DOI: *10.4081/aiua.2025.13933*

ORIGINAL PAPER

Learning curve of a multidisciplinary team for magnetic resonance imaging/transperineal ultrasonography fusion prostate biopsy

Marcello Scarcia [1], Vincenzo Andracchio [2], Alberto Piana [3], Roberto Calbi [4], Michele Zazzara [1], Francesco Chiaradia [2], Antonio Greco [2], Flavio Sidoti [2], Gianluca Scarpelli [2], Pierluigi Rizzo [1], Guglielmo Mantica [5], Alessandro Calarco [6], Rosario Leonardi [7], Giuseppe Mario Ludovico [1], Stefano Alba [2]

[1] Division of Urology, Ente ecclesiastico Ospedale Generale Regionale "Miulli" 70021- Acquaviva delle Fonti (BA), Italy;
[2] Department of Urology, Romolo Hospital, Rocca di Neto, Italy;
[3] Division of Urology, Department of Oncology, School of Medicine, University of Turin, San Luigi Hospital, Turin, Italy;
[4] Division of Radiology, Ente ecclesiastico Ospedale Generale Regionale "Miulli", Acquaviva delle Fonti (BA), Italy;
[5] Department of Surgical and Diagnostic Integrated Sciences (DISC), University of Genoa, Genoa, Italy;
[6] Department of Urology, San Carlo di Nancy Hospital, Rome, Italy;
[7] Division of Urology, School of Medicine, University of KORE, Enna (EN), Italy.

Summary

Introduction: *This study aimed to evaluate the learning curve of transperineal magnetic resonance imaging (MRI)/ultrasound (US) fusion biopsy performed by a multidisciplinary team comprising a single urologist, radiologist, and pathologist. We analyzed the temporal changes in overall prostate cancer detection rates and clinically significant prostate cancer (csPCa) detection rates.*

Methods: *We retrospectively enrolled consecutive patients with clinically suspected prostate cancer (PCa) who underwent MRI/US fusion prostate biopsy at a single center from January 2019 to December 2022. The patients were divided into four cohorts based on the year of biopsy to assess temporal variations in the outcomes. Univariate and multivariate analyses were performed to model detection rate curves.*

Results: *Overall, 291 patients underwent targeted biopsy (TBx) and standard biopsy (SBx) during the study period. Multivariate analysis showed that the overall PCa diagnosis was significantly higher when prostate biopsy was performed after the first year (2019; 74 patients), particularly in 2022 (OR 11.68, CI 3.08-49.1). The csPCa detection rate increased significantly from 13.5% to 40.0%, p = 0.03).*

Conclusions: *Cumulative experience and teamwork may increase the overall PCa detection rate, specifically csPCa detection rate. Transperineal MRI fusion-guided biopsies combined with a standard template provided a higher overall cancer and csPCa detection rate than the standard template or targeted biopsy alone. Multidisciplinary team meetings and procedure standardization are key factors in overcoming the learning curve.*

KEY WORDS: *Image-guided; Magnetic-resonance imaging; Ultrasonography; Prostatic neoplasms; Transperineal biopsy; Learning curve.*

Submitted 28 April 2025; Accepted 21 July 2025

INTRODUCTION

In recent years, *prostate cancer* (PCa) management has undergone significant advancements in both diagnostic and therapeutic fields (1-2). Innovations in diagnosis and staging, including the widespread adoption of *multiparametric magnetic resonance imaging* (mpMRI) and *prostate-specific membrane antigen positron emission tomography* (PSMA-PET), have markedly improved disease detection and characterization (3). Moreover, the development and integration of clinical tools such as nomograms and dedicated applications have enhanced risk stratification and individualized treatment planning (4-6). Therapeutic strategies have also evolved, with refinements in surgical techniques and the emergence of new systemic therapies, offering a broader range of tailored options for patients across different stages of the disease (7).

mpMRI has significantly transformed the diagnostic pathway for the management of PCa. Due to its superior ability to detect *clinically significant PCa* (csPCa) compared to traditional methods, MRI/*ultrasound* (US) fusion biopsy has gained a pivotal role, including in contexts such as active surveillance (8). Nevertheless, the diagnostic performance of this technique can be affected by various factors, notably the operator's level of expertise (9).

Interpreting mpMRI scans remains challenging for both radiologists and urologists, often leading to discrepancies between readers (10). This, combined with the technical skills required for proficient ultrasound use, underscores the complexity of the fusion biopsy technique.

As a result, relatively few surgeons are adequately trained in this method, potentially impacting csPCa detection rates, particularly in the early stages of the learning curve (11-12).

To date, only a limited number of studies have explored the learning curve for transperineal MRI/US fusion prostate biopsy, yielding inconsistent findings. Reported

case numbers required to achieve proficiency range from 52 to 156 procedures (13-14). However, just one study has assessed the learning curve for an established multidisciplinary team specialized in prostate biopsy (15).
The main aim of this study was to investigate how the overall detection rate of PCa evolved over time in patients undergoing transperineal fusion biopsy at a high-volume institution. A secondary aim was to analyze trends in csPCa detection rates in relation to the accumulating experience of both the operators performing the fusion biopsies and the radiologists preparing the imaging.

Materials and methods

We analyzed data from a prospectively maintained database of consecutive patients who underwent transperineal fusion biopsy between January 2019 and December 2022. All patients provided informed consent for the use of data obtained from clinical records after anonymization. All the procedures complied with the ethical principles for biomedical research outlined in the Declaration of Helsinki. This study was approved by the *Institutional Ethics Committee of the Hospital of Bari* (Decision n°6331).
We included men aged over 18 years with clinical suspicion of PCa, based on elevated *prostate-specific antigen* (PSA) levels, abnormal *digital rectal examination* (DRE) findings, clinical suspicion, and/or a family history of prostate cancer.

Radiological protocol

All patients who underwent prostatic mpMRI (< 90 days) with at least one lesion with a PI-RADS v2 score of ≥ 3 were considered for this study. All mpMRI examinations were performed using a 1.5 T scanner with a 32-channel phased-array surface coil. A morphological study of the prostate was performed using T2-weighted turbo spin-echo (TSE) sequences in the sagittal, axial, and coronal planes, including the prostate gland and seminal vesicles. Functional studies were performed using *diffusion-weighted imaging* (DWI) and DCE. All patients underwent the same mpMRI protocol. The MRI scans were reviewed by the same expert uroradiologist.

Procedure details

Each patient underwent targeted (TBx) and standard (SBx) biopsies in the same session, performed by a single operator with extensive experience in fusion biopsy (> 100 procedures). Similarly, the same pathologist and radiologist were involved in the procedures. TBx and SBx sample numbers were performed according to current European guidelines for PCa and antibiotic prophylaxis (16). For SBx, 10-14 biopsy fragments were collected from the peripheral prostate zones, including the base, central gland, and apex. For TBx, 3-7 biopsy fragments were obtained per patient; the transition zone was biopsied only if mpMRI indicated suspicious areas. All biopsies were performed transperineally under local anesthesia using the *BiopSee System®* from *MedCom GmbH*, which integrates MRI and US images to provide accurate 3D mapping and real-time guidance during biopsy. Biopsy samples were analyzed by the same dedicated uropathologist and reported according to ISUP 2014 guidelines (17). csPCa was defined as an ISUP score of ≥ 2, whereas *clinically insignificant PCa* (ciPCa) was defined as an ISUP score of 1.

Multidisciplinary team

The multidisciplinary team for prostate biopsy consisted of urologists, pathologists, and radiologists. The team met bimonthly to evaluate the results and re-evaluate, discuss, and improve the protocol to reduce possible complications and improve outcomes.

Statistical analysis

The baseline characteristics of patients who underwent fusion prostate biopsy were compared by year (2019 *vs*. 2020 *vs*. 2021 *vs*. 2022). Continuous variables are expressed as median and *interquartile range* (IQR) and compared using the ANOVA test, while categorical variables are presented as counts and percentages and compared using a proportion test. An *estimated annual percentage change* (EAPC) analysis was conducted to evaluate the trends in PCa detection rates over the years for both overall and csPCa. Multivariate logistic regression analysis was performed to determine predictive factors for PCa detection, both overall and csPCa, including the year of biopsy, pre-biopsy PSA levels, prostate volume on mpMRI, PI-RADS score, target area location and volume, number of previous biopsies, and number of SBx and TBx samples. Statistical significance was set at $p < 0.05$, and analyses were conducted using the R software (*www.rproject.org, version 4.0.0*).

Results

A total of 291 patients underwent TBx and SBx. The clinical, radiological, and pathological characteristics of the patients are presented in Table 1.
Of these, 246 (84.6%) were biopsy-naïve, and 45 (15.4%) had previously negative biopsies. The median age was 64.5 years (range 59-70), with a median PSA level of 6 ng/ml (range 4.3-8). The median prostate volume detected on mpMRI is 53 ml, with a decreasing trend from 2019 (60 ml) to 2022 (45 ml). PI-RADS score distributions were as follows: 42 patients (14.3%) scored PI-RADS 3, 221 (75.4%) scored PI-RADS 4, and 28 (9.6%) scored PI-RADS 5, with an increasing trend in PI-RADS 5 cases over the years (6 in 2019 to 12 in 2022). The median number of biopsy cores was 16 (range 16-22), with a significant decrease over time (22 in 2019 vs. 16 in 2022), reflecting both reduced prostate volume and increased operator confidence. The median number of standard biopsy cores decreased from 12 in 2019 to 10 in 2022, while the target biopsy cores remained consistent (range 4-7 based on PI-RADS lesion size). Overall, PCa was detected in 137 of 291 patients (47.1%), of whom 76 had csPCa (26.1%) and 61 had ciPCa (21%) (Table 2).
The highest PCa detection rate (67.7%) was observed in 2022 among 65 patients. In 2021, 52.2% of 92 patients were positive for PCa. In 2020, 41.7% of 60 patients tested positive, and in 2019, 27% of 74 patients tested positive. csPCa detection increased over the years, from 13.5% in 2019 to 40% in 2022. TBx detected csPCa in 35.4% and ciPCa in 24.6% of cases in 2022. SBx PCa

Table 1.
Characteristics of patients participating in the study.

Characteristics		Prostate biopsy year					
		Overall (n = 291)	2019 (n = 74, 25.4%)	2020 (n = 60, 20. 6%)	2021 (n = 92, 31.6%)	2022 (n = 65,22. 4%)	P-value
Age	Median (IQR)	64.5 (59-70)	64 (58-70.8)	64 (61-69.5)	65 (61.8-68.2)	65 (58-70)	0.4
PSA	Median (IQR)	6 (4.3-8)	6 (5-8)	6 (4-8)	5 (4-7)	6 (4.7-7.9)	0.8
Prostate volume at MRI	Median (IQR)	53 (40-70)	60 (45-70.8)	54 (44-70.2)	50.5 (40-74.2)	45 (31-59)	0.001
Lesion volume 1	Median (IQR)	0.7 (0.5-1.1)	0.8 (0.6-1.2)	0.5 (0.4-1)	0.6 (0.5-0.8)	0.9 (0.6-1.2)	0.2
Zone lesion 1	ZP	204 (70.1)	51 (68.9)	36 (60)	63 (68.5)	54 (83.1)	0.04
	CZ/TZ	85 (29.2)	23 (31.1)	23 (38.3)	28 (30.4)	11 (16.9)	0.06
Highest PIRADS	3	42 (14.3)	10 (13.5)	6 (10)	18 (19.6)	8 (12.3)	0.4
	4	221 (75.4)	58 (78.4)	50 (83.3)	68 (73.9)	45 (69.2)	0.3
	5	28 (9.6)	6 (8.1)	4 (6.7)	6 (6.5)	12 (18.5)	0.05
Number of lesions at MRI	1	221 (75.4)	54 (73.0)	45 (75.0)	70 (76.1)	51 (78.5)	0.9
	2	63 (21.5)	17 (23.0)	15 (25.0)	17 (18.5)	13 (20.0)	0.8
	3	9 (3.1)	3 (4.1)	0 (0)	5 (5.4)	1 (1.5)	0.2
Number of previous biopsy	0	248 (84.6)	59 (79.7)	41 (68.3)	85 (92.4)	61 (93.8)	0.001
	1	42 (14.3)	13 (17.6)	18 (30.0)	7 (7.6)	4 (6.2)	0.001
	2	3 (1)	2 (2.7)	1 (1.7)	0 (0)	0 (0)	03
Total number of biopsy cores	Median (IQR)	16 (16-21)	22 (20-24)	21 (16-22.2)	16 (16-16)	16 (16-16)	0.001
Number of systematic biopsy cores	Median (IQR)	12 (10-16)	16 (16-16)	16 (12-16)	10 (9-12)	10 (10-10)	0.001
Number of target biopsy cores	Median (IQR)	6 (4-7)	6 (4-8)	6 (4.8-7)	6 (4-7)	6 (6-8)	0.2
* Total number of positive biopsy cores	Median (IQR)	5 (3-8)	6.5 (3.8-12.2)	5 (3-7)	5 (2.8-6)	6 (3.8-8)	0.1
* Number of positive systematic biopsy cores	Median (IQR)	3 (2-4)	3.5 (2-5)	3 (1-3)	3 (2-4)	3 (2-5)	0.7
* Number of positive target biopsy cores	Median (IQR)	2 (1-4)	2.5 (0.8-8.2)	3 (2-4)	1.5 (1-3)	2.5 (1-4)	0.2
* Overall Core ratio	Median (IQR)	27.8 (18.2-38.9)	26.5 (17.4-52.5)	22.2 (18.2-36.4)	31.2 (16.1-37.5)	37.5 (19.7-47.8)	0.2
* Standard Coreratio	Median (IQR)	18.8 (9.1-33.3)	14.6 (4.7-51.6)	18.8 (12.5-25)	16.2 (8.3-30)	27.5 (10-40)	0.4
* Target Core ratio	Median (IQR)	45.5 (25-75)	47.7 (33.3-71.9)	40 (25-60)	50 (25-80)	45 (28.8-76.2)	0.9

Table 2.
Gleason Grade group distribution.

		Prostate biopsy year					
		Overall (n = 291)	2019 (n = 74, 25.4%)	2020 (n = 60, 20.6%)	2021 (n = 92, 31.6%)	2022 (n = 65, 22.4%)	P-value
	No PCa	154 (52.9)	54 (73)	35 (58.3)	44 (47.8)	21 (32.3)	0.001
Gleason Grade	1	61 (21.0)	10 (13.5)	7 (11.7)	26 (28.3)	18 (27.7)	0.01
Group overall	2	46 (15.8)	4 (5.4)	11 (18.3)	17 (18.5)	14 (21.5)	0.04
	3	21 (7.2)	3 (4.1)	4 (6.7)	5 (5.4)	9 (13.8)	0.1
	4	7 (2.4)	3 (4.1)	3 (5)	0 (0)	1 (1.5)	0.2
	5	2 (0.7)	0 (0)	0 (0)	0 (0)	2 (3.1)	0.1
	No PCa	180 (61.9)	59 (79.7)	39 (65.0)	55 (59.8)	27 (41.5)	0.001
Gleason Grade	1	59 (20.3)	7 (9.5)	13 (21.7)	24 (26.1)	15 (23.1)	0.05
Group of target biopsy cores	2	32 (11.0)	3 (4.1)	6 (10.0)	10 (10.9)	13 (20.0)	0.03
	3	14 (4.8)	3 (4.1)	1 (1.7)	3 (3.3)	7 (10.8)	0.1
	4	4 (1.4)	2 (2.7)	1 (1.7)	0 (0)	1 (1.5)	0.5
	5	2 (0.7)	0 (0)	0 (0)	0 (0)	2 (3.1)	0.1
Overall detection rates		137 (47.1)	20 (27)	25 (41.7)	48 (52.2)	44 (67.7)	0.001

detection rate rose from 20.4% in 2019 to 58.5% in 2022; for csPCa, detection rates increased from 10.9% in 2019 to 35.4% in 2022 (Figures 1-3).

Multivariate analysis showed significantly higher PCa detection rates after the first year (2019), particularly in 2022 (OR 11.68, CI 3.08-49.1). PCa detection was positively correlated with higher PSA levels (OR 1.08, CI 1.01-1.17), lower prostate volume (< 60 ml, OR 0.97, CI 0.95-0.98), target lesions in the peripheral zone (OR 0.39, 0.18-0.79), higher lesion volume (OR 5.81, CI 2.60-13.8), and biopsy-naïve status (OR 2.98, CI 1.17-7.78). csPCa detection was similarly associated with

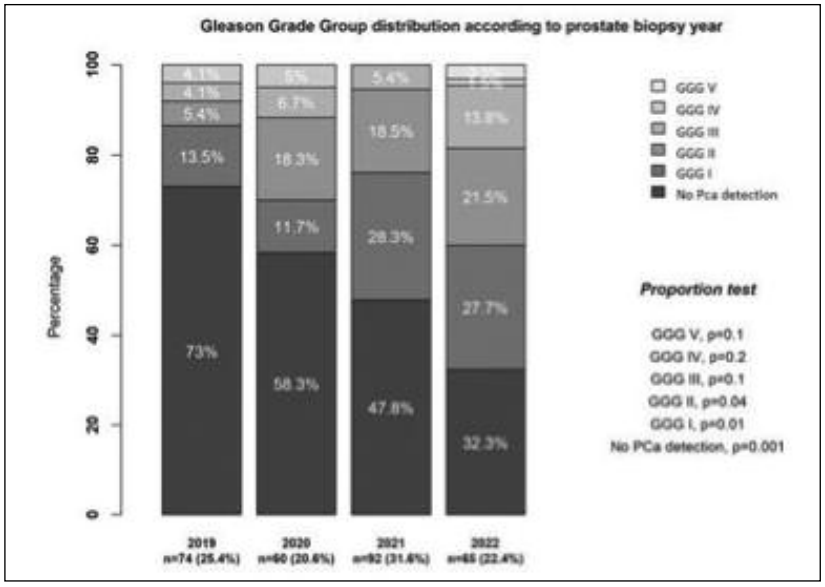


Figure 1.
GGG found over the years in patients undergoing Target Biopsy and Standard Biopsy.

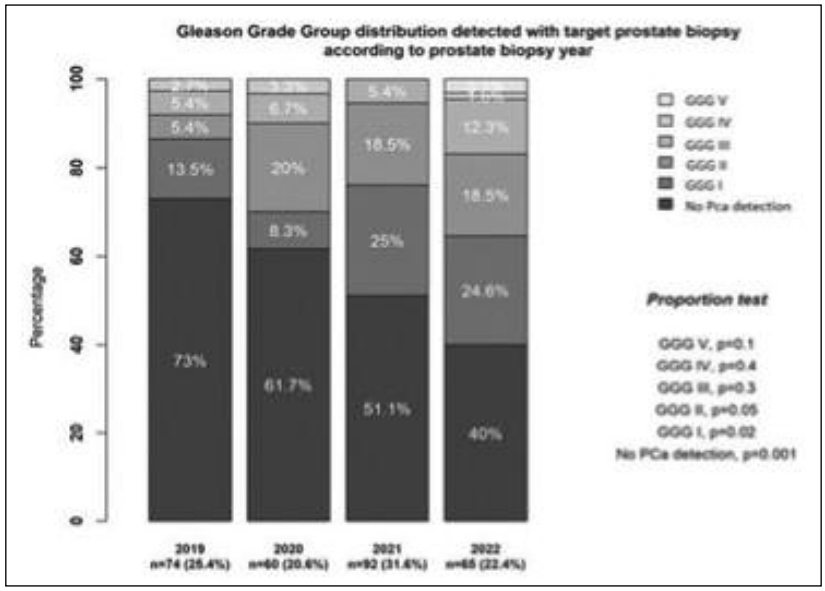


Figure 2.
GGG found over the years considering only Target Biopsy.

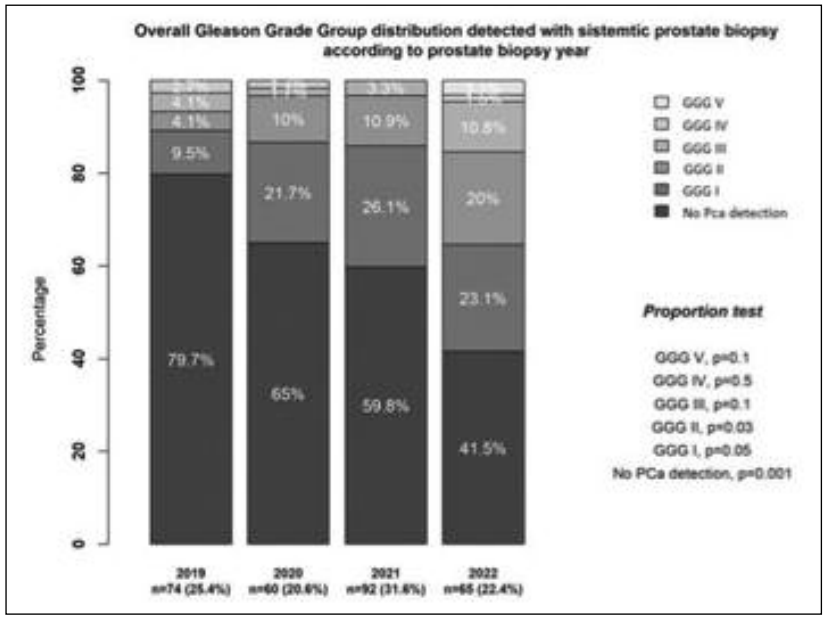


Figure 3.
GGG found over the years considering only Standard Biopsy.

Table 3.
Multivariate logistic regression analysis.

	Multivariable LRM predicting prostate cancer overall detection rate		Multivariable LRM predicting clinically significant prostate cancer detection rate	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Prostate biopsy year, 2019	Ref			
2020	5.09 (1.83-15.0)	0.01	4.6 (1.46-15.79)	0.01
2021	15.45 (4.38-62.4)	0.001	6.87 (1.64-33.6)	0.01
2022	11.68 (3.08-49.1)	0.001	7.15 (1.66-35.6)	0.01
PSA	1.08 (1.01-1.17)	0.02	1.04 (0.98-1.18)	0.1
MRI prostate volume	0.97 (0.95-0.98)	0.001	0.96 (0.95-0.98)	0.001
PIRA DS, 3	Ref			
4	1.29 (0.52-3.28)	0.5	2.02 (0.67-7.57)	0.2
5	2.35 (0.51-12.24)	0.2	4.58 (1.03-23.67)	0.05
Zone lesion 1, ZP	Ref			
CZ/TZ	0.39 (0.18-0.79)	0.01	0.35 (0.14-0.83)	0.02
Lesion volume 1	5.81 (2.60-13.8)	0.001	3. 05 (1.43-6.70)	< 0.01
Number of previous bioosy, 0	Ref			
1	2.98 (1.17-7.78)	0.02	8.22 (3.01-23.9)	0.001
Number of targetbiopsy cores	1.21 (1.03-1.43)	0.01	1.06 (0.88-1.29)	0.5
Number of standard biopsy cores	1.12 (0.82-0.95)	0.18	1.05 (0.87-1.29)	0.5

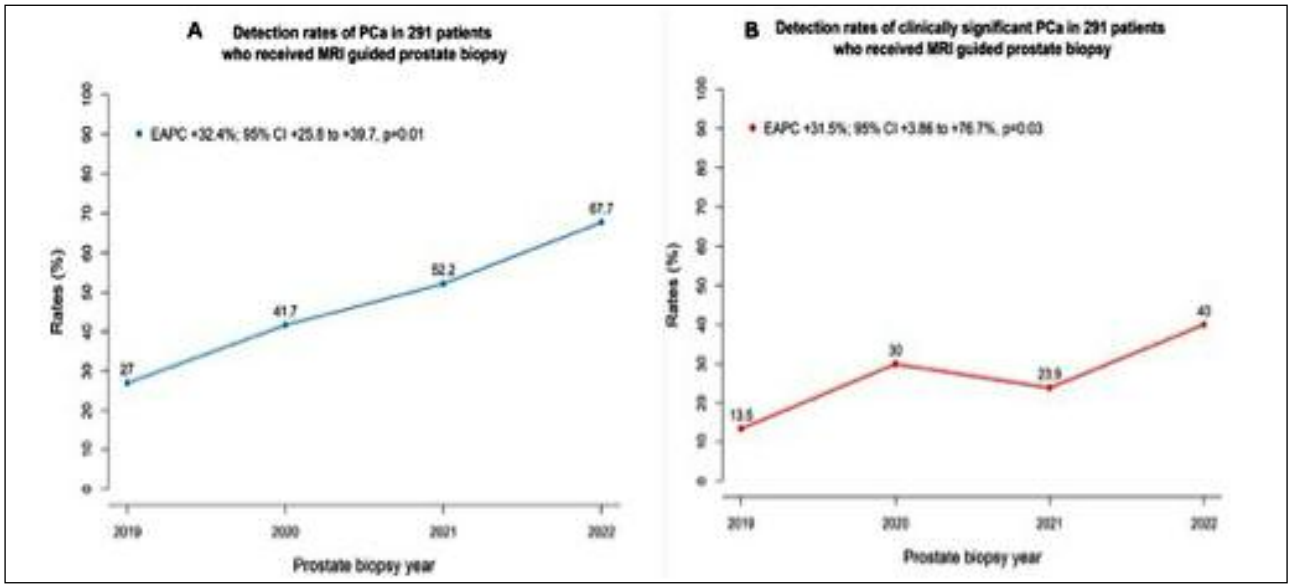
the biopsy year (especially in 2022), low prostate volume, PI-RADS 5 score, peripheral zone lesion location, and biopsy-naïve status (Table 3).

Discussion

The accuracy of pathological diagnosis in PCa, particularly for tumors classified as clinically significant (18), remains crucial for appropriate therapeutic decision-making (19-20). *Siddiqui et al.* previously demonstrated that MRI-targeted fusion biopsies preferentially detect high-grade Gleason score tumors, thus reducing the diagnosis of clinically insignificant PCa, as confirmed by two systematic reviews (21-22).

In our experience, close collaboration among the urologist performing the biopsy, the radiologist interpreting the mpMRI, and the pathologist evaluating the biopsy cores led to a progressive improvement in overall PCa detection rates, with particular attention to clinically significant disease. Over the 4-year study period, the detection rate for PCa significantly increased from 27% to 67.7% (p = 0.001) when comparing the first and last year of analysis (Figure 4A). Similarly, the csPCa detection rate rose from 13.5% to 40% (p = 0.01) (Figure 4B).

Figure 4.
(A) Detecton rate PCa over the years, (B) Detecton rate csPCa over the years.



Our findings further support the combined use of *systematic biopsy* (SB) and *targeted biopsy* (TB) to enhance csPCa detection (23), in line with results reported by *Ahdoot et al.* (24), and reinforce the value of performing systematic 12-core biopsies (25-26).

Nonetheless, the *learning curve* (LC) for *transperineal* (TP) fusion biopsy appears to be slower than that for *transrectal* (TR) fusion biopsy. Approximately 52 cases were required to reach a stable PCa and csPCa detection rate with TR fusion biopsy, comparable to outcomes achieved by experienced urologists (27).

Prostate biopsy strategies should therefore be adapted based on local expertise, available resources, and institutional needs. Although targeted biopsy improves the ratio of csPCa to insignificant cancer diagnoses, some csPCa cases may still be missed. Software-based TBx offers greater precision, particularly for less experienced operators, but its higher costs may not always be justified.

The TP approach offers advantages in terms of infection prevention, although it requires greater resource allocation (28).

In patients with suspicious mpMRI findings, combining TP MRI fusion-guided biopsy with systematic template biopsy provides higher overall and csPCa detection rates compared to either approach alone (29). Therefore, in the presence of mpMRI-detected lesions, both targeted and systematic biopsies should be included in the TP procedure (30).

The improvement in detection rates, particularly for csPCa, can also be attributed to the progressive completion of the learning curve by both urologists and radiologists. *Hsieh et al.* reported similar findings, demonstrating that multidisciplinary collaboration significantly increased csPCa detection rates using transperineal MRI/US fusion TBx over a four-year period (from 35.3% to 60.0%, $p = 0.01$). Combining TBx and SBx consistently yielded the highest csPCa detection rates annually. Furthermore, with increasing experience, detection rates for small (≤ 1 cm) and anterior lesions improved (from 41.2% to 51.6%, $p = 0.5$ and from 54.5% to 88.2%, $p = 0.8$, respectively), while the percentage of positive cores on TBx significantly increased (from 18.1% to 44.2%, $p = 0.001$). Notably, the rate of Gleason score upgrading after radical prostatectomy decreased over time (from 22.2% to 11.1%, $p = 0.4$) (15). The progressive improvement in detection rates likely reflects not only the growing experience of the urologist, but also the stable collaboration within the multidisciplinary team, including consistent radiological and pathological evaluation throughout the study period.

When evaluating learning curves in surgical and interventional procedures, it is essential to consider multiple factors, including technological advancements, institutional characteristics, patient populations, and operator experience. Moreover, in prostate biopsy, the absence of a definitive gold standard for cancer detection introduces variability influenced by disease prevalence and distribution within the study cohort (31).

Recent developments have emphasized the potential of *artificial intelligence* (AI) to further enhance the detection of clinically significant tumors. Integration of AI with MRI fusion TBx could offer a more comprehensive assessment of prostate cancer aggressiveness, analyzing lesion size, location, and mpMRI features. AI-driven analysis of large imaging and clinical datasets may facilitate the identification of predictive biomarkers and disease progression patterns.

The combination of AI technologies with MRI fusion biopsy represents a significant advancement, enhancing diagnostic accuracy, informing therapeutic strategies, and broadening access for clinicians. These innovations offer substantial benefits for both patients and healthcare providers (32). Similarly, a better and standardized training using simulators and cadaveric models (33) may improve outcomes and learning curves.

In conclusion, our study suggests that establishing a multidisciplinary team involving urologists, radiologists, and pathologists can minimize procedural variability and improve clinical outcomes.

Our study has several limitations that must be acknowledged. First, it was a retrospective analysis, which inherently introduces the potential for selection and information biases. Second, this study was conducted in a single high-volume academic center with a dedicated multidisciplinary team, regular clinical meetings, and standardized mpMRI and biopsy protocols. while these factors likely contributed to the observed improvements in diagnostic performance, they may not reflect the reality of lower-volume Institutions or settings without structured multidisciplinary collaboration. Therefore, the external validity of our findings may be limited, and caution is warranted when extrapolating these results to different clinical environments with varying levels of experience, infrastructure, or workflow integration. Third, although the sample size was adequate to detect significant trends, it remains relatively modest, potentially limiting the power to explore certain subgroups or rare outcomes in greater depth. Fourth, the performance of the operators (both urologists and radiologists) progressively improved over time, but we did not formally assess individual learning curves or account for potential variations in performance among different operators. Fifth, no external validation cohort was included, and our findings should therefore be interpreted cautiously until confirmed by larger, prospective multicenter studies.

In addition, we acknowledge that the observed improvement in prostate cancer detection over time may not be solely attributed to the procedural learning curve. A significant factor may have been the evolution in patient selection criteria over the study period. While biopsy referrals were initially accepted from outside urologists based on basic clinical suspicion (elevated PSA or abnormal DRE), the *multidisciplinary team* (MDT) gradually introduced a more selective triage approach. From the second year onward, indications for biopsy were reviewed by the MDT and cases with low PSA density (< 0.15 ng/ml²) or non-suspicious MRI findings (PI-RADS < 3) were progressively excluded. This strategy likely contributed to the decrease in prostate volume observed over the years and may have impacted the increase in overall and csPCa detection rates, independently of operator experience. Consequently, this change in selection policy represents a potential confounding factor and should be considered a limitation of our study.

Furthermore, we acknowledge that we did not use a formal statistical model, such as CUSUM, to define the learning curve. Due to the retrospective nature of the study we based our conclusions on year-by-year trends. Therefore, we describe a progressive improvement over time rather than a formally modeled learning curve.
Finally, although biopsy outcomes were rigorously assessed, no long-term follow-up data (such as radical prostatectomy pathology or oncologic outcomes) were available to further validate the accuracy of the fusion biopsy findings.

Conclusions

mpMRI fusion biopsy for PCa diagnosis may be considered a relatively simple procedure. However, several factors appeared to significantly affect procedure accuracy. Along with the learning curve of the surgeon, the procedure is safe and effectiveness of the procedure (8). However, in our experience, the detection rate continued to increase until the fourth year of life. In our experience, the performance of radiologists seems to improve over time, which has played a key role in increasing the detection rate. Moreover, a low prostate volume (< 60 ml), a PIRADS score of 5 in the target area, a target area located in the peripheral zone, a higher lesion volume, and a biopsy-naive patient appeared to increase the diagnosis of csPCa, while the number of target biopsy cores harvested did not correlate with csPCa diagnosis.

Declarations

Ethical approval and consent for participate: *All the procedures complied with the ethical principles for biomedical research outlined in the Declaration of Helsinki. This study was approved by the Institutional Ethics Committee of the Hospital of Bari (Decision n° 6331).*

Consent for publication: *All authors gave the consent for publication.*

Availability of data and material: *On demand to the corresponding author.*

Competing interests: *None.*

Funding: *None.*

Authors' contributions:
WRITING: Scarcia, Andracchio, Piana, Alba; DATA: Calbi, Zazzara, Chiaradia, Rizzo; EDITING and CRITICAL REVIEW: Greco, Sidoti, Scarpelli, Mantica., Calarco, Leonardi, Ludovico.

Acknowledgments: *None.*

References

1. MacLennan S, Azevedo N, Duncan E, et al. Mapping European Association of Urology Guideline Practice Across Europe: An Audit of Androgen Deprivation Therapy Use Before Prostate Cancer Surgery in 6598 Cases in 187 Hospitals Across 31 European Countries. Eur Urol. 2023; 83:393-401.

2. Vatrano S, Pepe P, Pepe L, et al F. BRCA mutations and prostate cancer: should urologist improve daily clinical practice? Arch Ital Urol Androl. 2025; 97:13635.

3. Bauckneht M, Rebuzzi SE, Ponzano M, et al. Prognostic Value of the BIO-Ra Score in Metastatic Castration-Resistant Prostate Cancer Patients Treated with Radium-223 after the European Medicines Agency Restricted Use: Secondary Investigations of the Multicentric BIO-Ra Study. Cancers (Basel). 2022; 14:1744.

4. Mantica G, Malinaric R, Dotta F, et al. Urology apps: overview of current types and use. Cent European J Urol. 2020; 73:369-372.

5. De Nunzio C, Lombardo R, Baldassarri V, et al. Rotterdam mobile phone app including MRI data for the prediction of prostate cancer: A multicenter external validation. Eur J Surg Oncol. 2021; 47:2640-2645.

6. Cindolo L, Bertolo R, Minervini A, et al. External validation of Cormio nomogram for predicting all prostate cancers and clinically significant prostate cancers. World J Urol. 2020; 38:2555-2561.

7. Mondaini N, Abramo A, Romeo C, et al. Laparoscopic radical prostatectomy with the simultaneous implant of a penile prosthesis: ten years follow up. Arch Ital Urol Androl. 2025; 97:13541.

8. Klotz L, Loblaw A, Sugar L, et al. Active Surveillance Magnetic Resonance Imaging Study (ASIST): Results of a Randomized Multicenter Prospective Trial. Eur Urol 2019; 75:300-9.

9. Kasabwala K, Patel N, Cricco-Lizza E, et al. The Learning Curve for Magnetic Resonance Imaging/Ultrasound Fusion-guided Prostate Biopsy. Eur Urol Oncol 2019; 2:135-40.

10. Rosenkrantz AB, Taneja SS. Radiologist, be aware: ten pitfalls that confound the interpretation of multiparametric prostate MRI. AJR Am J Roentgenol. 2014; 202:109-20.

11. Mantica G, Pacchetti A, Aimar R, et al. Developing a five-step training model for transperineal prostate biopsies in a naïve residents' group: a prospective observational randomised study of two different techniques. World J Urol. 2019; 37:1845-1850.

12. Checcucci E, Piramide F, Amparore D, et al. Beyond the Learning Curve of Prostate MRI/TRUS Target Fusion Biopsy after More than 1000 Procedures. Urology 2021; 155:39-45.

13. Halstuch D, Baniel J, Lifshitz D, et al. Characterizing the learning curve of MRI-US fusion prostate biopsies. Prostate Cancer Prostatic Dis. 2019; 22:546-551.

14. Cata ED, Van Praet C, Andras I, et al. Analyzing the learning curves of a novice and an experienced urologist for transrectal magnetic resonance imaging-ultrasound fusion prostate biopsy. Transl Androl Urol. 2021; 10:1956-1965.

15. Hsieh PF, Li PI, Lin WC, et al. Learning Curve of Transperineal MRI/US Fusion Prostate Biopsy: 4-Year Experience. Life (Basel). 2023; 13:638.

16. Kranz J, Bartoletti R, Bruyère F, et al. European Association of Urology Guidelines on Urological Infections: Summary of the 2024 Guidelines. Eur Urol. 2024; 86:27-41.

17. Egevad L, Delahunt B, Srigley JR, Samaratunga H. International Society of Urological Pathology (ISUP) grading of prostate cancer - An ISUP consensus on contemporary grading. APMIS 2016; 124:433-5.

18. Matoso A, Epstein JI. Defining clinically significant prostate cancer on the basis of pathological findings. Histopathology 2019; 74:135-45.

19. Martorana E, Pirola GM, Scialpi M, et al. Lesion volume predicts prostate cancer risk and aggressiveness: validation of its value alone and matched with prostate imaging reporting and data system score. BJU Int 2017; 120:92-103.

20. Narayan V, Jiang S, Warlick CA. Early Stage Cancer in Older Adults: Prostate-Avoiding Overtreatment and Undertreatment. Cancer J 2017; 23:238-41.

21. Siddiqui MM, Rais-Bahrami S, Truong H, et al. Magnetic resonance imaging/ultrasound-fusion biopsy significantly upgrades prostate cancer versus systematic 12-core transrectal ultrasound biopsy. Eur Urol 2013; 64:713-9.

22. Silberstein JL, Pal SK, Lewis B, Sartor O. Current clinical challenges in prostate cancer. Transl Androl Urol 2013; 2:122-36.

23. Fulco A, Chiaradia F, Ascalone L, et al. Multiparametric Magnetic Resonance Imaging-Ultrasound Fusion Transperineal Prostate Biopsy: Diagnostic Accuracy from a Single Center Retrospective Study. Cancers (Basel) 2021; 13:4833.

24. Drost F-JH, Osses DF, Nieboer D, et al. Prostate MRI, with or without MRI-targeted biopsy, and systematic biopsy for detecting prostate cancer. Cochrane Database Syst Rev 2019; 4:CD012663.

25. Ahdoot M, Wilbur AR, Reese SE, et al. MRI-Targeted, Systematic, and Combined Biopsy for Prostate Cancer Diagnosis. N Engl J Med 2020; 382:917-28.

26. Rastinehad AR, Turkbey B, Salami SS, et al. Improving detection of clinically significant prostate cancer: magnetic resonance imaging/transrectal ultrasound fusion guided prostate biopsy. J Urol 2014; 191:1749-54.

27. Cata ED, Van Praet C, Andras I, et al. Analyzing the learning curves of a novice and an experienced urologist for transrectal magnetic resonance imaging-ultrasound fusion prostate biopsy. Transl Androl Urol 2021; 10:1956-65.

28. Marra G, Ploussard G, Futterer J, Valerio M, EAU-YAU Prostate Cancer Working Party. Controversies in MR targeted biopsy: alone or combined, cognitive versus software-based fusion, transrectal versus transperineal approach? World J Urol 2019; 37:277-87.

29. Porpiglia F, Checcucci E, DE Cillis S, et al. A prospective randomized controlled trial comparing target prostate biopsy alone approach vs. target plus standard in naïve patients with positive mpMRI. Minerva Urol Nephrol 2023; 75:31-41.

30. Kim MM, Wu S, Lin SX, et al. Transperineal Multiparametric Magnetic Resonance Imaging-Ultrasound Fusion Targeted Prostate Biopsy Combined with Standard Template Improves Prostate Cancer Detection. J Urol 2022; 207:86-94.

31. Calleris G, Marquis A, Zhuang J, et al. Impact of operator expertise on transperineal free-hand mpMRI-fusion-targeted biopsies under local anaesthesia for prostate cancer diagnosis: a multicenter prospective learning curve. World J Urol 2023; 41:3867-76.

32. Lenfant L, Seisen T, Rouprêt M, et al. Unleashing the Power of Artificial Intelligence and Fusion Magnetic Resonance Imaging-Targeted Biopsy: Transforming Prostate Cancer Diagnosis. Eur Urol Oncol 2023; 6:541-2.

33. Mantica G, Leonardi R, Diaz R, et al. Reporting ChAracteristics of cadaver training and sUrgical studies: The CACTUS guidelines. Int J Surg. 2022; 101:106619.

Correspondence

Marcello Scarcia
scarciam@hotmail.com

Michele Zazzara
michele.zazzara@miulli.it

Pierluigi Rizzo
pierluigirizzo@miulli.it

Giuseppe Mario Ludovico
g.ludovico@miulli.it

Division of Urology, Ente ecclesiastico Ospedale Generale Regionale "Miulli" - 70021 Acquaviva delle Fonti (BA), Italy

Vincenzo Andracchio
urologoandracchio@gmail.com

Francesco Chiaradia
francescochiaradia@pec.omceo.bari.it

Antonio Greco
antonio.greco992@miulli.it

Flavio Sidoti
flavio.sidoti@miulli.it

Gianluca Scarpelli
g.scarpelli@magnagrecia.it

Stefano Alba
stefanoalba78@gmail.com

Department of Urology, Romolo Hospital - 88821 Rocca di Neto, Italy

Alberto Piana
alb.piana@gmail.com

Division of Urology, Department of Oncology, School of Medicine, University of Turin, San Luigi Hospital, 10043 Turin, Italy

Roberto Calbi
calbi.roberto@gmail.com

Division of Radiology, Ente ecclesiastico Ospedale Generale Regionale "Miulli" - 70021 Acquaviva delle Fonti (BA), Italy

Guglielmo Mantica (Corresponding Author)
guglielmo.mantica@gmail.com

Department of Surgical and Diagnostic Integrated Sciences (DISC), University of Genova, Genoa, Italy

Alessandro Calarco
alecalarco@gmail.com

Department of Urology, San Carlo de Nancy, Rome, Italy.

Rosario Leonardi
rosario.leonardi@unikore.it

Division of Urology, School of Medicine, University of KORE, Enna (EN), Italy