Forrest *et al. European Radiology*
https://doi.org/10.1007/s00330-025-12136-5

EUROPEAN SOCIETY OF RADIOLOGY
European Radiology

UROGENITAL

Detection of clinically significant prostate cancer using targeted MRI-informed microultrasound biopsy

Allison B. Forrest[1], Danielle E. Kruse[1], Brian Calio[2], Michael C. Ivey[1], Jeffrey Gahan[2], Martus Gn[2], Rajan T. Gupta[1,2,3*] and Tara Morgan[2]

Abstract

Objectives This study compares the rate of detection of clinically significant prostate cancer (csPCa) using multiparametric MRI (mpMRI)-informed microultrasound-guided (microUS) biopsy to historical published data using mpMRI-ultrasound (mpMRI-US) fusion biopsy at the same institution.

Materials and methods A single-center retrospective study of patients who underwent mpMRI-informed microultrasound-guided (microUS) biopsy was performed. Positive predictive value (PPV) of targeted lesions by PI-RADS and PRI-MUS (Prostate Risk Identification Using Microultrasound) was calculated and compared to published data using an mpMRI-US fusion platform.

Results 169 subjects and 244 total lesions were identified by mpMRI. 44/244 (18.0%), 167/244 (68.4%), and 33/244 (13.5%) were PI-RADS 5, 4, and 3, respectively. 206/244 (84.4%) lesions seen on mpMRI were identified on microUS. 26 additional lesions were identified by microUS only. PCa was identified in 120/169 (71.0%) patients, and csPCa was identified in 70/169 (41.4%) by targeted microUS-guided biopsy of MRI lesions. Targeted biopsy of lesions seen only on microUS added three cases of csPCa (73/169, 43.2%). PPV of targeted PI-RADS 5, 4, and 3 lesions for all PCa and csPCa was 0.80, 0.61, and 0.39, and 0.64, 0.31, and 0.12, respectively. Findings were not significantly different compared to historical data using mpMRI-US fusion biopsy ($p > 0.05$). PPV for csPCa was 0.18 for mpMRI lesions when no correlate was identified by microUS, compared to 0.37 for lesions when a correlate was seen ($p < 0.05$).

Conclusions This retrospective study demonstrates successful implementation of microUS-guided biopsy, with similar rates of identification of csPCa compared to historical data using mpMRI-US fusion.

Key Points

Question There is limited real-world comparison of the rate of detection of clinically significant prostate cancer using mpMRI-informed microUS-guided biopsy compared to historical mpMRI-ultrasound fusion biopsy.
Findings Identification of clinically significant prostate cancer by microUS-guided biopsy was similar to mpMRI-US fusion biopsy, suggesting microUS-guided biopsy performs as well as mpMRI-US fusion biopsy.
Clinical relevance Our study shows the complementary role of mpMRI and microUS for the detection of clinically significant prostate cancer, supporting the combined approach of these techniques.

Keywords Prostate cancer, Multiparametric magnetic resonance imaging, Ultrasound, Image-guided biopsy

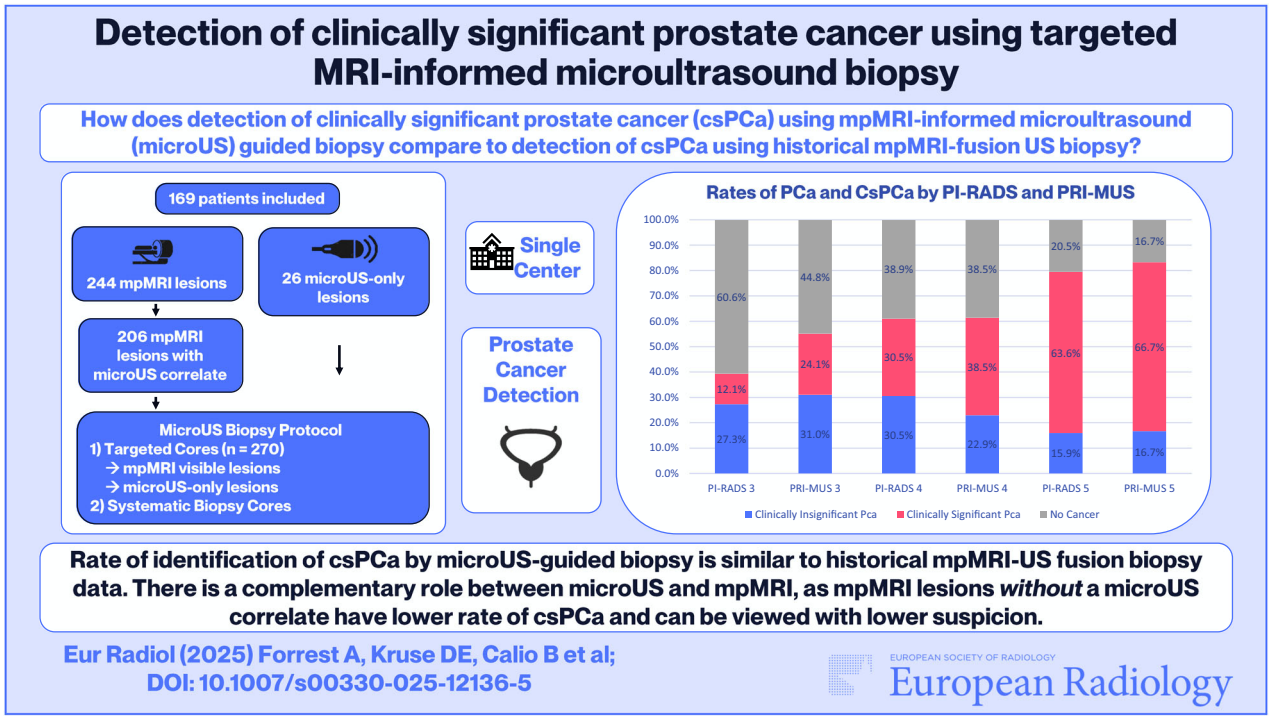
Allison B. Forrest and Danielle E. Kruse contributed equally to this work.

Rajan T. Gupta and Tara Morgan jointly supervised this work.

*Correspondence:
Rajan T. Gupta
rajan.gupta@duke.edu
Full list of author information is available at the end of the article

Springer

Graphical Abstract



Introduction

Prostate cancer (PCa) is the most common cancer among men, with an estimated 288,300 new cases and more than 30,000 associated deaths annually [1]. Clinically significant prostate cancer (csPCa) is usually defined as International Society of Urological Pathology (ISUP) Grade Group (GG) ≥ 2. Identification of localized intermediate- and high-risk PCa is essential for the initiation of timely management, compared to lower risk PCa, which can be managed with active surveillance [2, 3].

Prostate biopsy is critical in diagnosis, risk determination, and treatment guidance. Multiparametric magnetic resonance imaging (mpMRI) using Prostate Imaging Reporting and Data System (PI-RADS) v.2.1, followed by mpMRI-US fusion biopsy, improves diagnostic accuracy and increases detection of csPCa. Targeted biopsy decreases the discovery of clinically insignificant PCa, which can lead to overtreatment [4], compared to prostate-specific antigen (PSA) and transrectal ultrasound (TRUS) systematic biopsy without mpMRI fusion [5, 6].

Transrectal US using B-mode ultrasound alone has poor identification of clinically significant prostate cancer, with one study reporting hypoechoic areas seen in 67% of cases, with a positive predictive value (PPV) of 40% [7]. TRUS is primarily used for random systematic biopsy and mpMRI-fusion US biopsy targeting, which has challenges including patient motion, errors in image registration, prostate deformation by the probe, and mismatch of imaging planes, which can lead to targeting error [8].

Microultrasound (microUS) is an emerging technique that utilizes a higher frequency probe of 29 MHz, compared to 6–9 MHz of traditional US. This allows for improved spatial resolution of 70 μm, compared to approximately 200 μm. Ductal anatomy can be evaluated by microUS during real-time biopsy, improving visualization of the gland and suspicious lesions [8].

MicroUS of the prostate using the ExactVu system (Exact Imaging) was studied in a randomized clinical trial by Ghai et al in 2016. During the trial, Prostate Risk Identification Using Micro-Ultrasound score (PRI-MUS) was created as a five-point grading system to characterize lesions, with a one unit increase in PRI-MUS score demonstrating a 10.1% increase in rates of csPCa [9].

Numerous studies have assessed the performance of mpMRI-informed microUS-guided biopsy for the detection of clinically significant prostate cancer, with promising results [10–14]. However, there is limited evaluation of the real-world performance of mpMRI-informed microUS-guided biopsy with direct comparison to fusion biopsy techniques. The purpose of our study is

to compare the rate of detection of clinically significant prostate cancer using the microUS biopsy technique to historical published data using mpMRI-ultrasound fusion biopsy at the same institution.

Materials and methods

Patient selection

This HIPAA-compliant retrospective study was granted a waiver of informed consent by an institutional review board. Patients who underwent microUS-guided biopsy between June 2024 and April 2025 at our institution were included. Exclusion criteria included prior focal treatment for prostate cancer and those without index lesions undergoing a systematic, nontargeted biopsy.

MRI protocol and interpretation

mpMRIs at our institution were completed using 3-Tesla (3-T) (Skyra/Vida, Siemens Healthcare) scanners with multichannel surface coils ± a single-channel endorectal coil (eCoil, DxTx Medical). The imaging sequences were carried out in accordance with PI-RADS v2.1 technical specifications and included thin-section (3-mm section thickness) fast spin-echo T2-weighted images (T2WI) in the coronal and axial planes. Diffusion-weighted images (DWI) were obtained using two b-values ($b = 50$ and 800 s/mm^2) with matched 3 mm slice thickness to T2WI in the axial plane, matrix size of 80 × 128, field of view of 150 mm. Apparent diffusion coefficient (ADC) maps were calculated, as well as high b-value imaging ($b = 1400$ s/mm^2). After administering a weight-based dose of extracellular contrast agent (gadopiclenol, Vueway, Bracco Diagnostics), dynamic contrast-enhanced sequences were acquired with 4- to 5-s temporal resolution for 5–6 min.

All mpMRIs from our institution were interpreted as per our standard protocol by one of a team of 10 radiologists, each with abdominal imaging fellowship training and between 2 and 30 years of post-fellowship experience. Patient information, including PSA, was available at the time of interpretation. All suspicious lesions were classified based on imaging features using PI-RADS v2.1.

A subset of MRIs submitted from outside institutions was included in the study when no institutional MRI had been performed. Seventeen outside studies were included, three of which were secondarily interpreted at our institution as per a program that we provide, allowing for formal outside interpretations of imaging acquired outside our institution. For the studies without re-interpretation requested by the ordering provider, the original lesions reported in the original reports were included as target lesions.

Microultrasound and biopsy protocol

All microUS biopsies were performed by a team of three urologists with between 2 and 13 years post-training experience (J.G., M.G., T.M.). With the patient in the extended lithotomy position, the transrectal micro-ultrasound probe was advanced, and a detailed sweep of the prostate was performed. Any concerning lesions were noted, with PRI-MUS scores documented. Lesion locations were recorded in relation to laterality, prostate zone (transition, peripheral, or central zone), degrees from the urethral midline, and region on the two other axes (anterior, mid, posterior and apex, mid, base). MRI-fusion software was then activated, and the live ultrasound image was registered with the imported MRI images. All MRI-visible lesions were then systematically targeted and sampled via trans-perineal targeted biopsy, with 3 to 6 cores obtained from each region of interest. Following targeted biopsies of MRI-identified lesions, any PRI-MUS regions of interest not matched with an MRI target were biopsied in the same fashion. Finally, systematic trans-perineal biopsies were obtained using a standardized template adjusted from the Michigan Urological Surgery Improvement Collaborative (MUSIC) TP biopsy template, with a minimum of 16 additional cores.

Board-certified pathologists with experience in genitourinary pathology examined the specimens and reported the ISUP Grade Group for each core submitted.

Quality improvement protocol

A previously published, quality improvement protocol from the same institution was implemented to review cases in which a higher Grade Group was found on systematic cores compared to targeted cores of PI-RADS lesions [15]. Nontargeted cores within or adjacent to the segment, including the mpMRI region of interest, were considered "nearest neighbors." PPV for PCa and csPCa was calculated for PI-RADS lesions before and after the implementation of this quality improvement protocol to assess for improvement in performance.

Statistical analysis

Descriptive statistics were generated using mean and standard deviation or median and interquartile range for continuous data and counts and percentages for categorical data. Differences in continuous and categorical variables were assessed using the *t*-test and Fisher's exact test, respectively. p-value < 0.05 was considered significant.

Positive predictive value (PPV) of PI-RADS and PRI-MUS was calculated for the diagnosis of all prostate cancer and for csPCa. PPV for PI-RADS was compared to historical data from the same institution using the mpMRI-US fusion platform (UroNav, Philips) using two independent proportions test (z-test).

All statistical analyses were performed using RStudio (R Foundation for Statistical Computing).

Results

Baseline characteristics of patients

A total of 169 men were included with a median age of 67.3 years (IQR 62.5–71.7), median baseline prostate-specific antigen (PSA) level of 6.7 ng/mL (IQR 4.6–9.1), and median PSA density of 0.17 ng/mL^2 (IQR 0.11–0.24).

Imaging results

The median MRI-based prostate volume was 39.0 cm^3 (IQR 31.1–50.1). A total of 244 lesions were identified by MRI, with PI-RADS 3 in 33/244 (13.5%), PI-RADS 4 in 167/244 (68.4%), and PI-RADS 5 in 44/244 (18.0%). The mean number of lesions detected per patient was 1.5 (± 0.76). 167 lesions (68.4%) were located in the peripheral zone. Gross extra-prostatic extension was associated with 12 lesions (4.9%). Table 1 shows the baseline clinical and imaging characteristics.

Patient-level analysis

Prostate cancer was identified in 120/169 (71.0%), and clinically significant cancer was identified in 70/169 (41.4%) with targeted biopsy of MRI lesions. Grade Grade groups of the highest MRI-targeted lesions were GG1 in 50/169 (29.6%) and GG2 or above in 70/169 (41.4%). Breakdown of GG2 and above disease is as follows: GG2 in 50/169 (29.6%), GG3 in 11/169 (6.5%), GG4 in 5/169 (3.0%), and GG5 in 4/169 (2.7%). 49/169 (29.0%) were benign. Targeted biopsy of lesions seen only on microUS added three additional cases of GG2 csPCa (73/169, 43.2%), for a relative increase of 1.8%. Two additional cases of GG1 PCa were added by biopsy of a micro-US-only lesion. Systematic biopsy led to an additional 25 patients with prostate cancer (150/169, 88.5%) and 20 additional cases of csPCa, resulting in 93/169 (55.0%).

Lesion-level analysis

Targeted biopsy of all lesions, including those seen on mpMRI and microUS-only lesions, resulted in benign tissue in 108/270 (40.0%), GG1 in 71/270 (26.3%) and GG2 or above in 91/270 (33.7%). Breakdown of GG2 and above disease is as follows: GG2 in 68/270 (25.2%), GG3 in 14/270 (5.2%), GG4 in 5/270 (1.9%), and GG5 in 4/270 (1.5%). Table 1 shows tissue biopsy findings. Representative case examples of lesions seen on both mpMRI and microUS are shown in Figs. 1 and 2.

PPV of PI-RADS lesion

PPV of targeted PI-RADS 5, 4, and 3 lesions for all PCa and csPCa was 0.80, 0.61, and 0.39, and 0.64, 0.31, and 0.12, respectively. Higher PI-RADS was associated with increased rates of PCa and csPCa ($p < 0.05$). Rates of clinically significant, clinically insignificant PCa, and benign results by PI-RADS are shown in Fig. 3.

Table 1 Description of study population with clinical and mpMRI, microUS, and tissue biopsy findings

Total number of patients, *n*	169
Age (years) (IQR)	67.3 (62.5–71.7)
PSA (ng/mL) (IQR)	6.7 (4.6–9.1)
Prostate volume (mL) (IQR)	39.0 (31.1–50.1)
PSAD (ng/mL^2) (IQR)	0.17 (0.11–0.24)
Total number of mpMRI identified lesions, *n*	244
Zones, *n* (%)	
PZ lesions	167 (68.4%)
TZ lesions	72 (29.5%)
CZ lesions	5 (2.0%)
PI-RADS of all mpMRI lesions	
3	33 (13.5%)
4	167 (68.5%)
5	44 (18.0%)
Total number of microUS-identified lesions, *n*	232
PRI-MUS of microUS lesions	
1	1 (0.4%)
2	12 (5.2%)
3	87 (37.5%)
4	96 (41.4%)
5	36 (15.6%)
Total number of lesions identified by both mpMRI and microUS, *n*	270
Lesion biopsy pathology, *n* (%)	
Benign tissue	108 (40.0%)
GGG1	71 (26.3%)
GGG2	68 (25.2%)
GGG3	14 (5.2%)
GGG4	5 (1.9%)
GGG5	4 (1.5%)

Findings were not significantly different compared to historical published data from our same institution using mpMRI-US fusion biopsy, in which PPV of PI-RADS 5, 4, and 3 for all PCa and csPCa was 0.80, 0.55, 0.24 and 0.63, 0.33, and 0.09, respectively ($p > 0.05$) [15]. There were no significant differences in the patient population between the studies, with similar age and PSA ranges. Comparison of PPVs between mpMRI-informed microUS-guided biopsy by PI-RADS, historical mpMRI-US fusion biopsy by PI-RADS, and microUS-guided biopsy by PRI-MUS is shown in Fig. 4.

No significant difference was found when comparing the rates of PCa and csPCa at the time of fusion biopsy using MRIs performed and interpreted at our institution compared to outside institutions ($p > 0.05$).

Of 244 lesions seen on mpMRI, 206 (84.4%) were also identified on microUS. Of the 38 lesions without microUS correlate identified, six were PI-RADS 3, 30 were PI-

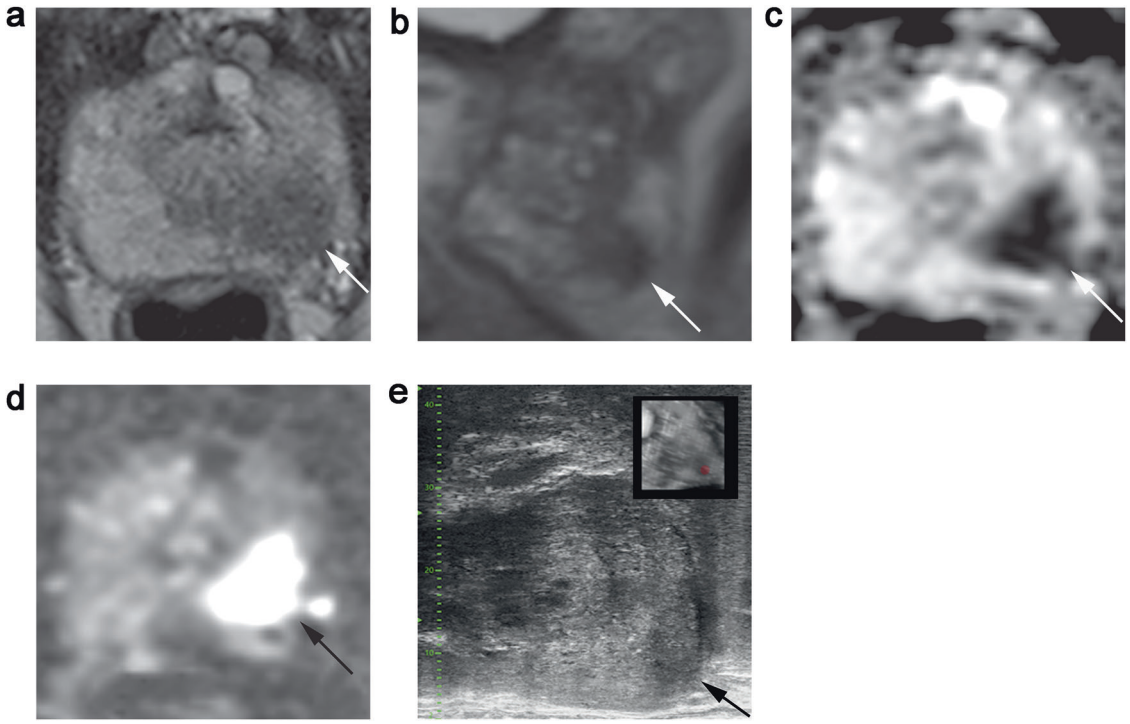


Fig. 1 71-year-old male with PSA of 3.61 ng/mL and PSA density of 0.10 ng/mL^2. T2-weighted images show a T2 hypointense lesion (arrow) in the left posterior lateral peripheral zone at the apex in axial (**a**) and sagittal planes (**b**), with corresponding ADC hypointensity (arrow) (**c**) and DWI hyperintensity (arrow) (**d**), corresponding to a PI-RADS 5 lesion. There is a PRI-MUS 5 correlate with mixed echoes and irregular prostate border at the −29° position (arrow), seen in the sagittal plane, with inset corresponding to the sagittal MRI localizer (**e**). Targeted biopsy revealed Grade Group 4 + 5 = 9 prostate cancer

RADS 4, and two were PI-RADS 5. 23/38 (60.1%) were in the peripheral zone. Overall, PPV for csPCa of all PI-RADS lesions not seen by microUS was 0.18, compared to PPV of 0.37 for lesions that had a microUS correlate ($p < 0.05$). PPV of PI-RADS 3 lesions seen by MRI but not identified by microUS was 0.33 for PCa and 0.17 for csPCa, compared to 0.41 for PCa and 0.11 for csPCa for lesions seen by microUS, with statistical analysis limited due to small sample size. PPV of PI-RADS 4 lesions seen by MRI, but not identified by microUS, was 0.57 for PCa and 0.17 for csPCa, compared to 0.62 for PCa and 0.34 for csPCa for lesions seen by microUS, although not statistically significant. One microUS-invisible PI-RADS 5 lesion was biopsied with benign results, and the other was GG2 csPCa.

PPV of PRI-MUS lesions

PPV of PRI-MUS 5, 4, 3, and 2/1 lesions for all PCa and csPCa was 0.83, 0.61, 0.55, and 0.36 and 0.67, 0.39, 0.24, and 0.14, respectively. A higher PRI-MUS score was associated with increased rates of PCa and csPCa ($p < 0.05$). Rates of clinically significant, clinically insignificant PCa, and benign results by PRI-MUS are shown in Fig. 3.

A total of 26 lesions were seen on microultrasound, but not identified by mpMRI. These lesions were re-assessed based on correlation with biopsy pathology results and/or re-review of mpMRI images by a board-certified radiologist with specific expertise in prostate imaging (R.G.) when possible due to the differing localization methodologies used in microUS vs. mpMRI. Four were PRI-MUS 3, 18 were PRI-MUS 4, and four were PRI-MUS 5. PPV of microUS-only PRI-MUS 5 and 4 lesions for all PCa was 0.75 (3/4 lesions) and 0.50 (9/18 lesions) and for csPCa was 0.50 (2/4 lesions) and 0.33 (6/18 lesions), respectively. All microUS-only PRI-MUS 3 lesions were biopsied with benign results. A representative case example of a microUS-only lesion without an MRI correlate is shown in Fig. 5.

Quality improvement outcomes

Upon re-review of pathology results using the quality improvement protocol, 11 PI-RADS 4 and two PI-RADS 5 lesions were found to have a systematic biopsy core either bordering or within the targeted zone, which resulted in an upgrade to PCa or csPCa. Following this review, the updated PPV of PI-RADS 5 lesions for PCa and csPCa

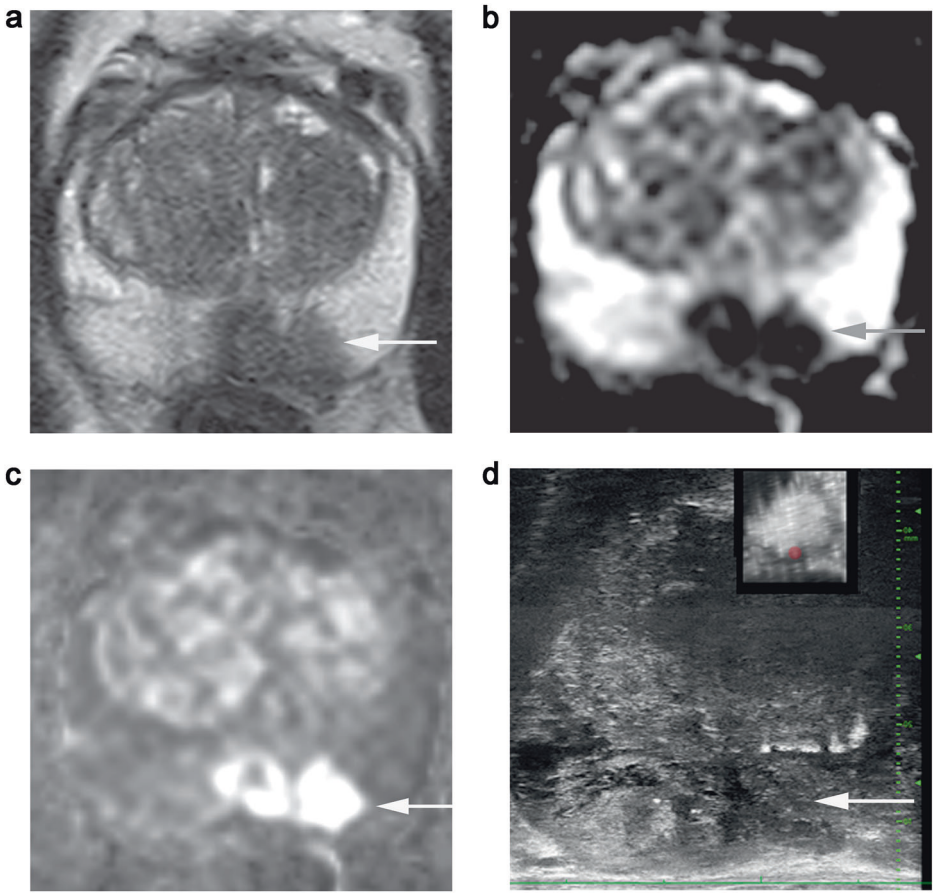


Fig. 2 71-year-old male with PSA of 4.85 ng/mL and PSA density of 0.06 ng/mL^2. Axial T2-weighted images show a T2 hypointense lesion (arrow) in the left posterior medial peripheral zone at the mid gland (**a**), with corresponding ADC hypointensity (arrow) (**b**) and DWI hyperintensity (arrow) (**c**), corresponding to a PI-RADS 5 lesion. There is a PRI-MUS 5 correlate with irregular shadowing at the −34° position (arrow), seen in the sagittal plane, with inset corresponding to the sagittal MRI localizer (**d**). Targeted biopsy revealed Grade Group 3 + 4 = 7 prostate cancer

increased to 0.84 and 0.68, from 0.80 and 0.64. The updated PPV of PI-RADS 4 lesions for PCa and csPCa increased to 0.68 and 0.34, from 0.61 and 0.31.

Discussion

The rate of detection of csPCa by microUS-guided biopsy in our study is similar to csPCa detection by mpMRI-US fusion biopsy from our institution, suggesting microUS-guided biopsy of suspicious lesions seen on MRI performed as well as mpMRI-US fusion biopsy [15]. Our PPVs for csPCa are similar to a multicenter review of PPV of targeted biopsy of PI-RADS lesions, with PPV for PI-RADS 5 of 0.72 (IQR 0.61–0.82) and PI-RADS 4 of 0.39 (IQR 0.25–0.55) [16].

This study demonstrates the complementary role of mpMRI and microUS. Three additional patients were diagnosed with csPCa following targeted biopsy of a microUS-only lesion, a relative increase of 1.8%. Other studies utilizing microUS have demonstrated similar increases in rates of detection of csPCa, for example 2.6% increase seen by Lughezzani et al [12]. Others have reported higher rates of increase with microUS, including Wiemer et al, with a 17% increase of csPCa in addition to nontargeted and MRI-targeted lesions [11]. Further studies are needed, given these varied results.

Lesions identified by mpMRI were identified in 84.4% by microUS, similar to the 90.0% visibility reported by Cornud et al [13] and increased compared to 67% by Ghai et al [14]. The microUS technique allows improved direct visualization of the target, rather than dependence on fusion techniques with less sensitive B-mode US using lower frequency US transducers.

When a lesion seen on mpMRI was not identified on microUS, overall PPV for csPCa was lower in our study (0.37 vs 0.18, $p < 0.05$). This suggests that lesions without microUS correlates can be viewed with lower suspicion. Similar findings were demonstrated by Ghai et al, who

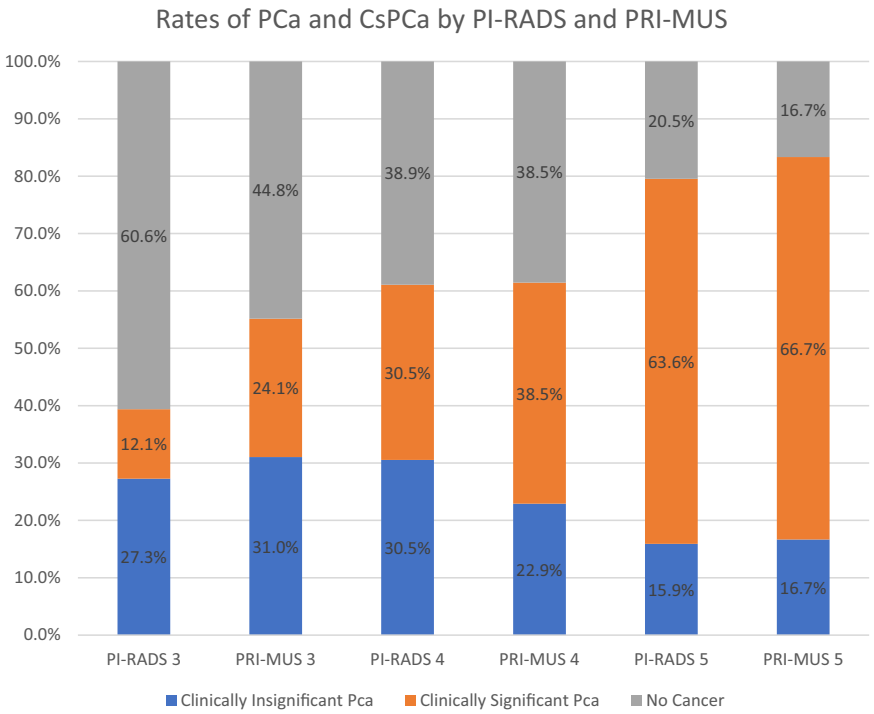


Fig. 3 Rates of clinically insignificant PCa and csPCa by PRI-MUS and PI-RADS using microUS-guided biopsy

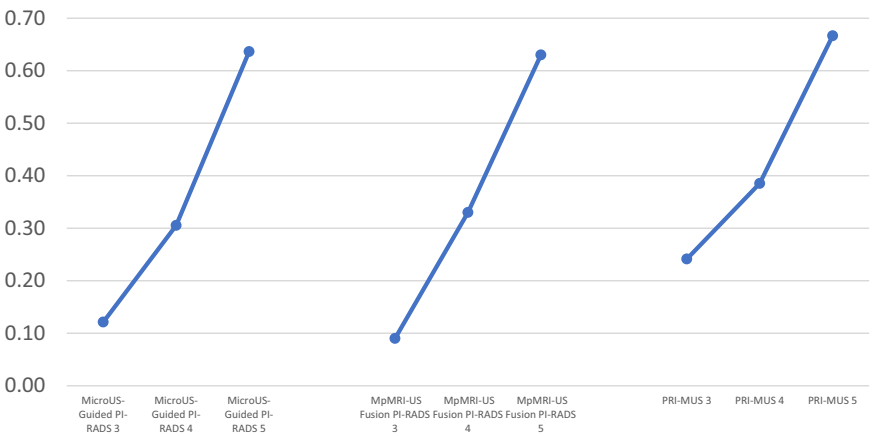


Fig. 4 Positive predictive values of clinically significant prostate cancer for PI-RADS using microUS-guided biopsy, PI-RADS using mpMRI-US fusion biopsy (historical data), and PRI-MUS

found lesions seen on both microUS and MRI had a rate of csPCa of 58%, compared to 26% of lesions seen on MRI but not microUS [14]. A study by Avolio et al reviewed microUS of PI-RADS 3 lesions and found that lesions without microUS correlate had no csPCa at biopsy, compared to 20% with csPCa when a PRI-MUS ≥ 3 correlate was identified with microUS [17].

PPVs for csPCa for PRI-MUS 5, 4, and 3, in our study, were similar to PI-RADS. The csPCa PPVs for PRI-MUS in our study were slightly higher compared to those reported by Klotz et al, which were 0.61, 0.39, and 0.19, respectively, for that study [10]. There is a lack of published data on the interobserver agreement of PRI-MUS, which may contribute to varied results. A higher PRI-MUS score was associated with increased PPV of csPCa in our study, similar to prior studies [9].

In our study, systematic biopsy led to an increase of 11.8% of men with clinically significant cancers, although

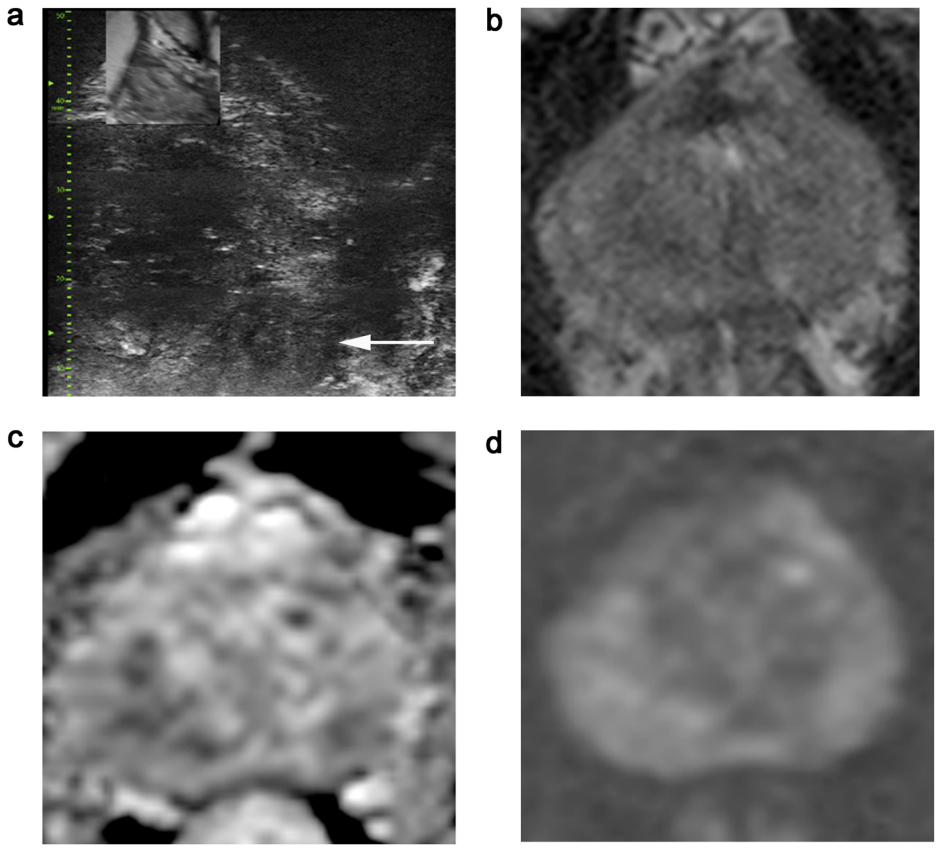


Fig. 5 70-year-old male with PSA of 5.54 ng/mL and PSA density of 0.15 ng/mL^2. A PRI-MUS 4 lesion (arrow) was seen on microUS at the −13° position with smudgy/mottled appearance (**a**). No definite corresponding abnormality lesion was seen on re-review of the MRI at the expected location on T2-weighted axial (**b**), ADC (**c**), and DWI (**d**). Targeted biopsy revealed Grade Group 3 + 4 = 7 prostate cancer

it also led to an 8.9% increase in clinically insignificant cancers. A study by Lughezzani et al similarly found an increase of 10.3% cases of csPCa by nontargeted systematic biopsy following microUS biopsy, whereas a prior study by Ghai et al found no additional cases of csPCa with the addition of systematic biopsy [12, 14]. Ghai et al found a similar increase in the detection of clinically insignificant prostate cancer at 11% [14].

Our study demonstrates the applicability of a quality improvement process previously implemented for mpMRI-fusion biopsy at our institution to better manage imaging-histology discordance. The increase in the rate of csPCa with systematic biopsy in our study may be related to the "nearest neighbor" phenomenon, whereby a targeted biopsy was negative, but an adjacent systematic biopsy was positive. Some error or tolerance is known in the MRI-US fusion systems, which also appears to apply to the microUS-fusion algorithm. The quality improvement process resulted in an increase in PPV, where PI-RADS 4 or 5 lesions with benign results had adjacent nontargeted cores with csPCa. Potential sources of error include undersampling, lesion identification/segmentation, and fusion technique. This process led to an overall increase in PPVs, similar to prior studies from our institution [15].

Learning curve may have impacted our results, particularly cases performed early during the study period, which included 169 patients, with biopsies performed by three urologists. Pavlovich et al showed that training and increased experience increased detection of csPCa by microUS by 7%, potentially impacting rates of detection early in our longitudinal study [18].

Limitations of our study include the single-center, retrospective nature.

Next, the PPV of PI-RADS lesions in this study was compared to historical data, rather than a prospective comparison, although the patient populations were similar and the majority of the mpMRIs were interpreted by the same cohort of radiologists. Head-to-head comparison of microUS versus mpMRI-US fusion biopsy was not feasible in this study, as it would have required patients to undergo both biopsy types simultaneously.

Also, some variability was introduced by the inclusion of MRIs performed at outside hospitals, although PPVs were not significantly different between the two groups of patients. This is an inherent limitation of any study involving MRI, as patients often obtain an MRI locally and then move to other centers for biopsy. To mitigate this effect, our institution offers an over-read option where our radiologists will re-interpret the outside MRI, and this option was used in some of the patients in this study.

It is also worth noting that while correlation with biopsy pathology results was performed on all cases with microUS only visible lesions and specific attention was paid to lesions scored as PRI-MUS 4 or PRI-MUS 5 by the urologists, a systematic re-review of the mpMRI was challenging due to the different localization methods between microUS and mpMRI. In addition, while one example was shown (Fig. 5) in which a microUS-only PRI-MUS 4 lesion did not have an MRI correlate, even on re-review of imaging by a dedicated radiologist with special expertise in prostate MRI, specialized re-review of all MRI images was not able to be performed in cases of microUS-only visible lesions. This replicates real-world clinical practice, both in microUS and MRI-US fusion biopsy. The impact of specialized reads and the need for quality improvement programs in this space have been studied previously, including by members of this group, and is an area of future research in this setting [15, 19].

Another potential limitation is that three urologists performed the microUS, potentially introducing inter-operator variability, though all three urologists had the same training and followed a strict template and biopsy process.

Finally, all patients included in this study who underwent microUS had a known positive MRI with a PI-RADS ≥ 3 lesion, potentially introducing bias, although the location of the MRI lesion was not reviewed immediately prior to the microUS.

Conclusion

This retrospective study demonstrates successful implementation of mpMRI-informed microUS-guided prostate biopsy, with similar rates of identification of csPCa compared to historical data using mpMRI-US fusion techniques. Our study shows the complementary role of mpMRI and microUS, supporting the combined approach of these techniques.

Future efforts include further validation of PRI-MUS with evaluation of inter-operator variability and quality improvement efforts to evaluate the concordance of mpMRI and microUS with cancer detection rate.

Abbreviations

3-T	3-Tesla
ADC	Apparent diffusion coefficient
csPCa	Clinically significant prostate cancer
DWI	Diffusion-weighted images
ISUP GG	International Society of Urological Pathology Grade Group
MicroUS	Microultrasound
mpMRI	Multiparametric magnetic resonance imaging
PCa	Prostate cancer
PPV	Positive predictive value
PRI-MUS	Prostate risk identification using micro-ultrasound
PSA	Prostate-specific antigen
T2WI	T2-weighted images
TRUS	Transrectal ultrasound

Funding

The authors state that this work has not received any funding.

Compliance with ethical standards

Guarantor

The scientific guarantor of this publication is Rajan T. Gupta.

Conflict of interest

The authors of this manuscript declare no relevant relationships with any companies, whose products or services may be related to the subject matter of the article. Unrelated to this work, Dr. Gupta reports consulting fees from Bard, Bayer Pharma AG, Bracco Diagnostics, Philips, and Quibim.

Statistics and biometry

No complex statistical methods were necessary for this paper.

Informed consent

Written informed consent was waived by the Institutional Review Board.

Ethical approval

Institutional Review Board approval was obtained.

Study subjects or cohorts overlap

No study subjects or cohorts have been previously reported.

Methodology

- Retrospective
- Observational
- Performed at one institution

Author details

[1]Department of Radiology, Duke University Medical Center, Durham, NC, USA. [2]Department of Urology, Duke University, Raleigh, NC, USA. [3]Duke Cancer Institute Center for Prostate and Urologic Cancers, Durham, NC, USA.

Received: 4 July 2025 Revised: 29 September 2025 Accepted: 26 October 2025
Published online: 22 November 2025

References

1. Siegel RL, Miller KD, Wagle NS, Jemal A (2023) Cancer statistics, 2023. CA Cancer J Clin 73:17–48. https://doi.org/10.3322/caac.21763
2. Albertsen PC, Hanley JA, Fine J (2005) 20-Year outcomes following conservative management of clinically localized prostate cancer. JAMA 293:2095–2101. https://doi.org/10.1001/jama.293.17.2095

3. Bill-Axelson A, Holmberg L, Garmo H et al (2018) Radical prostatectomy or watchful waiting in prostate cancer—29-year follow-up. N Engl J Med 379:2319–2329. https://doi.org/10.1056/NEJMoa1807801
4. Yilmaz EC, Shih JH, Belue MJ et al (2023) Prospective evaluation of PI-RADS version 2.1 for prostate cancer detection and investigation of multiparametric MRI-derived markers. Radiology 307:e221309. https://doi.org/10.1148/radiol.221309
5. Siddiqui MM, Rais-Bahrami S, Turkbey B et al (2015) Comparison of MR/ultrasound fusion-guided biopsy with ultrasound-guided biopsy for the diagnosis of prostate cancer. JAMA 313:390–397. https://doi.org/10.1001/jama.2014.17942
6. Kasivisvanathan V, Rannikko AS, Borghi M et al (2018) MRI-targeted or standard biopsy for prostate-cancer diagnosis. N Engl J Med 378:1767–1777. https://doi.org/10.1056/NEJMoa1801993
7. Loch T, Eppelmann U, Lehmann J, Wullich B, Loch A, Stockle M (2004) Transrectal ultrasound guided biopsy of the prostate: random sextant versus biopsies of sono-morphologically suspicious lesions. World J Urol 22:357–360. https://doi.org/10.1007/s00345-004-0462-4
8. Laurence Klotz CM (2020) Can high resolution micro-ultrasound replace MRI in the diagnosis of prostate cancer? Eur Urol Focus 6:419–423. https://doi.org/10.1016/j.euf.2019.11.006
9. Ghai S, Eure G, Fradet V et al (2016) Assessing cancer risk on novel 29 MHz micro-ultrasound images of the prostate: creation of the micro-ultrasound protocol for prostate risk identification. J Urol 196:562–569. https://doi.org/10.1016/j.juro.2015.12.093
10. Klotz L, Lughezzani G, Maffei D et al (2021) Comparison of micro-ultrasound and multiparametric magnetic resonance imaging for prostate cancer: a multicenter, prospective analysis. Can Urol Assoc J 15:E11–E16. https://doi.org/10.5489/cuaj.6712
11. Wiemer L, Hollenbach M, Heckmann R et al (2021) Evolution of targeted prostate biopsy by adding micro-ultrasound to the magnetic resonance imaging pathway. Eur Urol Focus 7:1292–1299. https://doi.org/10.1016/j.euf.2020.06.022
12. Lughezzani G, Maffei D, Saita A et al (2021) Diagnostic accuracy of microultrasound in patients with a suspicion of prostate cancer at magnetic resonance imaging: a single-institutional prospective study. Eur Urol Focus 7:1019–1026. https://doi.org/10.1016/j.euf.2020.09.013
13. Cornud F, Lefevre A, Flam T et al (2020) MRI-directed high-frequency (29MhZ) TRUS-guided biopsies: initial results of a single-center study. Eur Radiol 30:4838–4846. https://doi.org/10.1007/s00330-020-06882-x
14. Ghai S, Perlis N, Atallah C et al (2022) Comparison of micro-US and multiparametric MRI for prostate cancer detection in biopsy-naive men. Radiology 305:390–398. https://doi.org/10.1148/radiol.212163
15. Arcot R, Sekar S, Kotamarti S et al (2022) Structured approach to resolving discordance between PI-RADS v2.1 score and targeted prostate biopsy results: an opportunity for quality improvement. Abdom Radiol (NY) 47:2917–2927. https://doi.org/10.1007/s00261-022-03562-w
16. Westphalen AC, McCulloch CE, Anaokar JM et al (2020) Variability of the positive predictive value of PI-RADS for prostate MRI across 26 centers: experience of the Society of Abdominal Radiology Prostate Cancer Disease-focused Panel. Radiology 296:76–84. https://doi.org/10.1148/radiol.2020190646
17. Avolio PP, Lughezzani G, Paciotti M et al (2021) The use of 29 MHz transrectal micro-ultrasound to stratify the prostate cancer risk in patients with PI-RADS III lesions at multiparametric MRI: a single institutional analysis. Urol Oncol 39:832 e831–832.e837. https://doi.org/10.1016/j.urolonc.2021.05.030
18. Pavlovich C, Hyndman M, Eure G et al (2020) A multi-institutional randomized controlled trial comparing first-generation transrectal high-resolution micro-ultrasound with conventional frequency transrectal ultrasound for prostate biopsy. BJUI Compass 2:126–133. https://doi.org/10.1111/bco2.59
19. Tay KJ, Gupta RT, Brown AF, Silverman RK, Polascik TJ (2016) Defining the incremental utility of prostate multiparametric magnetic resonance imaging at standard and specialized read in predicting extracapsular extension of prostate cancer. Eur Urol 70:211–213. https://doi.org/10.1016/j.eururo.2015.10.041

Publisher's Note