ORIGINAL ARTICLE

Comparing the Diagnostic Performance of MRI-targeted and Systematic Biopsy in Prostate Cancer and Exploring the Predictive Factors.

Norlisa Khalid[1,2], Noorjehan Omar[3], Huzlinda Hussin[1,2]

[1] Department of Pathology, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[2] Department of Pathology, Hospital Sultan Abdul Aziz Shah, Persiaran Mardi – UPM, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[3] Department of Pathology, Hospital Sultan Idris Shah, Jalan Puchong, 43000 Kajang, Selangor, Malaysia

ABSTRACT

Introduction: Prostate cancer is a leading malignancy among men worldwide, including in Malaysia, with increasing incidence and challenges in early detection. While transrectal ultrasound-guided systematic biopsy (SB) has been the standard diagnostic method, its limitations have led to the adoption of multiparametric MRI (mpMRI) and MRI-targeted biopsy (MRI-TB) to improve diagnostic accuracy. **Methods:** This retrospective study analysed 258 patients who underwent both MRI-TB and SB at Hospital Sultan Abdul Aziz Shah in Selangor, Malaysia, from January 2023 to October 2024. A total of 308 biopsy samples were examined to compare the diagnostic accuracy of both methods in diagnosing prostate cancer and to determine the cancer's predictive factors. Statistical analyses included diagnostic accuracy metrics, McNemar's test, and logistic regression. **Results:** MRI-TB showed superior sensitivity (80.3%) and negative predictive value (NPV) (89.3%) compared to SB (59.0% and 79.9%, respectively), while both methods achieved 100% specificity. MRI-TB detected a higher rate of clinically significant prostate cancer (csPCa) (30.5%) than SB (22.4%) ($p < 0.001$). Systematic biopsy missed 11.7% of csPCa cases, whereas MRI-TB missed only 3.6%. Independent predictors of csPCa in multivariate analysis were PI-RADS 5 (OR = 3.73, p= 0.001), prostate volume (OR = 0.98, $p <0.001$), suspicious palpable prostates (OR = 2.80, p = 0.028), age (OR = 1.10, $p < 0.001$) and Chinese ethnicity (OR=1.85, p=0.047). **Conclusion:** MRI-TB enhances csPCa detection and reduces false negatives, while SB remains complementary. Combining both methods with key predictive factors improves diagnostic precision and patient management.
Malaysian Journal of Medicine and Health Sciences (2025) 21(SUPP12): 47-54.doi:10.47836/mjmhs.21.s12.8

Keywords: Prostate cancer, Multiparametric MRI, Image-Guided biopsy, Diagnostic imaging, Prostate neoplasms

Corresponding Author:
Huzlinda Hussin, MPath
Email: huzlinda@upm.edu.my
Tel: +60397692781

INTRODUCTION

Prostate cancer is a major public health concern, ranking among the most common malignancies in men worldwide and in Malaysia. According to the Malaysian National Cancer Registry Report (2012–2016), the age-standardized incidence rate (ASR) is 6.7 per 100,000 men, with most cases occurring in individuals aged 60 and above (1). Ethnic variations are notable, with Chinese men exhibiting higher incidence rates than Malays and Indians, possibly due to genetic predisposition, lifestyle factors, or disparities in healthcare access (1,2). Additionally, late-stage diagnosis is prevalent, with 58.1% of cases detected at advanced stages, contributing to higher mortality rates and poorer survival outcomes (2).

Traditional diagnostic methods, such as systematic transrectal ultrasound-guided biopsies (TRUS), employ a 10–12-core sampling approach targeting the peripheral and transition zones of the prostate. Despite its widespread use, this method has limitations, including a higher risk of missing clinically significant prostate cancer (csPCa) in challenging areas, such as the anterior prostate, and the overdiagnosis of indolent lesions (3).

The Gleason grading system is critical for determining prostate cancer aggressiveness. It assesses glandular differentiation on a scale of 1 to 5, with the Gleason score derived from the sum of the two most predominant patterns. Scores range from 2 to 10, with those of 7 or higher indicating clinically significant cancer with a greater potential for progression and metastasis. Gleason

score combinations, such as 3+4 and 4+3, provide important prognostic information, with 3+4 cancers generally associated with more favorable outcomes than 4+3 cancers (4). Features such as cribriform morphology further denote aggressive disease characteristics (5). When integrated with Gleason grading, advanced imaging techniques, including multiparametric MRI (mpMRI), enhance diagnostic accuracy and support personalised treatment approaches (6).

In the early 2000s, mpMRI emerged as a pivotal tool for detecting csPCa, offering improved accuracy over conventional imaging techniques. It combines T2-weighted imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced imaging (DCE) to provide detailed assessments of prostate tissue. T2-weighted imaging highlights structural abnormalities, while DWI and DCE identify tumour-specific characteristics, such as restricted diffusion and increased vascularity (7).

Comparative studies, including PRECISION and the Patient-Reported Outcomes Measurement Information System (PROMIS), emphasise the benefits of MRI-targeted biopsy (MRI-TB) over systematic biopsy (SB), particularly in biopsy-naïve patients (3,8). The 2020 European Association of Urology (EAU) guidelines recommend combining MRI-TB with SB for biopsy-naïve patients with PI-RADS scores ≥3 while advising MRI-TB alone for those with prior negative biopsies (9–11). These recommendations highlight the importance of personalised diagnostic approaches to optimising prostate cancer detection. MRI-TB improves the identification of csPCa while reducing the detection of clinically insignificant cancers, which can lead to overtreatment (3). However, SB remains relevant for comprehensive sampling and detecting cancers that MRI may overlook (10,13,14). Combining both methods is particularly valuable in cases with equivocal MRI findings (PI-RADS 3) or a high clinical suspicion of csPCa (12–14).

The Prostate Imaging Reporting and Data System (PI-RADS) standardises mpMRI interpretation. The latest version, 2.1, released in 2019, further improves reproducibility by clarifying the definitions of DWI and DCE MRI scoring (15,16). Lesions with PI-RADS scores of 4 or 5 strongly indicate csPCa, whereas PI-RADS 3 lesions require further clinical and pathological evaluation (15,16). Studies suggest combining PI-RADS with clinical parameters such as prostate-specific antigen (PSA) levels and prostate volume enhances diagnostic precision (17).

Transperineal (TP) and TRUS biopsy techniques complement MRI-based diagnostics. While TP biopsy is associated with a lower risk of infection, it requires intravenous sedation due to its invasive nature (18, 19). In contrast, TRUS biopsy is less invasive but has a higher risk of infection and sepsis due to rectal flora contamination (20, 21). The choice of biopsy method depends on patient-specific factors, including prostate size, lesion location, and clinical presentation (18–21).

This study examines the diagnostic performance of MRI-TB and SB in detecting csPCa while evaluating PI-RADS scores, prostate-specific antigen (PSA) levels, prostate volume, and tumour palpability to address critical gaps in prostate cancer diagnostics within the Malaysian healthcare setting. The findings aimed to provide evidence-based recommendations to optimise biopsy protocols and improve patient outcomes in line with international standards.

MATERIALS AND METHODS

Sample

This retrospective cohort study analysed clinicopathological and radiological data from patients who underwent prostate biopsies for prostate lesions at Hospital Sultan Abdul Aziz Shah (HSAAS) between January 2023 and October 2024. Patient data were retrieved from archived histopathological and clinical records within the Laboratory Information System (LIS) and the electronic Hospital Information System (eHIS). The inclusion criteria for this study were patients who underwent both MRI-TB and SB, while patients who received neoadjuvant therapy before biopsy were excluded.

Patients with PI-RADS ≥ 3 on mpMRI underwent both MRI-targeted biopsy (MRI-TB) and SB in accordance with our institutional protocol. This dual-approach strategy aligns with international guidelines, including the National Institute for Health and Care Excellence (NICE) guideline for prostate cancer diagnosis and management, where the aim is to maximise cancer detection while minimising the risk of missing csPCa. All prostate biopsy histological assessments were performed by experienced pathologists, and grading adhered to the 2014 International Society of Urological Pathology (ISUP) Gleason grading system.

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics, version 29.0. Descriptive analysis summarised demographic and clinicopathological variables, including age, ethnicity, prostate volume and palpability, PSA level and PI-RADS score. Continuous variables were reported as means with standard deviations (SD) or medians with interquartile ranges (IQR), while categorical variables were presented as frequencies and percentages.

Diagnostic accuracy, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), was assessed for MRI-TB and SB, using the combined results as the reference standard. Mcnemar's test was used to analyse the comparison between MRI-

TB and SB in prostate cancer detection.

Univariate logistic regression examined associations between demographic and clinicopathological factors (age, ethnicity, PSA levels, prostate volume, palpable prostate, and PI-RADS scores) and csPCa detection. Significant variables from univariable analysis were included in multivariable logistic regression to identify independent predictors. Results were reported as odds ratios (OR) with 95% confidence intervals (CI), with statistical significance set at $p < 0.05$.

Ethical approval

The study was approved by the Ethics Committee for Research Involving Humans (JKEUPM-2023-1432).

RESULTS

A total of 451 patients who underwent prostate biopsies during the study period were identified. After applying the inclusion and exclusion criteria, 258 patients were selected for analysis. For patients with multiple lesions showing different PI-RADS scores on mpMRI, each corresponding biopsy sample was analysed separately, based on its anatomical location and PI-RADS score Each biopsy sample was analysed separately for patients with multiple PI-RADS scores, resulting in 308 samples.

Demographic and clinicopathological analysis

Patients with prostate cancer were generally older than those in the overall cohort, with a mean age of 70.0 years (SD: 5.6) vs 68.3 years (SD: 6.2). The median PSA level was slightly higher in patients diagnosed with prostate cancer (11.0 ng/mL (IQR: 10.0)) compared to the overall cohort (10.0 ng/mL (IQR: 8.5)). Additionally, prostate volume was lower among cancer patients (42.6 mL vs. 48.7 mL), consistent with findings that smaller prostate size may be associated with clinically significant cancer. Regarding ethnic distribution, Malays comprised the majority of recruited patients (60.0%), followed by Chinese (32.1%) and Indians (7.8%). Among prostate cancer cases, a similar trend was observed, with Malays (58.3%), followed by Chinese (36.1%) and Indians (5.6%).

In terms of digital rectal examination (DRE) findings, the proportion of patients with a suspicious prostate on palpation was slightly higher in the cancer group (10.2%) compared to the overall cohort (9.7%). Some patients had multiple PI-RADS scores, leading to 308 PI-RADS scores in the prostate lesion group and 157 PI-RADS scores among cancer cases. The distribution showed that PI-RADS 5 lesions were more frequent in patients with prostate cancer (45.2%) compared to PI-RADS 3 (15.9%) and PI-RADS 4 (38.9%) (Table I).

Table I: Demographic and clinicopathological characteristics of patients with prostate lesions and prostate cancers.

Characteristics	Prostate lesions (n=258)	Prostate cancers (n=108)
Age (years)		
Mean (SD)	68.3 (6.2)	70.0 (5.6)
PSA level (ng/ml) Median (IQR)	10.0 (8.5)	11.0 (10.0)
Prostate volume (ml) Median (IQR)	48.7 (35.0)	42.6 (20.0)
Ethnicity, n (%)		
Malay	155 (60.0)	63 (58.3)
Chinese	83 (32.1)	39 (36.1)
Indian	20 (7.8)	6 (5.6)
Palpable prostate, n (%)		
Benign	233 (90.3)	97 (89.8)
Suspicious	25 (9.7)	11 (10.2)
PI-RADS Score*, n (%)		
PI-RADS 3	57 (18.5)	25 (15.9)
PI-RADS 4	151 (49.0)	61 (38.9)
PI-RADS 5	100 (32.5)	71 (45.2)

*Some patients had multiple PI-RADS scores, leading to a higher total count of PI-RADS scores (n=308) compared to the total number of cases

Diagnostic accuracy of MRI-targeted vs. systematic biopsy

MRI-targeted biopsy demonstrated higher sensitivity (80.3%, 95% CI: 71.98–87.11) than SB (59.0%, 95% CI: 49.50–67.98). Both biopsy techniques had 100% specificity (95% CI: 98.09–100.00), and the positive predictive value (PPV) was also 100% for both methods. The negative predictive value (NPV) was higher for MRI-TB (89.3%, 95% CI: 85.20–92.30) compared to SB (79.9%, 95% CI: 76.21–83.18) (Table II).

Table II: Diagnostic Accuracy of MRI-Targeted vs. Systematic Prostate Biopsies for Clinically Significant Prostate Cancer

Variable	MRI-targeted biopsy	Systematic biopsy
Sensitivity (%), 95% CI	80.3 (71.98 to 87.11)	59.0 (49.50 to 67.98)
Specificity (%), 95% CI	100.0 (98.09 to 100.00)	100.0 (98.09 to 100.00)
Positive Predictive Value (PPV, %), 95% CI	100.0 (96.15 to 100.00)	100.0 (94.79 to 100.00)
Negative Predictive Value (NPV, %), 95% CI	89.3 (85.20 to 92.30)	79.9 (76.21 to 83.18)

Comparison between MRI-targeted and systematic biopsy in detection rates, agreement, and missed cases of clinically significant prostate cancers

MRI-targeted biopsy detected a significantly higher percentage of overall prostate cancers (40.3%) compared to systematic biopsy (34.1%) (p = 0.013). Additionally, it identified more clinically significant prostate cancers (Gleason Score ≥7) (30.5%) than systematic biopsy (22.4%) (p < 0.001). However, there was no significant difference in the detection of clinically insignificant prostate cancer (Gleason Score 6) between the two biopsy techniques (p = 0.430) (Table III).

Table III: Comparison between MRI-targeted biopsy and systematic biopsy in prostate cancer detection

		MRI-Targeted biopsy n=308	Systematic biopsy n=308	p-value
Benign, n (%)		184 (59.7)	203 (65.9)	_
Prostate cancer, n (%)		124 (40.3)	105 (34.1)	0.013*
Clinically significant prostate cancer, n (%)	(Gleason score ≥7)	94 (30.5)	69 (22.4)	<0.001*
Clinically insignificant prostate cancer, n (%)	(Gleason score 6)	30 (9.7)	36(11.7)	0.430

*Statistically significant values (p < 0.05)

MRI-targeted and systematic biopsies both detected 58 cases (18.8%) of csPCa, demonstrating true positive concordance. Likewise, both methods classified 203 cases (65.9%) as non-csPCa, indicating true negative agreement. However, MRI-targeted biopsy missed 11 csPCa cases (3.6%) that were identified by systematic biopsy, while systematic biopsy missed 36 csPCa cases (11.7%) that were detected by MRI-targeted biopsy. Combining both techniques resulted in the detection of 105 csPCa cases (34%), with an incremental detection rate of 15.23 % compared to using either method alone. The discordance between MRI-TB and SB was statistically significant (p < 0.001) (Table IV)

Table IV: Agreement and missed detection of clinically significant prostate cancer (csPCa) between MRI-Targeted and systematic biopsies

		Systematic Biopsy, n (%)		
		Non-clinically significant prostate cancer	Clinically significant prostate cancer	p-value
MRI-Targeted Biopsy, n (%)	Non-clinically significant prostate cancer	203 (65.9)	11 (3.6)	<0.001
	Clinically significant prostate cancer	36 (11.7)	58 (18.8)	
Total		308		

*Statistically significant values (p < 0.05)

Factors associated with clinically significant prostate cancer

In the univariate analysis (Table V), age was significantly associated with clinically significant prostate cancer detection, with each additional year increasing the odds (OR: 1.10, 95% CI: 1.04–1.13, p < 0.001). Similarly, prostate volume showed an inverse relationship, with larger prostate volume being associated with lower odds of cancer detection (OR: 0.98, 95% CI: 0.97–0.99, p < 0.001). Patients with a suspicious prostate on digital rectal examination (DRE) had significantly higher odds of cancer detection compared to those with benign findings (OR: 5.10, 95% CI: 2.32–11.28, p < 0.001). Regarding ethnicity, Chinese patients had significantly higher odds of clinically significant prostate cancer detection compared to Malays (OR: 2.26, 95% CI: 1.36–3.77, p = 0.002). Indian patients also showed an increased risk (OR: 0.45, 95% CI: 1.29–7.52, p = 0.012), though further analysis was needed to determine if this association remained after adjustment for other variables. For PI-RADS scores, patients with PI-RADS 5 lesions had a significantly higher likelihood of clinically significant prostate cancer detection compared to PI-RADS 3 (OR: 4.91, 95% CI: 2.28–10.56, p < 0.001). However, PI-RADS 4 did not show a significant association (OR: 1.50, 95% CI: 0.71–3.19, p = 0.284).

Table V: Univariate analysis of factors associated with clinically significant prostate cancer (n= 105)

Variable	Mean (SD)	n (%)	Crude OR (95% CI)	p-value
Age (years)	70.7 (5.3)		1.10 (1.04 to 1.13)	<0.001*
PSA level (ng/ml)	16.8 (17.2)		1.00 (0.997 to 1.029)	0.112
Prostate volume (ml)	46.1 (21.4)		0.98 (0.97 to 0.99)	<0.001*
Palpable Prostate				
Benign (Reference)		83 (79.0)	1.00 (ref)	–
Suspicious		22 (21.0)	5.10 (2.32 to 11.28)	<0.001*
Ethnicity				
Malay (Reference)		47 (44.8)	1.00 (ref)	–
Chinese		46 (43.8)	2.26 (1.36 to 3.77)	0.002*
Indian		12 (11.4)	0.45 (41.29 to 7.52)	0.012
PI-RADS Score				
PI-RADS 3 (Reference)		11 (10.5)	1.00 (ref)	–
PI-RADS 4		40 (38.1)	1.50 (0.71 to 3.19)	0.284
PI-RADS 5		54 (51.4)	4.91 (2.28 to 10.56)	<0.001*

*Statistically significant values (p < 0.05)

After adjusting for confounding factors in the multivariate analysis (Table VI), age remained a significant predictor, with increasing age continuing to be associated with a higher likelihood of clinically significant prostate cancer detection (OR: 1.10, 95% CI: 1.04–1.15, p < 0.001). Prostate volume remained inversely associated, confirming its protective effect (OR: 0.98, 95% CI: 0.97–0.99, p < 0.001). The association between a suspicious prostate on DRE and cancer detection weakened but remained statistically significant (OR: 2.80, 95% CI: 1.16–7.01, p = 0.028), indicating that while DRE findings are useful, their predictive value is affected by other clinical factors. Regarding ethnicity, Chinese patients continued to have significantly higher odds of prostate cancer detection compared to Malays, although the association was slightly attenuated (OR: 1.85, 95% CI: 1.01–2.29, p = 0.047). However, the association for Indian patients was no longer significant after adjustment (OR: 2.13, 95% CI: 0.76–6.02, p = 0.153), suggesting that confounding factors influenced the initial univariate result. For PI-RADS scores, PI-RADS 5 remained a strong and independent predictor of clinically significant prostate cancer detection (OR: 3.73, 95% CI: 1.62–8.56, p = 0.001). PI-RADS 4, however, did not show a significant association (OR: 1.00, 95% CI: 0.56–2.12, p = 0.574), reinforcing the notion that PI-RADS 5 is the strongest imaging predictor.

Table VI: Adjusted odd ratios from multivariate analysis of factors associated with clinically significant prostate cancer

Variable	Adjusted OR (95% CI)	p-value
Age (years)	1.10 (1.04 to 1.15)	<0.001*
Prostate volume (ml)	0.98 (0.97 to 0.99)	<0.001*
Palpable prostate		
Benign (Reference)	1.00 (ref)	–
Suspicious	2.80 (1.16 to 7.01)	0.028*
Ethnicity		
Malay (Reference)	1.00 (ref)	–
Chinese	1.85 (1.01 to 2.29)	0.047*
Indian	2.13 (0.76 to 6.02)	0.153
PI-RADS Score		
PI-RADS 3 (Reference)	1.00 (ref)	–
PI-RADS 4	1.00 (0.56 to 2.12)	0.574
PI-RADS 5	3.73 (1.62 to 8.56)	0.001*

*Statistically significant values (p < 0.05)

DISCUSSION

This is the first study in Malaysia to comprehensively evaluate both MRI-TB and SB for prostate cancer detection. The findings address a critical gap in local data and inform biopsy strategies that are adaptable to regional healthcare constraints, including radiological expertise and access to mpMRI .

The results provide valuable insights into patients' demographic and clinicopathological characteristics, compare the diagnostic accuracy and biopsy concordance between methods, and analyse risk factors of csPCa.

The majority of csPCa patients were Malay (58.3%), followed by Chinese (36.1%) and Indian (5.6%) patients (Table I). The cancer detection rate among Chinese patients was slightly higher than their population proportion, consistent with previous studies suggesting genetic or environmental (2,22). Possible explanations for this finding include genetic variations in androgen receptor activity, dietary factors, and differences in access to healthcare and screening practices, which have

been reported in studies from other Asian populations (23, 24).

Diagnostic accuracy of MRI-targeted vs. systematic prostate biopsies

This study revealed that MRI-TB demonstrated superior diagnostic accuracy for detecting csPCa than SB. This finding aligns with evidence from pivotal trials, such as the PROMIS Study and Leow et al. (2023), which reported higher sensitivity rates for targeted biopsy, 93% and 82.7%, respectively (8, 25). The sensitivity rate for SB was similar in the PROMIS study (48%). However, Leow et al. (2023) reported higher sensitivity (75.5%) than our study (59%). This result indicates that targeted biopsy had a superior ability to detect clinically significant prostate cancer. The superior diagnostic performance of MRI-TB is attributable to its ability to localise and sample suspicious lesions identified on MRI, focusing on regions most likely to harbour clinically significant disease (25). In contrast, SB randomly samples the prostate, which may lead to underdiagnosis in cases where lesions are less accessible or not evenly distributed across the gland.

The NPV of MRI-TB in this study was 89.3%, reflecting its reliability in ruling out csPCa. This aligns with findings from Leow et al. (2023), which reported a similar NPV of 89.9% (25). In contrast, the NPV of SB was 79.9%, highlighting its increased likelihood of false negatives when used in isolation. This discrepancy reinforces the limitations of SB, particularly when MRI provides high-quality imaging for lesion identification and targeting. MRI-targeted and systematic biopsy exhibited 100% specificity and positive predictive value (PPV), meaning all biopsy-confirmed cancers were truly malignant. However, this may reflect the high-risk nature of the study population or selection bias rather than the absolute diagnostic accuracy of these methods. Future studies with a broader patient cohort could provide more generalised findings.

In our study, MRI-TB missed 3.6% of csPCa cases, while SB missed 11.7%. By combining both techniques, an additional 15.3% of csPCa cases were detected compared to either method alone, indicating a substantial incremental benefit. This detection rate exceeds those reported in previous studies by Rouviиre et al. (2019) (5.2%) and Drost et al. (2020) (5%) [26,27], potentially reflecting differences in patient selection criteria, operator expertise, or MRI quality. In our context, variability in radiological interpretation, limited access to high-resolution mpMRI, and differences in biopsy execution may have contributed to this discrepancy.

The divergence in findings across studies may also be explained by differences in lesion visibility on MRI and heterogeneity in biopsy protocols. Notably, MRI-TB may miss low-volume csPCa, especially in anterior or MRI-invisible lesions, which SB may detect through random sampling. Moreover, the performance of MRI-TB is highly dependent on image quality and the radiologist's proficiency. Rosenkrantz et al. (2017) highlighted considerable interobserver variability in PI-RADS interpretation, with concordance rates ranging from 50% to 80% depending on the reader's experience [28]. In contrast, SB provides systematic coverage of the entire prostate, enhancing the likelihood of detecting smaller or radiologically occult tumors. These findings reinforce the complementary roles of MRI-TB and SB, particularly in settings with variable MRI quality or reader expertise.

Detection rate of clinically significant prostate cancer

MRI-targeted biopsy identified a significantly higher proportion of clinically significant prostate cancers (30.5%) compared to systematic biopsy (22.4%) ($p < 0.001$). This finding is crucial, as clinically significant cancers require definitive treatment, and improved detection may lead to earlier and more appropriate intervention. This finding aligns with the PRECISION trial (MRI-TB: 38%, SB: 26%) and Siddiqui et al. (2015) (MRI-TB: 30%, SB: 24%) (3, 29). The lower detection rate in our study compared to PRECISION may be due to differences in MRI quality, reader expertise, or differences in tumour biology in our patient population.

Conversely, there was no significant difference in the detection of clinically insignificant prostate cancer (Gleason Score 6) between MRI-targeted (9.7%) and systematic biopsy (11.7%) ($p = 0.430$). This suggests that MRI-targeted biopsy does not increase the detection of low-risk prostate cancer, which is important for avoiding overdiagnosis and overtreatment, the key concerns in prostate cancer management. These results align with previous studies that have shown MRI-targeted biopsy improves the detection of clinically significant prostate cancer while reducing the need for unnecessary biopsies (3, 26, 29, 30). The ability of MRI to pre-select suspicious areas for targeted sampling likely explains its higher diagnostic accuracy. However, systematic biopsy remains an important diagnostic tool, particularly in cases where MRI findings are inconclusive or when MRI is unavailable.

Association between clinical factors and csPCa detection

Table V shows significant associations between csPCa and age, Chinese ethnicity, prostate volume, palpable tumours, and PI-RADS scores. Older age correlated with increased csPCa risk (OR = 1.10, $p < 0.001$), while larger prostate volume was inversely associated with csPCa detection (OR = 0.98, $p < 0.001$). 3etin et al. (2023) noted that systematic biopsy performance declines in larger prostates, requiring more extensive sampling (31). Chinese patients exhibited a significantly higher likelihood of csPCa detection than Malay patients (OR = 2.26, $p = 0.002$), suggesting potential genetic and environmental factors contributing to this disparity. Table VI further confirms these trends in multivariate analysis. These findings align with studies by Washino et al. (2016) and Leow et al. (2023), which demonstrated

that higher PI-RADS scores and PSA density were strong predictors of csPCa (17,25).

PI-RADS 5 lesions were nearly four times more likely to indicate csPCa than PI-RADS 3 lesions (OR = 3.73, p = 0.001), while PI-RADS 4 lesions did not show statistical significance (Table VI). The lower predictive value of PI-RADS 4 in our study may be due to differences in inter-reader variability or indolent cancers misclassified as PI-RADS 5 in some studies. Some studies have reported that PI-RADS 4 lesions demonstrate a wider range of Gleason scores, leading to variable csPCa detection rates. Suspicious DRE findings significantly increased csPCa detection odds in both univariate (OR = 5.10, p < 0.001) and multivariate analysis (OR = 2.80, p = 0.028) (Table V and VI). This highlights the continued importance of DRE in clinical practice despite the growing reliance on MRI for prostate cancer detection. Despite moderate sensitivity for prostate cancer screening (51%), DRE remains a valuable diagnostic tool for identifying high-risk patients (31).

Study limitations

This study has limitations, including potential selection bias due to its retrospective design and single-centre setting, which may impact generalizability. The lack of whole-tissue histopathological analysis prevents definitive validation of biopsy results. Another limitation is the reliance on MRI quality and interobserver variability in PI-RADS interpretation, which may affect diagnostic performance.

CONCLUSION

MRI-TB demonstrates superior diagnostic accuracy over SB, with a higher detection rate of csPCa and fewer false negatives. However, SB plays a crucial complementary role in capturing cases missed by MRI-TB. PI-RADS 5 is a strong predictor of csPCa and should guide clinical decision-making, while factors such as prostate volume and suspicious DRE findings provide additional diagnostic value. Integrating MRI-TB with SB and refining risk stratification criteria may enhance diagnostic precision while minimising unnecessary procedures. Future studies should focus on improving MRI standardisation and identifying patients most benefit from combined biopsy approaches.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to the staff of the Department of Pathology and the Department of Urology at Hospital Sultan Abdul Aziz Shah for their invaluable contributions to this study.

REFERENCES

1. Malaysia Ministry of Health. Malaysia National Cancer Registry Report 2012–2016 [Internet]. Ministry of Health Malaysia; 2019 [cited 2021 Oct 5]. Available from: https://www.moh.gov.my/moh/resources/Penerbitan/Laporan/Umum/2012-2016%20(MNCRR)/MNCR_2012-2016_FINAL_(PUBLISHED_2019).pdf.
2. Lim J, Malek R, Toh CC, Sundram M, Woo SY, Yusoff NA, et al. Prostate cancer in multi-ethnic Asian men: Real-world experience in the Malaysia Prostate Cancer (M-CaP) Study. Cancer Med. 2021;10(22):8020-8. doi: 10.1002/cam4.4319. Epub 2021 Oct 9.
3. Kasivisvanathan V, Rannikko AS, Borghi M, Panebianco V, Mynderse LA, Vaarala MH, et al. MRI-targeted or standard biopsy for prostate-cancer diagnosis. N Engl J Med. 2018;378(19):1767-77. doi:10.1056/NEJMoa1801993.
4. Epstein JI, Egevad L, Humphrey PA, Montironi R. The 2014 International Society of Urological Pathology (ISUP) Consensus Conference on Gleason Grading of Prostatic Carcinoma: Definition of grading patterns and proposal for a new grading system. Am J Surg Pathol. 2016;40(2):244-52. doi:10.1097/PAS.0000000000000530.
5. Elfandy H, Armenia J, Pederzoli F, Pullman E, Pertega-Gomes N, Schultz N, et al. Genetic and epigenetic determinants of aggressiveness in cribriform carcinoma of the prostate. Mol Cancer Res. 2019;17(2):446-56. doi:10.1158/1541-7786.MCR-18-0440.
6. Elkhoury FF, Felker ER, Kwan L, Sisk AE, Delfin M, Natarajan S, et al. Comparison of targeted vs systematic prostate biopsy in men who are biopsy naive: The PAIREDCAP Study. JAMA Surg. 2019;154(9):811-8. doi:10.1001/jamasurg.2019.1734.
7. Turkbey B, Mani H, Shah V, Rastinehad AR, Bernardo M, Pohida T, et al. Multiparametric 3T prostate MRI to detect cancer: Histopathological correlation using prostatectomy specimens processed in MRI-based molds. J Urol. 2011;186(5):1818-24. doi: 10.1016/j.juro.2011.07.013.
8. Ahmed HU, El-Shater Bosaily A, Brown LC, Gabe R, Kaplan R, Parmar MK, et al. Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): A paired validating confirmatory study. Lancet. 2017;389(10071):815-22. doi:10.1016/S0140-6736(16)32401-1.
9. Cornford P, van den Bergh RCN, Briers E, Van den Broeck T, Cumberbatch MG, De Santis M, et al. EAU-EANM-ESTRO-ESUR-SIOG Guidelines on Prostate Cancer. Part II-2020 Update: Treatment of Relapsing and Metastatic Prostate Cancer. Eur Urol. 2021 Feb;79(2):263–82. doi:10.1016/j.eururo.2020.09.046.
10. Ahdoot M, Wilbur AR, Reese SE, Lebastchi AH, Mehralivand S, Gomella PT, et al. MRI-targeted, systematic, and combined biopsy for prostate cancer diagnosis. N Engl J Med. 2020;382(10):917-28. doi:10.1056/NEJMoa1910038.
11. Rebez G, Barbiero M, Simonato FA, Claps F,

Siracusano S, Giaimo R, et al. Targeted prostate biopsy: How, when, and why? A systematic review. Diagnostics (Basel). 2024;14(17):1864. doi:10.3390/diagnostics14171864.
12. Jдderling F, Bergman M, Engel JC, Mortezavi A, Picker W, Haug ES, et al. Tailoring biopsy strategy in the MRI-fusion prostate biopsy era: systematic, targeted or neither? BMC Urol. 2024 Aug 7;24(1):168. doi: 10.1186/s12894-024-01553-1.
13. Riskin-Jones HH, Raman AG, Kulkarni R, Arnold CW, Sisk A, Felker E, et al. Performance of MR fusion biopsy, systematic biopsy and combined biopsy on prostate cancer detection rate in 1229 patients stratified by PI-RADSv2 score on 3T multi-parametric MRI. Abdom Radiol (NY). 2025 Jan 18. doi: 10.1007/s00261-024-04753-3.
14. Neale A, Stroman L, Kum F, Jabarkhyl D, Di Benedetto A, Mehan N, et al. Targeted and systematic cognitive freehand-guided transperineal biopsy: is there still a role for systematic biopsy? BJU International. 2020;126(2):280–285. https://doi.org/10.1111/bju.15092.
15. Greenberg JW, Koller CR, Lightfoot C, Brinkley GJ, Leinwand G, Wang J, et al. Annual mpMRI surveillance: PI-RADS upgrading and increasing trend correlated with patients who harbor clinically significantdisease.UrolOncol.2024May;42(5):158.e11-158.e16. doi: 10.1016/j.urolonc.2024.01.005.
16. Nicola R, Bittencourt LK. PI-RADS 3 lesions: a critical review and discussion of how to improve management. Abdom Radiol (NY). 2023 Jul;48(7):2401–5. doi: 10.1007/s00261-023-03929-7.
17. Washino S, Okochi T, Saito K, Konishi T, Hirai M, Kobayashi Y, et al. Combination of prostate imaging reporting and data system (PI-RADS) score and prostate-specific antigen (PSA) density predicts biopsy outcome in prostate biopsy naпve patients. BJU Int. 2017 Feb;119(2):225–33. doi: 10.1111/bju.13465.
18. Cheng E, Davuluri M, Lewicki PJ, Hu JC, Basourakos SP. Developments in optimizing transperineal prostate biopsy. Curr Opin Urol. 2022;32(1):85–90. doi:10.1097/MOU.0000000000000947.
19. Sandberg M, Whitman W, Greenberg J, Hingu J, Thakker P, Rong A, et al. Risk factors for infection and acute urinary retention following transperineal prostate biopsy. Int Urol Nephrol. 2024;56(3):819-26. doi: 10.1007/s11255-023-03854-0.
20. Williamson DA, Barrett LK, Rogers BA, Freeman JT, Hadway P, Paterson DL. Infectious complications following transrectal ultrasound–guided prostate biopsy: new challenges in the era of multidrug-resistant Escherichia coli. Clin Infect Dis. 2013;57(2):267-74. https://doi.org/10.1093/cid/cit193.
21. Liss MA, Chang A, Santos R, Nakama-Peeples A, Peterson EM, Osann K, et al. Prevalence and significance of fluoroquinolone-resistant Escherichia coli in patients undergoing transrectal ultrasound-guided prostate needle biopsy. J Urol. 2011;185(4):1283–8. doi:10.1016/j.juro.2010.11.088.
22. Kim CS, Lee JY, Chung BH, et al. Report of the second Asian Prostate Cancer (A-CaP) study meeting. Prostate Int. 2017;5(3):95-103. doi:10.1016/j.prnil.2017.03.006.
23. Ito K. Prostate cancer in Asian men. Nat Rev Urol. 2014 Apr;11(4):197–212. doi:10.1038/nrurol.2014.42.
24. Poniah P, Mohamed Z, Apalasamy YD, Mohd Zain S, Kuppusamy S, Razack AH. Genetic polymorphisms in the androgen metabolism pathway and risk of prostate cancer in low incidence Malaysian ethnic groups. Int J Clin Exp Med. 2015;8(10):19232–40.
25. Leow JJ, Koh SH, Chow MW, Loke W, Salada IR, Hong SK, et al. Can we omit systematic biopsies in patients undergoing MRI fusion-targeted prostate biopsies? Asian J Androl. 2023;25(1):43-9. doi: 10.4103/aja2021128.
26. Rouvière O, Puech P, Renard-Penna R, Claudon M, Roy C, Mиge-Lechevallier F, et al. Use of prostate systematic and targeted biopsy on the basis of multiparametric MRI in biopsy-naive patients (MRI-FIRST): a prospective, multicentre, paired diagnostic study. Lancet Oncol. 2019 Jan;20(1):100–9. doi: 10.1016/S1470-2045(18)30569-2.
27. Drost FH, Osses DF, Nieboer D, Steyerberg EW, Bangma CH, Roobol MJ, et al. Prostate MRI, with or without targeted biopsy and systematic biopsy for detecting prostate cancer. Cochrane Database Syst Rev. 2020;4:CD012663. doi:10.1002/14651858.CD012663.
28. Rosenkrantz AB, Ginocchio LA, Cornfeld D, Froemming AT, Gupta RT, Turkbey B, et al. Interobserver Reproducibility of the PI-RADS Version 2 Lexicon: A Multicenter Study of Six Experienced Prostate Radiologists. Radiology. 2016 Sep;280(3):793–804. doi: 10.1148/radiol.2016152542.
29. Siddiqui MM, Rais-Bahrami S, Turkbey B, George AK, Rothwax J, Shakir N, et al. Comparison of MR/ultrasound fusion–guided biopsy with ultrasound-guided biopsy for prostate cancer. JAMA. 2015;313(4):390-7. doi:10.1001/jama.2014.17942.
30. Naji L, Randhawa H, Sohani Z, Dennis B, Lautenbach D, Kavanagh O, et al. Digital rectal examination for prostate cancer screening in primary care: a systematic review and meta-analysis. Ann Fam Med. 2018;16(2):149-54. doi:10.1370/afm.2205.
31. Зetin S, Olgun A, Bulut EC, Koparal M, Bayramlı E, Şen İ, et al. Factors predicting transrectal ultrasound-guided systematic prostate biopsy failure. Eur Res J. 2023;9(5):868-73. doi:10.18621/eurj.1198992.