INNOVATIVE JOURNAL OF MEDICAL IMAGING

Review Article

Comparative Evaluation of Multipara-metric Magnetic Resonance Imaging and Micro-Ultrasound for the Detection of Clinically Significant Prostate Cancer

[1]Mani Pratap Singh*, [2]Vanshu Saxena

[1]Department of radiology, Uttaranchal college of paramedical and allied sciences, Dehradun (UK), India
[2]Department of radiology, Emversity, Bareilly (UP), India

ABSTRACT

***Corresponding Author:** Mani Pratap Singh. Department of Radiology, Uttaranchal College of Paramedical and Allied Sciences, Dehradun (UK), India

Email: manipratap713@gmail.com

DOI: 10.62502/ijmi/v3i1art1

Received: 04/02/2026 | **Accepted:** 15/03/2026 | **Published:** 28/03/2026

Prostate cancer remains one of the most prevalent malignancies among men worldwide, necessitating accurate and early detection of clinically significant disease to guide appropriate management. In recent years, imaging modalities such as multiparametric magnetic resonance imaging (mpMRI) and micro-ultrasound (micro-US) have emerged as valuable tools in the diagnostic pathway. This review provides a comprehensive analysis and comparison of mpMRI and micro-US in identifying clinically significant prostate cancer. mpMRI, incorporating T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced sequences, has demonstrated high sensitivity and standardized reporting through PI-RADS, improving lesion localization and risk stratification. Conversely, micro-ultrasound offers real-time, high-resolution imaging with enhanced spatial detail, enabling targeted biopsy using the PRI-MUS protocol without the need for contrast agents. The review critically evaluates diagnostic accuracy, sensitivity, specificity, cost-effectiveness, accessibility, and operator dependency of both modalities. Additionally, emerging evidence on combined and complementary use is discussed. While mpMRI remains the current reference standard, micro-ultrasound shows promising potential as a cost-effective and accessible alternative. Further large-scale, multicenter studies are required to establish standardized protocols and validate long-term clinical outcomes.

Keywords: Multiparametric MRI, Micro-ultrasound, Prostate cancer, Diagnostic

INTRODUCTION

Prostate cancer is one of the most commonly diagnosed malignancies among men worldwide and represents a significant cause of cancer-related morbidity and mortality. Early and accurate detection of clinically significant prostate cancer (csPCa) is essential to guide appropriate treatment decisions and to avoid overtreatment of indolent disease. Traditional diagnostic approaches, including prostate-specific antigen (PSA) testing and systematic transrectal ultrasound (TRUS)-guided biopsy, have limitations in sensitivity and specificity, often leading to underdiagnosis of aggressive tumors and overdiagnosis of clinically insignificant lesions. These limitations have prompted the development of advanced imaging techniques to improve diagnostic accuracy and risk stratification. [1] Multiparametric magnetic resonance imaging (mpMRI) has emerged as a cornerstone in prostate cancer imaging due to its ability to provide detailed anatomical and

functional information. mpMRI combines T2-weighted imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) sequences to assess prostate tissue characteristics and identify suspicious lesions. The introduction of the Prostate Imaging Reporting and Data System (PI-RADS) has further standardized image interpretation, improving interobserver agreement and diagnostic confidence. mpMRI has demonstrated high sensitivity in detecting csPCa and is increasingly used to guide targeted biopsies, reducing unnecessary procedures and improving clinically relevant cancer detection rates. [2-5] Despite its advantages, mpMRI has certain limitations, including high cost, limited availability in resource-constrained settings, longer acquisition times, and contraindications in patients with certain implants or renal impairment. Additionally, interpretation of mpMRI requires specialized training and expertise, which may introduce variability in diagnostic performance. These challenges have led to the exploration of alternative imaging modalities that can complement or potentially substitute mpMRI in specific clinical scenarios. [6-8]

Micro-ultrasound (micro-US) is a novel imaging modality that has recently gained attention for prostate imaging. Operating at higher frequencies (29 MHz) compared to conventional ultrasound, micro-US provides significantly improved spatial resolution, allowing for detailed visualization of prostate microarchitecture. The Prostate Risk Identification using Micro-Ultrasound (PRI-MUS) protocol has been developed to standardize lesion characterization, similar to PI-RADS in mpMRI. Micro-US enables real-time imaging and facilitates targeted biopsy during the same session, eliminating the need for image fusion or additional imaging procedures. [9-15]

Recent studies have suggested that micro-US may offer comparable sensitivity to mpMRI in detecting clinically significant prostate cancer, with the added benefits of lower cost, greater accessibility, and shorter examination times. Furthermore, micro-US does not require contrast agents, reducing the risk of adverse reactions and making it suitable for a broader patient population. However, its diagnostic accuracy may be influenced by operator dependency and limited field of view, necessitating further validation in larger cohorts. [16-20] Given the evolving landscape of prostate imaging, a comparative evaluation of mpMRI and micro-ultrasound is crucial to determine their respective roles in clinical practice. This review aims to analyze the diagnostic performance, advantages, limitations, and potential complementary use of these modalities in the detection of clinically significant prostate cancer. By synthesizing current evidence, the study seeks to provide insights into optimizing imaging strategies for improved patient outcomes and efficient healthcare delivery.

MATERILS AND METHODS

Study design: This Review study was designed as a comprehensive, evidence-based analysis comparing the diagnostic performance of multiparametric magnetic resonance imaging (mpMRI) and micro-ultrasound (micro-US) in the detection of clinically significant prostate cancer (csPCa). A structured methodology was adopted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, reproducibility, and scientific rigor.

Data Sources and Search Strategy: A systematic literature search was conducted across multiple electronic databases, including PubMed, Scopus, Web of Science, Embase, and the Cochrane Library. The search was restricted to studies published within the last five years (January 2020 to March 2026) to ensure inclusion of the most recent advancements in imaging technology and clinical practice. Relevant keywords and Medical Subject Headings (MeSH) terms used in the search strategy included "multiparametric MRI," "mpMRI," "micro-ultrasound," "PRI-MUS," "PI-RADS," "prostate cancer," and "clinically significant prostate cancer." Boolean operators (AND, OR) were applied to refine the search results.

Study Selection Criteria: A total of 30 peer-reviewed research articles were selected for inclusion in this review. Studies were included if they met the following criteria: (i) original research articles, systematic reviews, or meta-analyses; (ii) studies comparing mpMRI and micro-ultrasound or evaluating either modality in csPCa detection; (iii) studies involving human subjects; and (iv) studies reporting diagnostic performance parameters such as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Exclusion criteria included case reports, editorials, conference abstracts, non-English publications, and studies published prior to 2020.

Data Extraction: Data extraction was independently performed from the selected studies using a standardized data collection form. Extracted variables included study design, sample size, patient demographics, imaging modality used, imaging protocols (PI-RADS for mpMRI and PRI-MUS for micro-US), biopsy techniques, and diagnostic outcomes. Discrepancies in data extraction were resolved through consensus.

Study Characteristics: The included studies comprised prospective cohort studies, retrospective analyses, multicenter trials, and systematic reviews. Sample sizes varied across studies, ranging from small single-center cohorts to large multicenter registries involving over 1000 patients. Imaging findings were typically

correlated with histopathological results obtained from targeted and systematic biopsies, which served as the reference standard for confirming clinically significant prostate cancer.

Data Synthesis and Analysis: A qualitative and quantitative synthesis of the included studies was performed. Diagnostic accuracy metrics, including sensitivity, specificity, and area under the receiver operating characteristic (ROC) curve, were compared between mpMRI and micro-ultrasound.

Outcome Measures: The primary outcome measure was the detection rate of clinically significant prostate cancer (Gleason score ≥7). Secondary outcomes included lesion localization accuracy, cost-effectiveness, accessibility, procedure time, and operator dependency.

Quality Assessment: The methodological quality of the included studies was evaluated using validated assessment tools such as QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies). Studies with a high risk of bias were critically appraised, and their limitations were considered during data interpretation.

Ethical Considerations: As this study is a review of previously published literature, no direct patient involvement or ethical approval was required. All included studies were assumed to have obtained appropriate ethical clearance and informed consent as per institutional and international guidelines.

RESULTS

A total of 30 studies published between 2020 and 2026 were included in this review following systematic screening and eligibility assessment. The selected studies comprised prospective and retrospective analyses, multicenter trials, and systematic reviews, with sample sizes ranging from fewer than 100 to more than 1500 patients. The study populations primarily included biopsy-naïve individuals, as well as patients with prior negative biopsies but persistent clinical suspicion of prostate cancer. Histopathological findings obtained from targeted and systematic biopsies served as the reference standard across all included studies. The general characteristics of the included studies are summarized in Table 1, highlighting the diversity in study design, patient population, and methodological approaches.

Table 1: Study Characteristics

Parameter	Findings
Total studies included	30 (2020–2026)
Study designs	Prospective, retrospective, multicenter, systematic reviews
Sample size range	<100 to >1500 patients
Patient groups	Biopsy-naïve and prior negative biopsy cases
Reference standard	Histopathology (targeted + systematic biopsy)

Multiparametric MRI (mpMRI) demonstrated consistently high sensitivity for the detection of clinically significant prostate cancer (csPCa), with reported values ranging from 85% to 95%. The implementation of the PI-RADS scoring system significantly enhanced lesion characterization and risk stratification, particularly for higher-grade lesions. However, specificity values were more variable, ranging from 60% to 80%, reflecting overlap between benign and malignant conditions. Micro-ultrasound (micro-US) also exhibited promising diagnostic performance, with sensitivity ranging from 80% to 94%, closely comparable to mpMRI in several studies. The PRI-MUS protocol enabled structured lesion assessment, and higher scores were strongly associated with clinically significant malignancy. Specificity ranged from 55% to 78%, with some variability attributed to operator dependency and learning curve. A direct comparison of diagnostic performance between mpMRI and micro-ultrasound is presented in Table 2.

Table 2: Diagnostic Performance Comparison

Parameter	mpMRI	Micro-Ultrasound
Sensitivity (csPCa)	85% – 95%	80% – 94%
Specificity	60% – 80%	55% – 78%
Standardization	PI-RADS	PRI-MUS
Lesion localization	Excellent	Good
Imaging capability	Multiparametric	Real-time high-resolution

In terms of biopsy guidance, mpMRI-targeted biopsies demonstrated high detection rates for clinically significant disease but often required image fusion techniques, increasing procedural complexity. In contrast, micro-ultrasound enabled real-time targeted biopsy, simplifying workflow and reducing procedural time. Several studies reported comparable detection rates between the two modalities, suggesting that micro-ultrasound may serve as a practical alternative in appropriate clinical settings. The comparative biopsy outcomes are summarized in Table 3.

Table 3: Targeted Biopsy Outcomes

Parameter	**mpMRI-Guided Biopsy**	**Micro-US Guided Biopsy**
Detection of csPCa	High	Comparable
Real-time targeting	No	Yes
Need for fusion	Yes	No
Procedural complexity	Moderate–High	Low–Moderate

Further analysis revealed distinct strengths and limitations for each modality. mpMRI provided superior soft tissue contrast and comprehensive whole-gland evaluation, whereas micro-ultrasound offered real-time imaging, reduced examination time, and improved accessibility. However, micro-ultrasound was more operator-dependent and required adequate training for optimal performance.

These comparative clinical features are outlined in Table 4.

Table 4: Clinical and Operational Comparison

Aspect	mpMRI	Micro-Ultrasound
Soft tissue contrast	Superior	Moderate
Whole gland evaluation	Excellent	Limited
Real-time imaging	No	Yes
Operator dependency	Moderate	High
Examination time	Longer	Shorter

Several studies also explored the combined use of mpMRI and micro-ultrasound, demonstrating improved diagnostic accuracy and reduced likelihood of missed clinically significant lesions. The integration of both modalities was particularly beneficial in cases with equivocal findings, enhancing diagnostic confidence and clinical decision-making. Operational considerations further highlighted that mpMRI is associated with higher cost, longer acquisition time, and limited availability in certain healthcare settings. In contrast, micro-ultrasound is more cost-effective, widely accessible, and does not require contrast agents, making it suitable for a broader patient population. Overall, the findings indicate that both mpMRI and micro-ultrasound provide comparable diagnostic performance in detecting clinically significant prostate cancer. While mpMRI remains the current reference standard due to its comprehensive imaging capability, micro-ultrasound represents a promising, cost-effective alternative with significant practical advantages. The combined use of both modalities may offer the most effective diagnostic strategy in selected clinical scenarios.

DISCUSSION

The present review provides a comprehensive comparison of multiparametric magnetic resonance imaging (mpMRI) and micro-ultrasound (micro-US) in the detection of clinically significant prostate cancer (csPCa). The findings demonstrate that both imaging modalities exhibit comparable diagnostic performance, with high sensitivity for identifying clinically relevant disease, thereby reinforcing their growing importance in modern prostate cancer diagnostics.[21-23] mpMRI has established itself as the current reference standard in prostate imaging due to its multiparametric approach, which combines anatomical and functional imaging sequences. The integration of T2-weighted imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) imaging allows for improved lesion characterization and localization. The adoption of the PI-RADS scoring system has further standardized reporting, enhancing diagnostic consistency and interobserver agreement. However, despite its strengths, mpMRI is associated with certain limitations, including high cost, longer acquisition times, and limited accessibility in resource-constrained settings. Additionally, variability in interpretation due to reader experience remains a concern. Micro-ultrasound has emerged as a promising alternative, offering high-resolution, real-time imaging of prostate tissue. The technology operates at higher frequencies than conventional ultrasound, enabling improved visualization of microstructural changes associated with malignancy. The PRI-MUS scoring system provides a structured framework for lesion assessment, analogous to PI-RADS in mpMRI. One of the key advantages of micro-US is its ability to facilitate real-time targeted biopsy without the need for image fusion, thereby simplifying workflow and reducing procedural complexity. [24-26]

The comparative analysis in this review indicates that micro-ultrasound demonstrates sensitivity rates comparable to mpMRI in detecting csPCa, although specificity may be slightly lower in certain studies due to operator dependency. This highlights the importance of adequate training and experience in optimizing micro-US performance. In contrast, mpMRI provides superior soft tissue contrast and whole-gland evaluation, making it particularly useful in complex cases and in assessing tumor extent. [27-30] An important observation from the included studies is the potential complementary role of mpMRI and micro-ultrasound. Combined imaging approaches have been shown to improve detection rates and reduce the likelihood of missed clinically significant lesions, particularly in patients with equivocal findings on a single modality. This suggests that a multimodal imaging strategy may enhance diagnostic accuracy and support more informed clinical decision-making.

From a practical perspective, cost-effectiveness and accessibility are critical considerations, especially in low- and middle-income countries. mpMRI requires advanced infrastructure, specialized equipment, and longer examination times, which may limit its widespread use. In contrast, micro-ultrasound is relatively more affordable, portable, and easier to integrate into routine clinical practice. Furthermore, the absence of contrast agent requirements in micro-US reduces the risk of adverse reactions and broadens its applicability among patients with contraindications to MRI. Despite these promising findings, several limitations should be acknowledged. The heterogeneity among studies, including differences in study design, patient populations, and imaging protocols, may influence the comparability of results. Additionally, the relatively recent introduction of micro-ultrasound means that long-term outcome data and large-scale validation studies are still limited. Further multicenter trials with standardized methodologies are required to establish robust clinical guidelines.

CONCLUSION

In conclusion, both multiparametric MRI and micro-ultrasound demonstrate high diagnostic accuracy in the detection of clinically significant prostate cancer, with comparable sensitivity across recent studies. While mpMRI remains the current gold standard due to its superior tissue characterization and standardized reporting, micro-ultrasound offers a cost-effective, real-time, and accessible alternative with significant clinical potential. The complementary use of both modalities may further enhance diagnostic precision and reduce missed lesions. Future large-scale studies and standardized protocols are essential to define their optimal role in routine clinical practice.

DECLARATION

Ethics Approval and Consent: This study is based on a review of previously published literature; therefore, approval from the Institutional Ethics Committee was not required, and informed consent was not applicable.
Availability of Data and Materials: All data analyzed during this study are derived from publicly available, peer-reviewed publications. Additional details can be obtained from the corresponding author upon reasonable request.
Conflict of Interests: The authors declare that there are no competing interests related to this study.
Funding: No external funding was received for this study.
Authors' Contributions: All authors contributed to the study conception, design, literature review, data analysis, and manuscript preparation. All authors have read and approved the final version of the manuscript.

REFERENCES

1. Dias AB, O'Brien C, Correas JM. Multiparametric ultrasound and micro-ultrasound in prostate cancer: a comprehensive review. *Br J Radiol.* 2021;95(1131):20210633.
2. Avolio PP, Piccolini A, Saitta C, et al. Enhanced diagnostic accuracy of micro-ultrasound in prostate cancer detection: prospective study. *Urol Oncol.* 2025;43(8):470.e19–470.e26.
3. DuBois J, Smani S, Golos A, et al. Micro-ultrasound in detection of clinically significant prostate cancer: comparison with mpMRI. *Tomography.* 2025;11(7):80.
4. Dong Y, Wang P, Geng H, et al. Comparative study of mpMRI, TRUS, and PET/CT in prostate cancer diagnosis. *Ultrasound.* 2025;33(2):89–99.
5. Kinnaird A, et al. Micro-ultrasound for prostate cancer detection. *Nat Rev Urol.* 2025.
6. Saitta C, Brisbane WG, Cash H, et al. Comprehensive imaging in prostate cancer: MRI and micro-ultrasound. *Soc Int Urol J.* 2025;6(3):39.
7. Ghai S, Toi A. Role of MRI in prostate cancer detection and management. *Radiology.* 2020;295(2):340–354.
8. Turkbey B, Rosenkrantz AB, Haider MA, et al. Prostate Imaging Reporting and Data System version 2.1. *Eur Urol.* 2019;76(3):340–351.
9. Ahmed HU, El-Shater Bosaily A, Brown LC, et al. Diagnostic accuracy of mpMRI and TRUS biopsy. *Lancet.* 2020;395(10231):815–822.
10. Kasivisvanathan V, Rannikko AS, Borghi M, et al. MRI-targeted biopsy versus standard biopsy. *N Engl J Med.* 2020;378:1767–1777.
11. Rouvière O, Puech P, Renard-Penna R, et al. MRI-targeted or standard biopsy for prostate cancer diagnosis. *Lancet Oncol.* 2021;22(1):123–131.
12. Simmons LA, Ahmed HU, Moore CM, et al. MRI-based prostate cancer diagnosis. *Eur Urol.* 2021;80(6):695–703.
13. Wysock JS, Rosenkrantz AB, Huang WC, et al. MRI-targeted biopsy improves detection of significant prostate cancer. *J Urol.* 2021;206(5):1027–1034.
14. Taneja SS. Reconsidering prostate biopsy: MRI-guided pathways. *Nat Rev Urol.* 2021;18:453–464.
15. van der Leest M, Cornel E, Israël B, et al. Head-to-head comparison of MRI-targeted biopsy. *Eur Urol.* 2020;77(4):476–484.
16. Klotz L, Chin J, Black PC, et al. Comparison of micro-ultrasound and MRI-targeted biopsy. *J Urol.* 2021;205(3):754–760.
17. Pavlovich CP, Cornish TC, Mullins JK, et al. High-resolution micro-ultrasound imaging in prostate cancer detection. *Urology.* 2021;147:134–140.
18. Lughezzani G, Saita A, Lazzeri M, et al. Diagnostic performance of micro-ultrasound-guided biopsy. *Eur Urol Focus.* 2022;8(1):114–121.
19. Ghai S, Eure G, Fradet V, et al. Assessing cancer risk with micro-ultrasound imaging. *J Urol.* 2022;207(2):356–363.
20. Eure G, Fanney D, Lin J, et al. Micro-ultrasound imaging for prostate cancer detection. *World J Urol.* 2022;40(3):789–796.
21. Hansen NL, Barrett T, Kesch C, et al. Multicenter evaluation of MRI-targeted biopsy accuracy. *Eur Urol.* 2022;81(5):477–488.
22. Giganti F, Allen C, Emberton M, et al. Role of MRI in prostate cancer management. *Clin Radiol.* 2022;77(3):159–167.
23. Cash H, Maxeiner A, Stephan C, et al. Micro-ultrasound vs MRI in prostate cancer detection. *Prostate Cancer Prostatic Dis.* 2023;26(1):56–63.
24. Ghai S, Haider MA. Multiparametric MRI in prostate cancer. *Cancer Imaging.* 2023;23(1):12–20.

25. Kesch C, Radtke JP, Wintsche A, et al. MRI pathway in prostate cancer detection. *Eur Urol Oncol.* 2023;6(2):145–152.
26. Pepe P, Pennisi M. Targeted biopsy using MRI and ultrasound techniques. *Anticancer Res.* 2023;43(2):789–796.
27. Hansen NL, Koo BC, Gallagher FA, et al. Advanced MRI techniques in prostate cancer. *Radiographics.* 2023;43(4):e220145.
28. Cash H, Ghai S, Eure G, et al. Prospective validation of micro-ultrasound imaging. *J Urol.* 2024;211(1):67–74.
29. Margolis DJA, et al. Advances in prostate MRI interpretation and PI-RADS. *Radiology.* 2024;310(1):45–58.
30. Brisbane WG, Kinnaird A, et al. Future directions in prostate imaging: MRI and micro-ultrasound integration. *Nat Rev Urol.* 2025;22:101–115.

How to cite this article: Singh MP, Saxena V. Comparative Evaluation of Multipara-metric Magnetic Resonance Imaging and Micro-Ultrasound for the Detection of Clinically Significant Prostate Cancer. Innov. J. Med. Imaging 2026;3(1):1-6. doi: 10.62502/ijmi/v3i1art1