and 5 had T2 abnormalities. DCE also showed strong lesion detection, with 100% in PIRADS 4 and 5. Diffusion restriction had clear progression; 71.4% of PI-RADS 3 lesions showed restriction, increasing to 100% in PI-RADS 4 and 5, and the progression was significant (p<0.05) (Table 3).

Table 4A: Diagnostic accuracy of pi-rads v2.1 with Histopathological examination (HPE) correlation

HPE	PIRADS Score		p value
	Positive (PI-RADS ≥ 4)	**Negative (PI-RADS < 4)**	
Positive (Gleason scores ≥ 7)	42 (TP)	7 (FN)	< 0.001*
Negative (Gleason scores=6)	7 (FP)	7 (TN)	

*p-value<0.05 – Statistically significant
TP-True Positives, FP-False Positives, FN-False Negative, TN-True Negatives

A highly significant association (p < 0.001) was observed between PI-RADS v2.1 score and histopathological outcomes, reinforcing the reliability

of PI-RADS v2.1 in prostate cancer detection (Table 4A).

Table 4B: Diagnostic accuracy of PI-RADS

Metric	Value	95% CI (%)
Sensitivity	85.7%	73.8–93.0
Specificity	100%	59.0–100
Positive Predictive Value (PPV)	100%	91.6–100
Negative Predictive Value (NPV)	73%	63.7–81.3
Accuracy	87.5%	75.9–94.8

Results confirmed strong diagnostic performance of PI-RADS v2.1; with high specificity and PPV of 100%, sensitivity of 85.7%, NPV of 73% and overall accuracy was 87.5% (Table 4B).

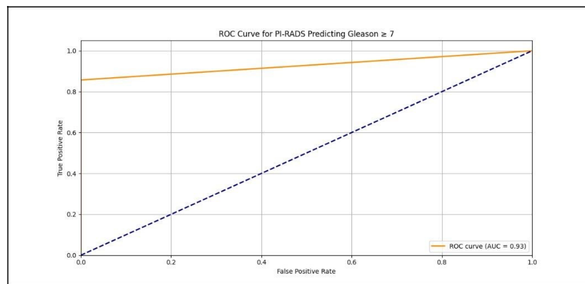

Figure 1: ROC analysis

Receiver operating characteristic (ROC) analysis yielded an area under the curve (AUC) of 0.93; this indicates excellent discrimination amongst clinically significant and insignificant prostate lesions (Figure 1)

Discussion:

This study aimed to evaluate prostate lesions using PI-RADS v2.1 scoring and assess diagnostic accuracy through histopathological correlation. Findings indicated a higher prevalence of prostate abnormalities in the older age group (61–80 years (73.2%) and 71–80 years (41.1%)), aligning with established epidemiological trends associating prostate pathology with increasing age[13]. All patients had detectable lesions (100%). Extra-capsular extension (14.3%) and seminal vesicle invasion (14.3%) were most common.

In the present study, PI-RADS 5 had the highest prevalence (42.9%), followed by PI-RADS 4 (32.1%) and PI-RADS 3 (25%), though distribution differences were statistically insignificant ($p = 0.156$). These findings showed a predominance of intermediate to high-risk lesions (PI-RADS 4 and 5), indicating the presence of aggressive lesion characteristics. Statistical insignificance of PI-RADS distribution suggested a relatively uniform representation of risk categories within the cohort.

Kim *et al.* (2021)[17] found that PI-RADS 5 lesions had the highest prevalence (45%) among 105 patients, strongly correlating with cancer occurrence. The PROMIS trial by Ahmed *et al.* (2017)[18] showed that MRI identified significant cancers in 40% of cases, with PI-RADS 5 linked to high-grade cancers and high sensitivity (93%). Hamoen *et al.* (2015)[19] reviewed multiple studies and confirmed a high probability of clinically significant cancer with PI-RADS 5, though PI-RADS 3 had the lowest predictive value. Puech *et al.* (2013)[20] highlighted that 75% of PIRADS 5 and 58% of PI-RADS 4 lesions were clinically significant, while PI-RADS 3 lesions required further testing for accurate diagnosis. These findings were comparable to those of the present study.

The present study revealed a 100% prevalence of detectable prostate lesions, with extra-capsular extension (14.3%) and seminal vesicle invasion (8.9%) notable. Invasion of the urinary bladder or rectum occurred in 8.9%, and neurovascular bundle invasion was also seen in 8.9%. Metastatic disease was present in 28.6% of cases, indicating extensive local and distant disease, suggesting late-stage presentations in many patients. Comparatively, other studies reported similar invasion patterns and highlighted the significance of MRI in detecting advanced disease features despite limitations in differentiating disease stages[18,20].

On digital rectal examination (DRE), nodular and hard prostates were frequently observed, indicating potential malignancy. Significant variability was noted in DRE findings ($p < 0.001$). The study emphasized DRE as a crucial initial diagnostic tool complementing imaging assessments. Ahmed *et al.* (2017)[18] highlighted that abnormal DRE findings correlated with higher PI-RADS scores, indicating significant prostate cancer, while Kim *et al.* (2021)[17] found DRE sensitivity at 58.4%. Hamoen *et al.* (2015)[19] reported a correlation of DRE findings with MRI lesions in 61–75% of cases, and Puech *et al.* (2013)[20] stated that many men with normal DRE results also had MRI-detected lesions, suggesting the necessity for integrated diagnostic strategies.

Prostate volumes across PI-RADS categories showed no statistically significant differences ($p = 0.42$), though larger volumes were noted in PI-RADS

5. Mean volumes were 51.9 cc (PI-RADS 3), 53.5 cc (PI-RADS 4), and 69.2 cc (PI-RADS 5). Similar findings from Kim *et al.* (2021)[17] and Ahmed *et al.* (2017)[18] confirmed that prostate size did not correlate significantly with lesion aggression. Meta-analyses further emphasized that prostate volume is not a reliable predictor of malignancy[19]. Additionally, DRE findings corroborated MRI detections, but sensitivity for clinically significant cancer remained moderate (58.4–69%), indicating the importance of combined diagnostic approaches.

Multiparametric MRI (mpMRI) findings across PI-RADS scores revealed that T2-weighted imaging identified abnormalities in all lesions graded PI-RADS 3–5. Dynamic contrast-enhanced (DCE) imaging showed 100% positivity for PI-RADS 4 and 5, while diffusion restriction increased from 71.4% in PI-RADS 3 to 100% in PI-RADS 4–5 ($p = 0.013$). Zone involvement varied, with transition zone presence rare in PI-RADS 3 (7.1%) but rising in PI-RADS 4 (27.8%) and 5 (20.8%). Peripheral zone lesions were consistently present across categories, indicating that higher PI-RADS scores correlated with greater diffusion restriction and enhancement—hallmarks of clinically significant disease.

Kim *et al.* (2021)[17] assessed prostate MRI in 105 patients, revealing T2 abnormalities in 100% of PI-RADS 3–5 lesions, DCE enhancement in 95.8% of PI-RADS 3 and 100% in 4–5, and diffusion restriction in 70.4% of PI-RADS 3, rising to 100% in higher categories—consistent with the present study. Ahmed *et al.* (2017)[18] confirmed similar findings in the PROMIS trial ($n = 576$), with T2 abnormalities in all clinically significant cancers and DCE enhancement in 94%. Hamoen *et al.* (2015)[19] also found T2 abnormalities across all PI-RADS scores, with DCE enhancement and diffusion restriction more prevalent in higher categories. Puech *et al.* (2013)[20] noted that PI-RADS 5 lesions often involved multiple prostate zones, reinforcing mpMRI's role in lesion characterization and risk stratification.

This study correlated PI-RADS v2.1 imaging findings with histopathological results to assess diagnostic accuracy. PI-RADS ≥ 4 achieved 42 true positives for Gleason ≥ 7, with no false positives—indicating high specificity. Seven false negatives were reported for PI-RADS < 4 with Gleason ≥ 7. Sensitivity was 85.7%, specificity 100%, PPV 100%, NPV 73%, and overall accuracy 87.5%. ROC analysis yielded an AUC of 0.93, reflecting strong discrimination between significant and insignificant lesions. Chi-square analysis confirmed a strong association between PI-RADS scores and histopathology ($p < 0.001$).

Kim et al. (2021)[17] (sensitivity 88.7%, specificity 100%, AUC 0.93) and Ahmed et al. (2017)[18] (sensitivity 93%, specificity 41%, NPV 89%). Puech et al. (2013)[20] (sensitivity 88%, specificity 46%) and Hamoen et al. (2015)[19] (pooled sensitivity 78%, specificity 53–91%, AUC 0.82–0.93) similarly demonstrated high diagnostic value of PI-RADS, though with interobserver variability and potential false positives—highlighting the need for standardized training and interpretation in clinical practice.

Conclusion:

Multiparametric MRI based on PI-RADS v2.1 has shown superior diagnostic efficacy, characterised by remarkable sensitivity and specificity in identifying clinically relevant prostate cancer. mpMRI proficiently distinguishes between significant and inconsequential lesions, facilitates precise staging, and minimises unneeded biopsies, therefore enhancing optimised, evidence-based patient care. Nevertheless, more multicentric investigations are necessary to further corroborate the diagnostic efficacy of PI-RADS v2.1 and to define its function in standardised prostate cancer screening and classification of risks.

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