Prostate International 12 (2024) 155–159

Contents lists available at ScienceDirect

Prostate International

journal homepage: https://www.journals.elsevier.com/prostate-international

Research Article

Does the type of the previous biopsy affect the fusion prostate biopsy results?

Gokhan Sonmez [a], Abdullah Golbasi [b,*], Unsal Bas [c], Emre C. Akınsal [c], Numan Baydilli [c], Sevket T. Tombul [c], Halil Tosun [c], Abdullah Demirtas [c], Deniz Demirci [a]

[a] Erciyes University, Department of Urology, Devision of UroOncology, Kayseri, Turkey
[b] Kayseri City Hospital, Department of Urology, Kayseri, Turkey
[c] Erciyes University, Department of Urology, Kayseri, Turkey

ARTICLE INFO

Article history:
Received 28 May 2024
Received in revised form
19 June 2024
Accepted 1 July 2024
Available online 9 July 2024

Keywords:
Biopsy type
Fusion prostate biopsy
Prostate cancer

ABSTRACT

Background: It has been more than a decade since fusion prostate biopsy (FPB) has been used in the diagnosis of prostate cancer (PCa). Therefore, patients with a previous history of negative FPB and ongoing suspicion of PCa are beginning to emerge. This study investigated whether the first biopsy type (standard or fusion) should be effective in deciding on a second biopsy.

Methods: Male patients aged 40–75, with a serum prostate-specific antigen (PSA) value of less than 10 ng/mL and a negative biopsy history within the last 24 months, who underwent FPB in our clinic due to persistent PSA elevation and/or suspicious multiparametric prostate magnetic resonance imaging (MpMRI) findings were included to the study. Patients were divided into groups according to the type of first biopsy (Group 1; those whose first biopsy was FPB, Group 2; those whose first biopsy was standard prostate biopsy). Some demographic and clinical data of the groups, as well as PCa detection rates, were compared. A p value of less than 0.05 was considered statistically significant.

Results: A total of 275 patients (Group 1: 84, Group 2: 191) were included in this study. The groups were similar in terms of age, PSA values before the first biopsy, PSA values before the second biopsy, family history of PCa, and prostate volume. PCa was detected at a higher rate in Group 2 than Group 1 (23% vs 15.5%, $p = 0.044$).

Conclusion: The data obtained from this study indicate that the type of initial biopsy should be taken into account when deciding on FPB in secondary patients with a previous negative biopsy history.

1. Introduction

Prostate cancer (PCa) is the second most common type of cancer in men in the world.[1] With the prostate-specific antigen (PSA) test into routine use in the early 1990s, the diagnosis of PCa increased rapidly, and after the widespread use of multiparametric prostate magnetic resonance imaging (MpMRI) in the 2010s, more accurate prostate biopsy results were achieved.[2–4]

Fusion Prostate Biopsy (FPB), which allows sampling from suspicious areas detected in mpMRI, allows better differentiation between malignant and benign, and also allows a more accurate determination of the stage of cancer.[5,6] Therefore, according to current professional guidelines, it is recommended that patients with elevated PSA should undergo MpMRI, and that, if possible, FPB should be performed in patients with ongoing PCa suspicion. In addition, it is strongly recommended that the second biopsy be performed as FPB in patients with a previous negative standard prostate biopsy (SPB) history and ongoing suspicion of prostate cancer.[7–9]

We believe that the FPB experience, which has now exceeded a decade, has begun to reveal patients with a previous negative FPB history and ongoing suspicion of PCa. This situation raises the question: In patients previously biopsied for suspicion of PCa but obtaining negative results, should the type of initial biopsy (whether it was conducted as the more reliable method, FPB, or as the traditional biopsy method known as SPB) influence clinicians' biopsy decision-making?

* Corresponding author.
E-mail addresses: gokhans72@hotmail.com (G. Sonmez), dr.abdullahgolbasi@gmail.com (A. Golbasi), unsal_bas@hotmail.com (U. Bas), emreakinsal@hotmail.com (E.C. Akınsal), dr_numan38@hotmail.com (N. Baydilli), toltom@gmail.com (S.T. Tombul), htosun@hotmail.com (H. Tosun), mesane@gmail.com (A. Demirtas), demirci@erciyes.edu.tr (D. Demirci).

https://doi.org/10.1016/j.prnil.2024.07.001

In this study, in order to find an answer to the above question, patients were divided into groups according to their first biopsy type (SPB or FPB), and it was aimed to investigate whether the first biopsy type affected the second FPB results.

2. Materials and methods

2.1. Patient selection and data collection

In this retrospective-cross-sectional comparative study, male patients aged 40–75 who underwent FPB in our clinic between June 2017 and March 2023 due to persistent PSA elevation and/or suspicious MpMRI findings (PIRADS 3, 4 or 5) were included. Other main inclusion criteria were patients with a serum PSA value of less than 10 ng/mL and a negative biopsy history within the last 24 months.

Patients with no previous biopsy history or with more than one negative biopsy history, patients with a serum PSA value higher than 10 ng/mL, and patients with a negative biopsy history older than 24 months were excluded from the study. In addition, patients whose first biopsy was FPB but performed outside our clinic were excluded from the study. Patients with first or second biopsy histopathology Atypical small acinar proliferation (ASAP) or High-Grade Prostatic Intraepithelial Neoplasia (HGPIN) were also excluded from the study. The working flow chart is shown in Fig. 1.

2.2. Study design and data analysis

Patients included in the study were divided into groups according to the type of first biopsy (Group 1; those whose first biopsy was FPB, Group 2; those whose first biopsy was SPB). In addition to the demographic data of the groups such as age, body mass index (BMI), family history of PCa; PSA values before the first biopsy, PSA values before the second biopsy, prostate volumes (transitional zone and peripheral zone), MpMRI results, numbers of second biopsy cores and quadrant, some clinical data, such as cancer detection rates and International Society of Urological Pathology (ISUP) scores, were recorded and compared.

2.3. Multiparametric prostate MRI and fusion prostate biopsies

Before biopsy procedures, all patients had 1.5 or 3 Tesla mpMRI (Magnetom, Siemens Medical Solutions, Malvern, USA). Suspicious areas on T2, T1 contrast-enhanced and diffusion-weighted images were classified according to the PI-RADS version-2 system.[10] The highest PI-RADS score of patients with multiple lesions and different PI-RADS score was accepted as the patient's overall PI-RADS score.

A negative urine culture was obtained from all patients before a biopsy. Antibiotic prophylaxis was administered appropriately to all patients. Biopsy procedures were performed under local or general anesthesia under outpatient clinic conditions. Images obtained from mpMRI were transferred to an ultrasonography device with rigid fusion software (Logic E9, GE Health, USA). After segmentation of MRI images and ultrasonography, lesions in mpMRI were marked. Calculation of prostate volumes was made according to the formula height × weight × length × 0.523. After the periprostatic block, 4 core target biopsies (TB) were taken from MRI-targeted PI-RADS 3 and above lesions. After TB was completed, mpMRI segmentation was reset and 12 core SPB was performed on all patients.

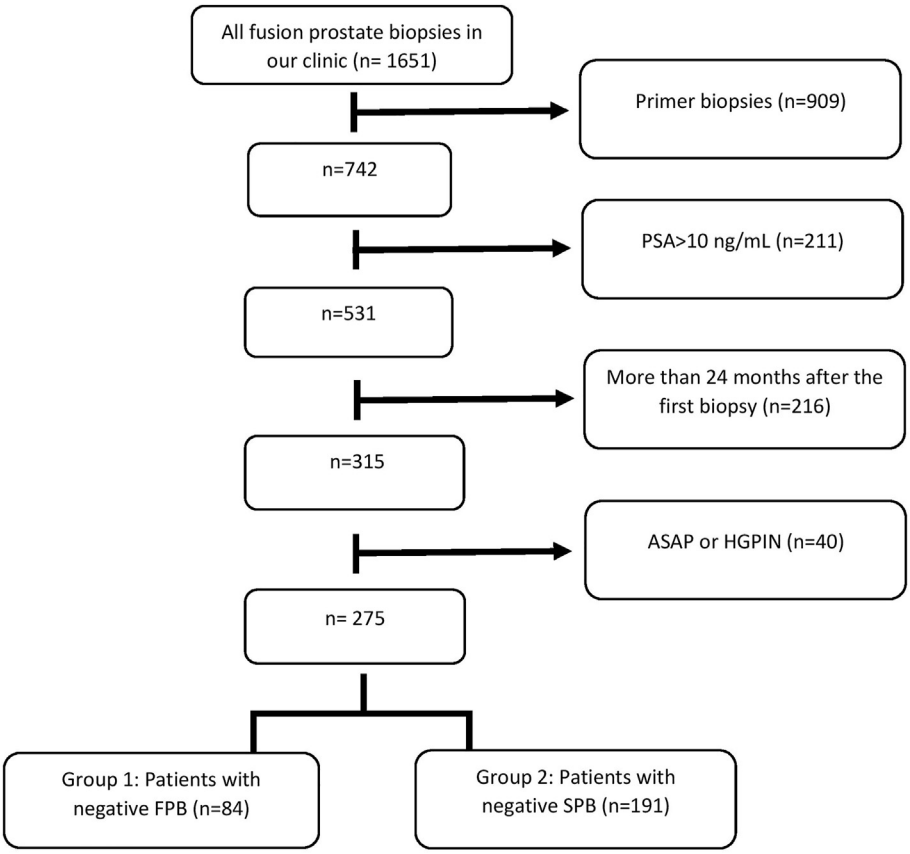

Fig. 1. Patient exclusion status and study flow-chart.

2.4. Primary and secondary endpoints

The primary endpoint of this study is to investigate whether the first biopsy type affects FPB results in secondary patients. The effect of the number of biopsy cores on cancer detection rates, biopsy negativity rates according to PIRADS scores, and the importance of the time from the first biopsy to the second biopsy are the secondary endpoints of the study.

2.5. Clinically significant prostate cancer

The definition of clinically significant prostate cancer (CSPCa) was determined with reference to previous studies.[11] Accordingly, biopsy Gleason Score (GS) $\geq$ 7 or maximum cancer core length $\geq$5 mm was accepted as CSPCa.

2.6. Statistical analyzes

Distribution characteristics of the data were determined according to the Shapiro-Wilk test and Histogram graphics. Normally distributed numerical data were expressed as mean ± standard deviation, non-normally distributed numerical data were expressed as median (1st–3rd quartile), and categorical data were expressed as percentage (%). Categorical variables belonging to independent groups were compared with the chi-square (Pearson and Fisher Exact test) test. Among the numerical variables belonging to independent groups, those with normal distribution were compared with the independent samples-*t* test, and those without normal distribution were compared with the Mann-Whitney U test. A p value of less than 0.05 was considered statistically significant.

3. Results

A total of 275 patients were included in this study. The mean age of the patients was 63.0 ± 6.5 years and the median PSA value was 7.8 (6.4–9.2) ng/mL. The overall cancer detection rate was 67/275 (24.4%), and the CSPCa rate was 57/275 (20.7%). When the patients were grouped according to their first biopsy type, it was determined that 84 patients had a negative history of FPB (Group 1), while 191 patients had a previous negative SPB (Group 2).

3.1. Comparison of demographic data of the groups

The groups were similar in terms of age, PSA values before the first biopsy, PSA values before the second biopsy, family history of PCa, and prostate volume. There was no difference between the groups in terms of PI RADS scores determined by MpMRI taken before FPB (Table 1).

3.2. Cancer detection rates and histopathology

PCa was detected at a higher rate in patients with a previous SPB than in patients with a previous FPB (23% vs 15.5%, $p = 0.044$). The most common ISUP score encountered in patients with cancer in both groups was 1 (Table 2).

3.3. Standard, target, and combined biopsy results

While the CSPCa detection rate with SPB in Group 1 was 13.1%, this rate in TB was 14.3% ($p = 0.824$). The most successful biopsy method in Group 1 was determined to be the combined method. In Group 2, cancer detection rates for SPB and TB were 15.2% and 20.4% ($p = 0.424$). Similar to Group 1, the most successful method in Group 2 was determined to be combined fusion biopsy (Fig. 2).

In Group 1, clinically insignificant PCa was detected in 3 out of 84 patients (3.6%) in TB and in 9 out of 84 patients (10.7%) in SPB. The difference was statistically significant ($p = 0.002$).

In Group 2, the rates of clinically insignificant PCa were 4.7% (9/191) for TB and 11.0% (21/191) for SPB. Similarly, in this group, a higher rate of clinically insignificant PCa was found with SPB compared to TB ($p < 0.001$).

3.4. Subgroup analysis of Group 1

When evaluating the initial PI-RADS scores of patients in Group 1 before their first negative biopsy, it was observed that the rates of PIRADS 3, 4, and 5 were 40 (47.6%), 35 (41.6%), and 9 (10.7%), respectively. Within the patient cohort, when assessed according to their initial and final MpMRI scores, it was found that 20 (23.8%) patients showed an upgrade in their PIRADS score, 11 (13.1%) patients showed a downgrade, and the PIRADS scores remained stable in other patients.

4. Discussion

With the increasing experience of FPB, whose effectiveness in the diagnosis of prostate cancer is indisputable, different questions are now coming to the fore. In our study, we sought to answer the question of whether the type of initial biopsy affects FPB results in secondary patients. Our data showed that the probability of detecting cancer in patients who had SPB for the first time and continued to be suspected of PCa was higher than in those whose first biopsy was FPB. This suggests that the type of initial biopsy should also be taken into consideration when deciding on FPB in patients with a previous negative biopsy history.

According to literature searches (PubMed-Medline, Scopus, Cochran Library Database, and Google Scholar), our study is the first in which patients were categorized into the first negative biopsy

Table 1
Pre-biopsy demographic and clinic data of the groups.

	Overall ($n = 275$)	Group 1 ($n = 84$)	Group 2 ($n = 191$)	p
Age (years)	63.0 ± 6.5	63.2 ± 6.7	62.9 ± 6.4	0.770
Body mass index (kg/m2)	27.2 (25.1–29.4)	27.3 (24.3–29.4)	27.1 (25.2–29.4)	0.681
PSA at First Biopsy (ng/mL)	7.0 (5.7–8.5)	6.9 (5.4–8.4)	7.2 (5.8–8.5)	0.298
PSA at Second Biopsy (ng/mL)	7.8 (6.4–9.2)	7.9 (6.5–9.3)	7.8 (6.3–9.1)	0.792
Family History of PCa (*n*, %)	29/275 (10.5%)	10/84 (11.9%)	19/191 (9.9%)	0.626
PIRADS Score				
• Score 3	95 (34.5%)	30 (35.7%)	65 (34.0%)	
• Score 4	114 (41.5%)	35 (41.6%)	79 (41.4%)	0.741
• Score 5	66 (24.0%)	19 (22.6%)	47 (24.6%)	
Total Prostate Volume (mm^3)	70.0 (50.0–94.0)	73.5 (53.0–91.0)	69.0 (48.0–95.0)	0.505
Transitional Zone Volume (mm^3)	42.0 (26.0–60.0)	43.5 (27.2–61.5)	41.0 (26.0–59.0)	0.746

PSA: Prostate specific antigen, PCa: Prostate cancer, PIRADS: Prostate Imaging Reporting and Data System, Group 1: Those whose first biopsy was a fusion prostate biopsy, Group 2: Those whose first biopsy was a standard prostate biopsy.

Table 2
Biopsy results and cancer detection rates of the groups.

	Overall (n = 275)	Group 1 (n = 84)	Group 2 (n = 191)	p
Number of Schemes (n)	13.0 (13.0–14.0)	13.0 (13.0–14.0)	13.0 (13.0–14.0)	0.784
Number of Target Core (n)	1.0 (1.0–2.0)	1.0 (1.0–2.0)	1.0 (1.0–2.0)	0.800
Overall Number of Samples (n)	16.0 (16.0–20.0)	16.0 (16.0–20.0)	16.0 (16.0–20.0)	0.780
CS Prostate Cancer Rate (n, %)	57/275 (20.7%)	13/84 (15.5%)	44/191 (23.0%)	0.044
Median ISUP Score	2.0 (1.0–2.0)	2.0 (1.0–2.0)	2.0 (1.0–2.0)	
ISUP Score Details (n, %)				
• Score 1	28 (4.9%)	5 (38.5%)	23(52.2%)	
• Score 2	19 (3.3%)	4 (30.7%)	15 (34.1%)	0.244
• Score 3	6 (10.6%)	3 (23.1%)	3 (6.8%)	
• Score 4	3 (0.5%)	1 (7.6%)	2 (4.5%)	
• Score 5	1 (0.2%)	-	1 (2.3%)	

ISUP: International Society of Urological Pathology, Group 1: Those whose first biopsy was a fusion prostate biopsy, Group 2: Those whose first biopsy was a standard prostate biopsy. CS: Clinically Significant.

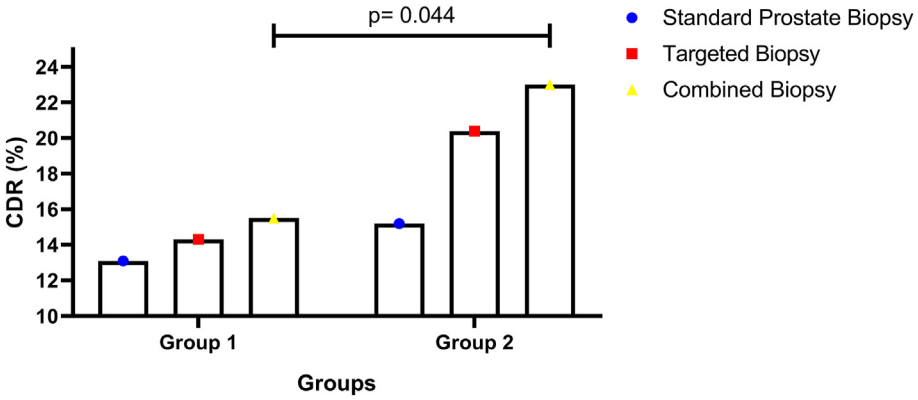

Fig. 2. Cancer detection rates (CDR) of the groups according to biopsy type.

type and these two groups were directly compared. Therefore, there is no study to directly compare our results. Besides, Sciarra et al reported that, in which they included patients with a previous negative SPB history and serum PSA value less than 10 ng/mL, they detected PCa in approximately 45% of these patients with FPB.[12] That study, unlike our study, consisted of patients who had previously only undergone SPB. In another study published in 2016, FPB was applied to patients with a negative SPB history and the cancer detection rate was reported as 26%.[13] However, it is noteworthy that in that study, only cognitive FPB was applied as the FPB technique, and the serum PSA value of the patients included in the study was approximately 13 ng/mL. In the FUTURE study, a higher rate of clinically significant cancer was detected when FPB was applied in patients with a previous negative biopsy history compared to SPB (32% vs 16%; $p < 0.001$).[14] Abe et al shared the results of FPB in 55 patients with a history of SPB in their recent study, reporting a cancer detection rate of approximately 45%.[15] Reasons for the significantly higher discrepancy between their study and ours could include the PSA cut-off value of 50 ng/mL used in their study and a smaller number of patients compared to our study. Finally, the most significant supporter of the results obtained from this study can be attributed to the outcomes of our series published in 2020.[16] According to that series, we applied the second biopsy as FPB in patients with a previous negative SPB history and detected clinically significant prostate cancer (CSPCa) in 27.9% (29/104) of cases. Over the approximately 5-year interval, patients with an initial negative FPB biopsy were added to our series, and in this study, we observe that the cancer detection rate in secondary cases has decreased to around 20.7%.

A current study published in 2023 included 85 patients with a negative FPB history and ongoing suspicion of cancer, with an average serum PSA value of approximately 8.5 ng/mL.[17] In the second round FPB applied to the patients, TB was detected in 21% and in the combined biopsy, csPCa was detected in 25%. It can be said that the patient characteristics and biopsy results included in this study are quite similar to our results. Pepe et al, on the other hand, applied only TB in the early stage to patients with negative FPB and PIRADS 3 or 4 lesions in the first stage, and detected cancer at a rate of approximately 10%.[18] In that study, the reasons why PCa TB results were detected at a much lower rate than ours can be listed as (i) the first biopsies were saturation + TB (ii) only TB was performed in the second biopsy, (iii) PIRADS 5 patients were not included in the study. When the PRECISION study, PRECISE study, MRI-FIRST study, and 4M study were examined, it was seen that TB had lower cancer detection rates than SPB in all of these important studies.[19–22] The results of our study are similar to these studies, but it should not be forgotten that in these studies, biopsy-naïve and secondary patients were given in a mixed manner. Therefore, there may be variations among the results.

In our study, when evaluating the initial and final MpMRI results of patients within Group 1, it was found that approximately 37% of patients exhibited changes in lesion characteristics. While the majority of patients maintained stable PIRADS scores, some showed an upgrade in PIRADS score, and others showed a downgrade. Steinkohl et al reported that after approximately 1 year of follow-up, 24.8% of patients who initially scored PIRADS 3 were upgraded to PIRADS 4, and 9.2% were downgraded to PIRADS 2.[23] The prostate cancer rate in their study was reported as 14.8%, which aligns with similar findings in our study. Another study by Zantoni et al reported an upgrade rate of 39% and a downgrade rate of 19% for PIRADS scores; however, unlike our study, they did not impose any PSA threshold, which may explain differences in

results.[24] Additionally, while our study lacked sufficient data on this matter, it should be noted that interpretation errors in mpMRI and targeting inaccuracies during fusion prostate biopsy could also influence outcomes.

With the use of FPB, it is known that there has been an increase in the rates of CSPCa. In this increase, TB plays a crucial role, particularly in targeting suspicious areas.[25] Through this approach, the rates of clinically insignificant PCa are reduced, thereby preventing unnecessary PCa treatments.[26] In a randomized controlled study published in 2018, SPB and TB were compared in terms of their rates of clinically insignificant PCa, revealing a higher detection rate of clinically insignificant PCa with SPB compared to TB (9% vs. 22%, $p < 0.001$).[24] Unlike our study, this study included not only secondary patients but all patients. Another study reported a higher rate of detecting high-risk PCa in patients undergoing TB (41.6% vs. 6.2%, $p < 0.001$).[27] Considering these studies, it can be said that our results are consistent with the literature.

Our study has some important limitations. The most important of these are: (i) the retrospective nature of our study, (ii) the small number of patients included in the study, (iii) Combined FPB was applied to all patients without perilesional sampling, and (iv) cancer diagnosis is based on needle biopsy results, not on histopathological examination of radical prostatectomy specimens.

In conclusion, the data obtained from this study indicate that the type of initial biopsy should be taken into account when deciding on FPB in secondary patients with a previous negative biopsy history. We believe that if PCa suspicion persists in patients whose first biopsy was performed as SPB, a bolder decision can be made, but it should be taken into consideration that PCa detection rates may be slightly lower in patients whose first biopsy type was already FPB.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2024;74:229–63. https://doi.org/10.3322/caac.21834.
2. Stinesen Kollberg K, Holmberg E, Josefsson A, Hugosson J, Arnsrud Godtman R. Prostate specific antigen and biopsy contamination in the Göteborg-1 randomized, population-based, prostate cancer screening trial. J Urol 2022;208:1018–27. https://doi.org/10.1097/JU.0000000000002835.
3. Nam R, Patel C, Milot L, Hird A, Wallis C, Macinnis P, et al. Prostate MRI versus PSA screening for prostate cancer detection (the MVP Study): a randomised clinical trial. BMJ Open 2022;12:e059482. https://doi.org/10.1136/bmjopen-2021-059482.
4. Boschheidgen M, Albers P, Schlemmer HP, Hellms S, Bonekamp D, Sauter A, et al. Multiparametric magnetic resonance imaging in prostate cancer screening at the age of 45 years: results from the first screening round of the PROBASE trial. Eur Urol 2024;85:105–11. https://doi.org/10.1016/j.eururo.2023.09.027.
5. Choi YH, Lee CU, Song W, Chang Jeong B, Seo SI, Jeon SS, et al. Combination of multiparametric magnetic resonance imaging and transperineal template-guided mapping prostate biopsy to determine potential candidates for focal therapy. Prostate Int 2023;11(2):100–6. https://doi.org/10.1016/j.prnil.2022.12.003.
6. Sönmez G, Tombul ŞT, Demirtaş T, Öztürk F, Demirtaş A. A comparative study: has MRI-guided fusion prostate biopsy changed the prostate-specific antigen gray-zone range? Cureus 2019;11e6329. https://doi.org/10.7759/cureus.6329.
7. Cornford P, van den Bergh RCN, Briers E, Van den Broeck T, Brunckhorst O, Darraugh J, et al. EAU-EANM-ESTRO-ESUR-ISUP-SIOG guidelines on prostate cancer-2024 update. Part I: screening, diagnosis, and local treatment with curative intent. Eur Urol 2024;S0302–2838(24):2254. https://doi.org/10.1016/j.eururo.2024.03.027, 1.
8. Eastham JA, Auffenberg GB, Barocas DA, Chou R, Crispino T, Davis JW, et al. Clinically localized prostate cancer: AUA/ASTRO guideline, part I: introduction, risk assessment, staging, and risk-based management. J Urol 2022;208:10–8. https://doi.org/10.1097/JU.0000000000002757.
9. Rastinehad AR, Turkbey B, Salami SS, Yaskiv O, George AK, Fakhoury M, et al. Improving detection of clinically significant prostate cancer: magnetic resonance imaging/transrectal ultrasound fusion guided prostate biopsy. J Urol 2014;191:1749–54. https://doi.org/10.1016/j.juro.2013.12.007.
10. Turkbey B, Rosenkrantz AB, Haider MA, Padhani AR, Villeirs G, Macura KJ, et al. Prostate imaging reporting and data system version 2.1: 2019 update of prostate imaging reporting and data system version 2. Eur Urol 2019;76:340–51. https://doi.org/10.1016/j.eururo.2019.02.033.
11. Porpiglia F, Manfredi M, Mele F, Cossu M, Bollito E, Veltri A, et al. Diagnostic pathway with multiparametric magnetic resonance imaging versus standard pathway: results from a randomized prospective study in biopsy-naïve patients with suspected prostate cancer. Eur Urol 2017;72:282–8. https://doi.org/10.1016/j.eururo.2016.08.041.
12. Sciarra A, Panebianco V, Ciccariello M, Salciccia S, Cattarino S, Lisi D, et al. Value of magnetic resonance spectroscopy imaging and dynamic contrast-enhanced imaging for detecting prostate cancer foci in men with prior negative biopsy. Clin Cancer Res 2010;16:1875–83. https://doi.org/10.1158/1078-0432.CCR-09-2195.
13. Taverna G, Bozzini G, Grizzi F, Seveso M, Mandressi A, Balzarini L, et al. Endorectal multiparametric 3-tesla magnetic resonance imaging associated with systematic cognitive biopsies does not increase prostate cancer detection rate: a randomized prospective trial. World J Urol 2016;34:797–803. https://doi.org/10.1007/s00345-015-1711-4.
14. Exterkate L, Wegelin O, Barentsz JO, van der Leest MG, Kummer JA, Vreuls W, et al. Is there still a need for repeated systematic biopsies in patients with previous negative biopsies in the era of magnetic resonance imaging-targeted biopsies of the prostate? Eur Urol Oncol 2020;3:216–23. https://doi.org/10.1016/j.euo.2019.06.005.
15. Abe M, Takata R, Ikarashi D, Sekiguchi K, Tamura D, Maekawa S, et al. Detection of anterior prostate cancer using a magnetic resonance imaging-transrectal ultrasound fusion biopsy in cases with initial biopsy and history of systematic biopsies. Prostate Int 2023;11(4):212–7. https://doi.org/10.1016/j.prnil.2023.08.002.
16. Sonmez G, Demirtas T, Tombul ST, Ozturk F, Demirtas A. What is the ideal number of biopsy cores per lesion in targeted prostate biopsy? Prostate Int 2020;8(3):112–5. https://doi.org/10.1016/j.prnil.2020.03.004.
17. Nisha Y, Yi S, Breau RH, Flood TA, Cagiannos I, Lavallée LT, et al. Yield of second-round MRI targeted ultrasound-guided fusion prostate biopsy after initial first-round targeted biopsy. Can Urol Assoc J 2023;17:393–401. https://doi.org/10.5489/cuaj.8366.
18. Pepe P, Garufi A, Priolo GD, Pennisi M, Fraggetta F. Early second round targeted biopsy of PI-RADS score 3 or 4 in 256 men with persistent suspicion of prostate cancer. In Vivo 2019;33:897–901. https://doi.org/10.21873/invivo.11556.
19. Kasivisvanathan V, Rannikko AS, Borghi M, Panebianco V, Mynderse LA, Vaarala MH, et al. Precision study group collaborators. MRI-targeted or standard biopsy for prostate-cancer diagnosis. N Engl J Med 2018;378:1767–77. https://doi.org/10.1056/NEJMoa1801993.
20. Klotz L, Chin J, Black PC, Finelli A, Anidjar M, Bladou F, et al. Comparison of multiparametric magnetic resonance imaging-targeted biopsy with systematic transrectal ultrasonography biopsy for biopsy-naive men at risk for prostate cancer: a phase 3 randomized clinical trial. JAMA Oncol 2021;7:534–42. https://doi.org/10.1001/jamaoncol.2020.7589.
21. Rouvière O, Puech P, Renard-Penna R, Claudon M, Roy C, Mège-Lechevallier F, et al, MRI-FIRST Investigators. 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;20:100–9. https://doi.org/10.1016/S1470-2045(18)30569-2.
22. van der Leest M, Cornel E, Israël B, Hendriks R, Padhani AR, Hoogenboom M, et al. Head-to-head comparison of transrectal ultrasound-guided prostate biopsy versus multiparametric prostate resonance imaging with subsequent magnetic resonance-guided biopsy in biopsy-naïve men with elevated prostate-specific antigen: a large prospective multicenter clinical study. Eur Urol 2019;75:570–8. https://doi.org/10.1016/j.eururo.2018.11.023.
23. Steinkohl F, Gruber L, Bektic J, Nagele U, Aigner F, Herrmann TRW, et al. Retrospective analysis of the development of PIRADS 3 lesions over time: when is a follow-up MRI reasonable? World J Urol 2018;36(3):367–73. https://doi.org/10.1007/s00345-017-2135-0.
24. Zattoni F, Pereira LJP, Marra G, Valerio M, Olivier J, Puche-Sanz I, et al. The impact of a second MRI and re-biopsy in patients with initial negative mpMRI-targeted and systematic biopsy for PIRADS $\geq$ 3 lesions. World J Urol 2023;41(11):3357–66. https://doi.org/10.1007/s00345-023-04578-7.
25. 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. https://doi.org/10.1056/NEJMoa1801993.
26. Ploussard G, Epstein JI, Montironi R, Carroll PR, Wirth M, Grimm MO, et al. The contemporary concept of significant versus insignificant prostate cancer. Eur Urol 2011;60(2):291–303. https://doi.org/10.1016/j.eururo.2011.05.006.
27. Arafa MA, Rabah DM, Khan FK, Farhat KH, Al-Atawi MA. Effectiveness of magnetic resonance imaging-targeted biopsy for detection of prostate cancer in comparison with systematic biopsy in our countries with low prevalence of prostate cancer: our first experience after 3 years. Prostate Int 2021;9(3):140–4. https://doi.org/10.1016/j.prnil.2021.01.001.