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Original Research Paper

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ROLE OF MULTIPARAMETRIC MAGNETIC RESONANCE IMAGING IN EVALUATING PROSTATIC LESIONS

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ABSTRACT **Background:** Prostate cancer being the second most common and a leading cause of cancer-related deaths; early detection and accurate staging are crucial for selecting appropriate therapeutic strategies. Multiparametric Magnetic Resonance Imaging (mpMRI) has emerged as a pivotal tool with increase in diagnostic accuracy for evaluating prostatic lesions. **Methods:** Prospective observational study conducted at the Multi-Speciality Hospital over one year. 88 male patients with clinically suspected prostatic lesions enrolled and undergone standardised mpMRI protocol using a 3.0 Tesla Philips MRI scanner. Correlation of mpMRI findings, including PI-RADS scores with Serum PSA, PSA density and biopsy results were done with appropriate statistical test. **Results:** The mean age of the participants was 67.3 ± 7.97 years, mean serum PSA 14.63 ± 17.43 ng/mL and PSA density of 0.5 ± 0.92. Radiological neoplastic lesions constituted 50% of cases, while histopathology confirmed malignancy in 38.6%. Mid region (70.5%) and peripheral zone (70.5%) most commonly involved area. PI-RADS categories IV and V were strongly associated with positive biopsy findings ($p < 0.0001$). MRI demonstrated a sensitivity 97.06%, specificity 67.67%, PPV 64.71%, NPV 97.3% and substantial agreement with biopsy ($k=0.62$). Significant association of malignant lesion seen with higher PSA density ($p=0.0005$) but not with S PSA ($p=0.7$). **Conclusion:** MpMRI, especially when combined with PSA density and PI-RADS classification, is a valuable non-invasive diagnostic tool for detecting, localising, and staging prostate cancer. Its high sensitivity and negative predictive value support its role in guiding biopsy decisions and reducing overdiagnosis.

KEYWORDS : Prostate cancer, multiparametric MRI, PI-RADS v2.1, PSA density, prostate biopsy, prostate imaging, 3T MRI.

INTRODUCTION

Prostate cancer ranks as the second most commonly diagnosed cancer and the fifth leading cause of cancer-related mortality among men worldwide. In 2020, approximately 1.41 million new cases were reported globally, with an estimated 375,304 deaths attributed to the disease (1). Data from the American Cancer Society indicated that in 2022 alone, 268,490 new diagnoses and 34,500 deaths occurred in the United States (2). While incidence rates remain relatively lower in regions like Asia and North Africa, countries such as India are witnessing a rising trend, likely driven by increasing urbanisation, lifestyle modifications, and greater accessibility to diagnostic facilities. This epidemiological shift is compounded by improvements in cancer awareness and registry systems (3).

The biological heterogeneity of prostate cancer underscores the importance of precise diagnostic tools for accurate staging and risk stratification. Differentiating organ-confined disease from locally advanced or metastatic forms is essential for appropriate treatment planning and prognostication. Current European Association of Urology (EAU) guidelines recommend imaging-based local staging, particularly in patients with intermediate to high-risk profiles defined by a prostate-specific antigen (PSA) level ≥10 ng/mL, Gleason score ≥7, or clinical stage T2b or above (4).

Traditional diagnostic methods such as serum PSA, digital rectal examination (DRE), and Gleason scoring, although widely used, have demonstrated limited accuracy in assessing disease extent, often underestimating tumour aggressiveness and burden (5). In contrast, combining multiparametric MRI (mpMRI) with clinical nomograms has shown improved predictive capability in identifying high-risk pathological features (6). Specifically, mpMRI combined with PSA density and the Prostate Imaging Reporting and Data System (PI-RADS) v2.1 scoring system offers a promising approach for risk stratification. Evidence suggests that patients with PI-RADS scores below 3 and PSA density under 0.3 ng/mL^2 may safely avoid invasive biopsy procedures (7).

The introduction of mpMRI has significantly enhanced the detection and localisation of prostate cancer, particularly in the setting of repeat biopsies or presurgical planning. It offers superior soft-tissue contrast resolution and the ability to detect lesions that might be missed using traditional transrectal ultrasound (8). Moreover, mpMRI-guided targeting can increase the detection rate of both overall and clinically significant prostate cancer while potentially reducing unnecessary biopsy rates by up to 73% (9). This reduction in invasive procedures also contributes to decreased healthcare costs and improved patient compliance. Furthermore, mpMRI facilitates targeted sampling by accurately delineating suspicious regions, thus enhancing diagnostic yield (10).

In advanced disease, accurate staging becomes vital. Extracapsular extension (ECE, T3a) and seminal vesicle invasion (SVI, T3b) are associated with worse oncological outcomes, including increased surgical margin positivity and biochemical recurrence (1). SVI also correlates with a higher risk of lymphatic dissemination (2). Precise anatomical assessment using mpMRI aids in determining treatment strategies, including decisions about nerve-sparing surgery or radiation field planning.

Despite its limitations in lymph node staging, mpMRI is a non-invasive alternative to extended pelvic lymph node dissection (ePLND), which, although considered the gold standard, carries procedural risks. Thus, mpMRI continues to evolve as a comprehensive imaging modality for the initial staging,

therapeutic planning, and follow-up evaluation in prostate cancer patients.

This study aims to evaluate the diagnostic utility of mpMRI in prostatic lesions, with a specific focus on its correlation with PSA levels, PI-RADS scoring, biopsy findings, and its role in assessing ECE, SVI, and nodal involvement.

MATERIALS & METHODS

Study Design and Setting: This prospective cohort study was conducted over a 12-month period, from April 2022 to March 2023, at the Department of Radiology, Kiran Multi-Speciality Hospital, located in the southern region of Gujarat, India.

Study Population and Sampling: 88 male patients presenting with clinically suspected prostatic lesions were enrolled. Patients undergoing MRI for post-treatment surveillance, or those with prior history of prostatectomy, radiotherapy, or androgen deprivation therapy were excluded, as PI-RADS v2.1 is not validated for assessment of treated or residual disease. Participants were selected using a convenient purposive sampling method based on specific inclusion and exclusion criteria.

Inclusion Criteria

- Male patients presenting to the radiology department with clinically suspected prostatic lesions based on elevated serum PSA, lower urinary tract symptoms, or abnormal digital rectal examination.

Exclusion Criteria

- Contraindications to MRI or gadolinium-based contrast agents.
- Inadequate imaging quality.
- Estimated glomerular filtration rate (eGFR) less than 30 mL/min/1.73 m^2.
- Prior treatment for prostate cancer including radical prostatectomy, radiotherapy, or androgen deprivation therapy.

Imaging Protocol

All mpMRI scans were conducted using a 3.0 Tesla Philips Ingenia MRI system. A uniform imaging protocol was followed for every participant. The imaging sequences included T1-weighted, T2-weighted, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) imaging. A total of 20 ml of gadopentetate dimeglumine (Magnilek, 469 mg/ml) was administered intravenously using a power injector, followed by a 10 ml saline flush at 4 ml/sec.

Detailed imaging parameters used are as follows:

Sequence	TR (ms)	TE (ms)	Flip Angle (°)	FOV (mm)	Matrix	Slices	Slice Thickness (mm)	Gap (mm)
Sagittal T2	2295	90	90	220×220	316×298	20	2.5	1
Coronal T2	3000	110	90	179×179	240×190	16	3	0.5
Axial T2	3500	110	90	183×183	244×185	16	3	0.74
Axial SPAIR T2 FS	3012	90	90	180×180	180×147	16	3.4	0.5
Axial T1	400	10	90	183×183	184×147	16	3	1
Axial DWI (b=50, 1500, 2000)	1680	70	90	375×305	124×100	15	3.6	0.36
Axial T1 FS PC	484	10	90	183×183	244×195	16	3	1
Coronal PC T1 FS	484	10	90	180×180	240×192	15	3	1
Sagittal PC T1 FS	533	10	90	180×180	240×190	15	3	1
DCE (T1 THRIVE 3D)	3.4	1.6	10	375×294	228×175	65	3	-1.5

Data Collection Process

Each patient was assigned a unique identification number to maintain confidentiality. Demographic and clinical data, including UHID, age, presenting complaints, serum PSA levels, and prostate volume were collected using a validated semi-structured questionnaire available in English, Hindi, and Gujarati. Patient input was recorded in their preferred language.

Image Analysis

Two experienced radiologists independently reviewed the MRI scans. The lesions were assessed according to the PI-RADS version 2.1 scoring system and classified accordingly. In cases of discrepancy, consensus was reached through discussion.

Statistical Analysis

Data entry was performed using Microsoft Excel 2019. Statistical analysis was carried out using MedCalc and Epi Info version 7.1. Categorical variables were summarized using frequencies and percentages, while continuous variables were expressed as mean ± standard deviation. Normality was assessed using the D'Agostino-Pearson test and histograms. Comparative analyses were done using the Student's t-test for quantitative variables and chi-square test for qualitative variables. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

Written informed consent was obtained from each participant prior to their inclusion in the study. The consent form was explained in a language understood by the patient and included all necessary details regarding their participation. The study protocol was reviewed and approved by the Institutional Ethics Committee. Patient confidentiality was strictly maintained throughout the study period, with no identifiable information used in reports or publications.

RESULTS:

Table 1: Baseline characteristics (N=88)

Variables	Mean ± SD
Age (years)	67.3 ± 7.97
Prostate size	47.35 ± 23.82
USG size	52.04 ± 26.04
Serum PSA*	14.63 ± 17.43
Malignant lesion	18.42 21.04
Benign lesion	8.71 5.75
PSA density**	0.5 ± 0.92
Malignant lesion	0.55 0.73
Benign lesion	0.43 1.16

p value 0.006 and 0.5** for malignant Vs Benign lesion.*

The mean age of patients was 67.3 years. The mean serum PSA was 14.63 ng/mL and mean PSA density was 0.5, indicating the cohort primarily consisted of elderly patients with elevated PSA levels suspicious for malignancy. Serum PSA level was significantly high in patients having malignant lesion compared to benign lesion. (Table 1)

Table 2: Distribution of prostatic lesion based on Radiological (mpMRI) and Histopathological finding (N=88)

Lesion	Radiological (mp MRI) n(%)	Histopathological n(%)
Neoplasm		
Total	44 (50)	34(38.6)
Apex region	15 (34.1)	

Mid region	31 (70.5)	
Base region	18 (40.9)	
Transitional zone	05 (11.4)	
Peripheral zone	31 (70.5)	
Periprostatic spread	04 (9.1)	
Seminal vesicle involvement	7 (15.9)	
Neurovascular bundle involvement	01 (2.3)	
Lymph node involvement	01 (2.3)	
Neoplasm + Prostatitis	07 (8)	--
Benign Prostatic Hyperplasia	24 (27.3)	39(44.3)
Prostatitis	12 (13.6)	06 (6.8)
Prostatitis + Haemorrhage	01 (1.1)	--
Normal	0	09 (10.2)

Radiological examination via mpMRI found overall 44(50%) patient's lesion consistent with neoplasia. Among the neoplastic lesion, mid region (70.5%) and peripheral zone (70.5%) were most commonly involved area. mpMRI detected involvement of seminal vesicle (15.9%), neurovascular bundle (2.3%) and lymph node (2.3%) in patient with neoplastic lesion. Histopathology confirmed malignancy in 38.6% of patients. BPH was the most common finding at 44.3%, with prostatitis and other benign changes forming the remainder (Table 2, image 1, 2&3).

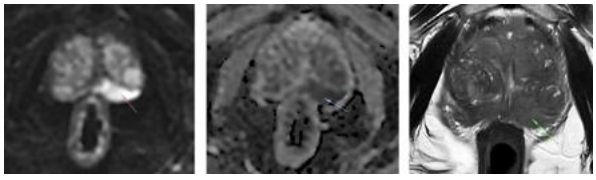

Image 1: DWI (b value 2000) showing diffuse hyperintensity involving left peripheral zone; ADC images showing corresponding hypointensity; T2W image showing hypointensity instead of normal hyperintensity-*these features categorizes this lesion as PIRADS 5.*

Image 2: T2W images hypointense diffuse infiltrative tumor involving seminal vesicle and neurovascular bundle (not visualized separately); T2W SPAIR image corresponding hypointense signals; Post contrast T1W images showing heterogeneous enhancement of tumor and involved seminal vesicle. Extraprostatic extension confirms the tumor and PIRADS V category is given to such patients.Local spread of tumor to seminal vesicles is very common and upgrades tumor T stage to T3b.Involvement of the neurovascular bundle should be specifically reported, as nerve-sparing surgery will not be possible.

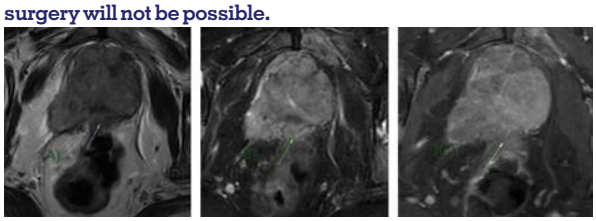

Image 3: T2W (A), T2 SPAIR (B) and post contrast T1W (C) images showing local infiltration of tumor into anterior wall or rectum.

Table 3: Correlation of PI-RADS category with biopsy-confirmed malignancy

PIRADS Category	Biopsy Yes n (%)	Biopsy No n (%)	Total N=88	p value
I	0	17 (100)	17	<0.0001
II	0	19 (100)	19	
III	2 (33.3)	4 (66.7)	6	
IV	12 (52.2)	11 (47.8)	23	
V	20 (86.9)	3 (13.1)	23	
Total	34 (38.6)	54 (61.4)	88	

A clear trend was noted showing higher biopsy-confirmed malignancy with increasing PIRADS category. No malignancies were observed in PIRADS I–II categories, whereas PIRADS IV and V showed malignancy rates of 52.2% and 86.9%, respectively (Table 3).

Table 4: Comparison of mp MRI lesion with Serum PSA and PSA density level

Biochemical parameter	Type of prostate lesion based on MRI finding		p value
	Malignant (N=50) n(%)	Benign (N=35) n(%)	
S. PSA			
Higher	49 (98)	35 (100)	0.7
Lower	01 (2)	00	
PSA density			
Higher	38 (76)	15 (42.9)	0.0005
Lower	12 (24)	20 (57.1)	

Only patients with available PSA and PSA density values were included in this analysis (n=85). Participants having higher PSA density level were more likely to be having radiological diagnosis of malignant prostatic lesion. This association was statistically significant. However S. PSA level was not found to have such association. (Table 4).

Table 5: Agreement of MRI Result with Biopsy Result

Test	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	PPV (%) (95% CI)	NPV (%) (95% CI)	Kappa test (95 %CI)
MRI finding of malignant lesion	97.06 (0.87-0.99)	67.67 (0.54-0.78)	68.71 (0.55-0.79)	97.30 (0.87-0.99)	0.62 (0.47-0.75)

Compared against biopsy results, mpMRI demonstrated sensitivity, specifity, positive predictive value (PPV) and negative predictive value of 97.06%, 67.67%, 68.71% and 97.30% respectively. Higher sensitivity suggests good detection power of mpMRI for prostatic malignancy while higher NPV suggests excellent capability for ruling out malignancy when MRI findings were negative (Table 5). A Kappa test showed substantial agreement between two methods in diagnosing prostatic malignancy.

DISCUSSION

Prostate cancer is among the most frequently diagnosed malignancies in men, representing a significant cause of cancer-related mortality globally, particularly in developed nations (1). Multiparametric magnetic resonance imaging (mpMRI) has become a crucial imaging modality in the diagnostic evaluation of prostate cancer due to its superior soft tissue contrast and ability to combine anatomical and functional imaging. When combined with clinical nomograms, mpMRI enhances the prediction of adverse pathological features, such as extracapsular extension, seminal vesicle invasion, and high Gleason scores, thereby improving the decision-making process for biopsy and treatment planning (6).

Clinical nomograms, when supplemented with mpMRI data, show greater predictive accuracy than when based solely on PSA or clinical staging. Rayn et al. demonstrated that the inclusion of mpMRI significantly improves the identification of patients at risk for adverse pathology during radical prostatectomy, thus facilitating better selection for definitive treatment strategies (6). This is especially relevant in intermediate- and high-risk patients, where precise staging can significantly impact outcomes.

The present study investigated the utility of mpMRI in a cohort of 88 patients, focusing on its correlation with serum PSA levels, PSA density, PI-RADS categorization, and histopathological biopsy results.

In terms of PSA metrics, the mean serum PSA level was 14.63 ± 17.43 ng/mL. Two separate analyses were performed — one comparing biomarkers against histopathologically confirmed malignancy, and another against MRI-based radiological diagnosis — and their results must be interpreted distinctly.

When serum PSA and PSA density were compared against histopathologically confirmed malignancy (Table 1), serum PSA was significantly higher in malignant cases compared to non-malignant cases (18.42 ± 21.04 vs. 8.71 ± 5.75 ng/mL; $p = 0.006$), consistent with prior literature that elevated PSA is associated with malignancy, though it lacks specificity (6). PSA density, however, did not show a statistically significant difference between histopathologically confirmed malignant and non-malignant groups (0.55 ± 0.73 vs. 0.43 ± 1.16; $p = 0.5$).

When the same biomarkers were compared against MRI-based radiological diagnosis (Table 4), the pattern differed — PSA density showed a highly significant association with MRI-diagnosed malignant lesions ($p = 0.0005$), while serum PSA did not demonstrate such an association ($p = 0.7$). This is consistent with findings from Massanova et al., who reported PSA density as an independent predictor of clinically significant prostate cancer on MRI (7). The differing results across the two reference standards are not contradictory — they reflect the known complementary roles of these biomarkers. Serum PSA elevation is a broader indicator of prostatic pathology including inflammation and hyperplasia, whereas PSA density, by accounting for prostate volume, more specifically correlates with MRI-detected malignant lesion characteristics.

In terms of local staging, mpMRI provides critical information about the extent of prostate cancer, especially extracapsular extension (ECE) and seminal vesicle invasion (SVI). Studies have highlighted mpMRI's capacity to visualize capsular breach and SVI with relatively high sensitivity, which are key determinants in surgical planning and prognosis (8). These staging parameters are fundamental to assessing eligibility for nerve-sparing surgery and defining radiation fields.

From a health economics and patient safety perspective, mpMRI also plays a role in reducing unnecessary repeat biopsies. The agreement between MRI findings and histopathology, measured using the kappa statistic ($\kappa = 0.62$), indicated substantial concordance, reinforcing the diagnostic credibility of mpMRI as a frontline tool in prostate cancer assessment, corroborating earlier findings by Lotan et al. who presented a decision analysis model indicating that mpMRI, when used prior to repeat biopsy, is not only cost-effective but also reduces patient morbidity and improves diagnostic yield for significant prostate cancer (9).

PI-RADS v2.1 remains the standard for structured mpMRI reporting. In our study, 53.3% of patients had PI-RADS scores of IV or V, with a statistically significant correlation to biopsy-confirmed malignancy (χ^2 trend = 59.84, $p < 0.0001$). The sensitivity and negative predictive value (NPV) of mpMRI in detecting malignancy in our study were 97.06% and 97.30%, respectively. The relatively modest specificity (67.67%) and positive predictive value (68.71%) highlight the potential for false positives, particularly in cases of prostatitis or post-biopsy changes. These results were consistent with findings by Barone et al., who reported similar diagnostic performance in both biopsy-naïve patients and those with prior negative biopsies. The study also confirmed mpMRI's high negative predictive value, which supports its role in ruling out significant malignancy (10).

Anatomically, the peripheral zone was the most common site for neoplastic lesions in our cohort, corroborating previous studies reporting that nearly 70% of prostate carcinomas originate in this region due to its glandular architecture and vascularity (11). The accurate delineation of such lesions on mpMRI enhances the targeting accuracy during fusion-guided or cognitive biopsies.

Beyond local staging, mpMRI is also instrumental in evaluating the involvement of adjacent structures. Boehmer et al. emphasized the role of imaging in radiation oncology protocols, where precise anatomical mapping improves tumor targeting while preserving normal tissue, ultimately leading to better clinical outcomes (12).

Additionally, many studies emphasized the incremental value of mpMRI in staging before radical prostatectomy, showing that imaging findings substantially altered surgical planning in a significant subset of patients (13-15). This highlights the growing consensus around integrating mpMRI into routine pre-treatment workflows in urology and oncology.

Overall, the integration of mpMRI with serum biomarkers and risk stratification tools significantly enhances diagnostic precision, facilitates personalized treatment planning, and supports the broader objective of improving prostate cancer outcomes through early and accurate detection.

CONCLUSION

In conclusion, the study validates mpMRI as a robust imaging modality that complements clinical parameters such as PSA and biopsy findings. It plays an integral role in enhancing diagnostic accuracy, reducing unnecessary biopsies, and guiding targeted intervention strategies.

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