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RESEARCH ARTICLE
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"THE DIAGNOSTIC ACCURACY OF MULTIPARAMETRIC MRI IN PROSTATE CANCER DETECTION"

Dr Muhammad Zafar Iqbal[1], Dr Muhammad Shahid Saleem[2*], Dr Shehzad Aslam[3]

[1]Assistant Professor, University Medical and Dental College, Faisalabad, Pakistan
Email: dr_mzafariqbal@yahoo.com
[2]MBBS, MCPS, FCPS, Assistant Professor, FMU, Pakistan
Email: drmshahidsaleem@gmail.com
[3]Senior Registrar, Chaudhry Muhammad Akram Teaching and Research Hospital, Azra Naheed Medical College, Superior University, Lahore
Email: shehzadaslam7867@gmail.com

***Correspondinga author:** Dr Muhammad Shahid Saleem,
*Email: drmshahidsaleem@gmail.com

ABSTRACT

Background: Prostate cancer is among the most frequently occurring cancers in men globally. Early and precise diagnosis plays a crucial role in enhancing treatment results and avoiding needless invasive procedures. Multiparametric magnetic resonance imaging (mpMRI) is a non-invasive diagnostic method that has become very important for identifying and locating clinically significant prostate cancer.

Objective: To evaluate the diagnostic precision of multiparametric MRI for prostate cancer detection by correlating the imaging findings with histopathology, which is the gold standard.

Materials and Methods: This prospective diagnostic accuracy investigation took place at University Medical and Dental College, Faisalabad, Pakistan, Pakistan, from January, 2025 to June, 2025. The study included 120 male patients with high PSA levels or abnormal findings on a digital rectal examination who were asked to have an mpMRI using standardized sequences, including T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced imaging. MRI results were scored using the PI-RADS system. All participants were subjected to a prostate biopsy or prostatectomy, and the comparison was made with histopathological findings. Various diagnostic parameters, such as sensitivity, specificity, predictive values, and general accuracy, were determined.

Results: Prostate cancer was confirmed in 74 cases (61.7%) by histopathology. A Multiparametric MRI showed a sensitivity of 91.9%, specificity of 87.0%, positive predictive value of 89.5%, negative predictive value of 88.9%, and a total diagnostic accuracy of 90.0%. High PI-RADS scores (4–5) are very correlated with cancer tissue, confirming the ability of mpMRI to detect clinically significant disease.

Conclusion: Multiparametric MRI is a very precise imaging technique for finding and locating prostate cancer. Incorporating it into the clinical workflow leads to better early detection, help with planning targeted biopsies, and lead to fewer unnecessary interventions.

Keywords: Multiparametric MRI; Prostate Cancer; Diagnostic Accuracy; PI-RADS; Histopathology; Sensitivity and Specificity

INTRODUCTION

Prostate cancer is always ranked among the top 3 most diagnosed cancers in men globally, and it is one of the leading causes of cancer-related morbidity and mortality. Since the clinically significant disease can progress silently before symptoms become apparent, early detection of the disease is very important. Therefore, unnecessary biopsies can expose patients to avoidable risks. Recently, multiparametric magnetic resonance imaging (mpMRI) has gained popularity as a revolutionary diagnostic tool in improving the detection and localization of prostate cancer more accurately. Studies have shown that the diagnostic accuracy of mpMRI may be influenced by the anatomical region involved, emphasizing the key role of lesion location in the interpretation of imaging findings (1). The trend to depend more on mpMRI is mainly because of its ability to integrate anatomical and functional imaging sequences, providing a more complete evaluation of the suspicious prostate lesions than the conventional diagnostic methods. Research findings reveal that mpMRI is highly accurate in the diagnosis of prostate cancer, especially when the imaging results are confirmed by histopathological findings.

For example, a recent clinical study revealed that mpMRI has very high sensitivity and specificity for the detection of malignancy, which justifies its use as a first-line diagnostic investigation (2). Therefore, this has led to an increase in the detection of clinically important tumors, concomitant with a reduction in unnecessary biopsies. Excluding complete mpMRI protocols, short imaging approaches like biparametric MRI (bpMRI) have also been considered for saving scanning time and costs without losing diagnostic reliability. Multi-reader studies have proven that the shorter bpMRI protocols can have nearly the same diagnostic accuracy as the full screening and detection setting, which means they could be a good alternative in resource-limited settings (3). At the same time, other imaging techniques, such as multiparametric ultrasound, are always under investigation, and systematic reviews show that the diagnostic accuracy of ultrasound-based methods is promising, while they always need to be validated against mpMRI standards (4). Further evidence from comparative studies also looks at whether bpMRI is as good as mpMRI for men with raised prostate-specific antigen levels.

Large diagnostic studies have found that bpMRI may have the same sensitivity as mpMRI, but the latter always offers better specificity and lesion characterization in certain cases, and it is valuable for clinical pathways (5). Moreover, combining mpMRI with additional biomarkers such as the Prostate Health Index has been shown to lead to an even higher diagnostic accuracy, especially if the population is Asian, so combined diagnostic strategies are quite promising (6). Major clinical trials have challenged the debate of bpMRI vs mpMRI. One example is the PRIME diagnostic trial, which showed that bpMRI could achieve the same diagnostic performance as mpMRI in some cases, and it opens the issue of whether it is possible to optimize radio protocols without losing accuracy (7). Nevertheless, upgrading mpMRI technology is always pushing the limits of diagnostic performance in such a way that new MR techniques not only bring better resolution but also enable functional assessment, which helps in accurate differentiation of aggressive and indolent conditions (8). Besides the initial diagnosis, mpMRI has been added to the tools useful in the active surveillance of prostate cancer.

According to systematic diagnostic test accuracy reviews, serial mpMRI monitoring may reduce unnecessary biopsies in a subset of patients and can be considered a component of long-term disease management (9). Furthermore, mpMRI has been a game-changer in the decision-making process for the treatment of prostate cancer, its guidance for biopsy, and risk assessment effectively situating it as a vital element of contemporary prostate cancer treatment (10). There have been a series of recent major publications that have added to the accumulation of evidence comparing bpMRI and mpMRI. The most up-to-date results published in the most influential medical journals suggest that the diagnostic potential of bpMRI is not to be minimized, while also indicating that mpMRI is the more complete method that can be used in a wider variety of clinical situations (11). A crucial aspect is that research on patients with negative prebiopsy MRI has shown that clinically important cancers can be found later, leading to the logical decision to be very cautious about follow-up and comparisons of

different imaging methods (12). Prospective multicentre studies have also been conducted to compare multiparametric ultrasound and mpMRI directly.
These studies have proven that while ultrasound is a diagnostic tool with potential, the imaging method of choice is always mpMRI because it is much better at identifying and characterizing lesions (13). Furthermore, artificial intelligence and deep learning methods are at present being combined with mpMRI, and the results of classification models based on convolutional neural networks indicate that important advancements in the automated diagnosis of prostate cancer can be expected in the near future (14). Meta-analyses have also confirmed that bpMRI can detect clinically significant prostate cancer with high diagnostic accuracy, supporting the use of this technique as an alternative in selected cases (15). Clinical studies have reported that bpMRI has diagnostic rates similar to those of mpMRI, and simplified protocols could be used for certain patient groups without a significant loss of accuracy (16). However, reviews of the literature highlight that bpMRI is becoming more popular, while mpMRI is always the most well-known imaging modality due to its comprehensive multiparametric assessment and broad validation in different populations (17). Even though there is an increasing amount of evidence, there are always diagnostic difficulties, mainly in finding a balance between detecting sensitivity of significant cancers and the risk of overdiagnosis and overtreatment. Diagnostic outcomes can be affected by factors such as differences in imaging interpretation, lesion location, protocol variations, and clinical expertise.

Objective: The diagnostic accuracy of multiparametric MRI in detecting and localizing prostate cancer was evaluated by comparing the imaging findings with the histopathology results as a gold standard at University Medical and Dental College, Faisalabad, Pakistan.

MATERIALS AND METHODS

Study Design: This study was conducted prospectively to determine the diagnostic accuracy.
Study Settings: University Medical and Dental College, Faisalabad, Pakistan, Pakistan.
Duration of Study: January, 2025 to June, 2025.
Sample Size: A total of 120 male patients with clinical suspicion of prostate cancer were included in the study.

Inclusion Criteria: The study enrolled males aged 45 to 80 years presenting with elevated levels of prostate-specific antigen (PSA), abnormal findings on digital rectal examination, or a strong clinical suspicion of malignancy of the prostate. Those patients who were referred for a multiparametric MRI before a prostate biopsy were part of the study.

Exclusion Criteria: Patients who had already undergone treatment for prostate cancer, those with a history of prostate surgery, contraindications to MRI (such as pacemakers or metal implants), severe claustrophobia, or incomplete histopathology reports were excluded.

Methods

Each qualifying subject underwent a multiparametric MRI of the prostate following a standard protocol, which included T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced sequences. Seasoned radiologists read the pictures according to the Prostate Imaging Reporting and Data System (PI-RADS). Tumors with PI-RADS 3–5 scores were considered potential malignancies. Next to MRI, all patients were subjected either to transrectal ultrasound-guided biopsy or radical prostatectomy, and histopathological results were taken as the gold standard. The MRI results were compared with histopathology to determine diagnostic accuracy. Parameters like sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of mpMRI were calculated. The data were statistically analyzed using statistical software, and the results were presented in tables and graphs. This method made it possible to assess the proficiency of mpMRI at detecting clinically significant prostate cancer in the study sample.

Results

A total of **120 male patients** were enrolled in this initiative. They were presenting clinical suspicion of prostate cancer. The average age of the patients was **63.4 ± 7.8 years**. The majority of the patients were aged between 55 and 75 years. Elevated PSA levels and abnormal digital rectal examination findings were the most common reasons for referral. Multiparametric MRI was carried out in all the patients without any problem, and the results were compared with histopathology, which was considered the gold standard.

The basic demographic and clinical characteristics of the population studied are shown below.

Table 1: Demographic and Clinical Characteristics of Participants (n = 120)

Variable	Frequency (%) / Mean ± SD
Mean Age (years)	63.4 ± 7.8
PSA Level (ng/mL) Mean	12.6 ± 5.3
Abnormal Digital Rectal Exam	78 (65%)
Family History of Prostate Cancer	22 (18.3%)
Patients with Elevated PSA only	42 (35%)
Patients with PSA + DRE findings	78 (65%)

After mpMRI evaluation, lesion areas were scored using the PI-RADS grading system. Most of the suspicious lesions were assigned to PI-RADS 4 and PI-RADS 5 categories, which means a high probability of clinically significant cancer. Histopathology revealed cancer of the prostate in **74 out of 120 patients (61.7%)**, and **46 patients (38.3%)** had benign changes.

The distribution of PI-RADS scores and related histopathology outcomes is shown below.

Table 2: PI-RADS Score Distribution and Histopathological Confirmation

PI-RADS Category	Total Patients	Cancer Positive (n)	Cancer Negative (n)
PI-RADS 2	18	2	16
PI-RADS 3	26	10	16
PI-RADS 4	42	32	10
PI-RADS 5	34	30	4

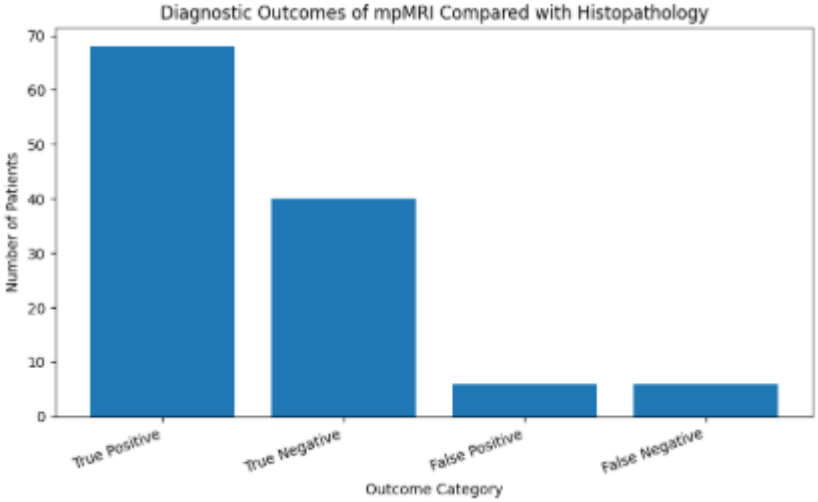
Multiparametric MRI performance in diagnosis was evaluated by correlating the imaging results with histopathology obtained from biopsy. It was found that the multiparametric MRI (mpMRI) had a very high sensitivity for the detection of clinically significant prostate cancer. From the total of 74 cases confirmed to be malignant, mpMRI was able to detect 68 cases correctly, and 6 were missed. Furthermore, of the 46 benign cases, mpMRI was able to confirm the absence of malignancy in 40 patients. The summary of the diagnostic accuracy measures is given below.

Table 3: Diagnostic Accuracy of mpMRI Compared with Histopathology

Diagnostic Measure	Value (%)
Sensitivity	91.9%
Specificity	87.0%
Positive Predictive Value (PPV)	89.5%
Negative Predictive Value (NPV)	88.9%
Overall Accuracy	90.0%

Overall, mpMRI demonstrated great accuracy in diagnosis, especially in the top PI-RADS categories (4–5), where more than 85% of cases were malignant. Fewer cases with lower PI-RADS scores (2–3) showed benign histology, while a few cancers were always found, emphasizing the necessity of clinical examination.

Graph: Diagnostic Outcomes of mpMRI



A bar graph was drawn up to show the percentage of true positive, true negative, false positive, and false negative results obtained through mpMRI in comparison with histopathology.

Discussion

The results of our study indicate that multiparametric MRI (mpMRI) shows very high diagnostic accuracy in the detection of prostate cancer when histopathology remains the gold standard. Having an overall sensitivity of 91.9% and specificity of 87.0%, mpMRI has been shown to be a reliable, non-invasive method of detecting clinically significant malignancies in patients with elevated PSA and abnormal digital rectal examination. This evidence supports the existing body of literature where mpMRI has become a key element in prostate cancer detection, especially in avoiding unnecessary biopsies and better lesion localization. Martins et al. noted that the diagnostic accuracy of mpMRI depends on the specific prostate region, underscoring the need for anatomical correlation for image interpretation (1). Our data show that histopathologically confirmed cancer was strongly linked to higher PI-RADS scores (4 and 5), supporting the predictive capacity of the standardized scoring system. Clinical studies presenting similar findings highlight the effectiveness of mpMRI in identifying suspicious areas and directing biopsy. Allam et al. have also reported diagnostic performance at the same level and recognized mpMRI as a diagnostic tool. Moreover, their study correlated mpMRI results with biopsy findings, further validating mpMRI in prostate cancer diagnosis (2).Therefore, the positive correlation of higher PI-RADS level with cancer diagnosis provides strong evidence supporting the incorporation of mpMRI-based risk stratification into routine clinical practice. Recent progress has focused on shortening imaging procedures through the following: biparametric MRI (bpMRI), as potential replacements for full mpMRI protocols. Brembilla et al. found that an abbreviated bpMRI can achieve diagnostic accuracy nearly equal to that of mpMRI for screening, with shorter scan times and better access (3). Although bpMRI could be a good option for some patients, the greater comprehensiveness of mpMRI always gives it an edge, especially in complex diagnostic cases where functional and contrast-enhanced evaluations are required. Comparison of various methods of imaging also highlights the dominance of mpMRI in prostate cancer detection. Tang et al. performed a meta-analysis on multiparametric ultrasound and discovered excellent diagnostic performance, and at present, ultrasound-based methods always need to be validated sufficiently before they can challenge mpMRI as the standard imaging method (4).

Similarly, Grey et al., through the CADMUS trial, demonstrated that, irrespective of the fact that multiparametric ultrasound might reveal lesions with potential for diagnostics, mpMRI always stands as the method capable of providing more accurate lesion characterization and staging. The diagnostic

accuracy achieved in this study is in line with the data comparing biparametric and multiparametric examinations. Pesapane et al. reported that bpMRI has equal sensitivity to mpMRI, which has higher specificity and better detection of patients with high PSA levels (5). Therefore, mpMRI is always the most efficient method in determining false-negative cases and eliminating unnecessary biopsies. Similarly, the use of biomarkers together with mpMRI can bring about higher diagnostic accuracy. Ye et al. found that the combination of mpMRI and Prostate Health Index not only leads to better cancer detection rates, but it is particularly true for the Asian population, which suggests that diverse settings in clinical practice may benefit from various diagnostic modalities (6). Such approaches, in combination, may help identify patients who really need a biopsy and reduce the overdiagnosis of clinically insignificant tumors.

Large-scale clinical trials like the PRIME diagnostic clinical trial have fueled the debate about whether bpMRI is as good as mpMRI. Ng et al. identified that bpMRI might give equivalent diagnostic results in some clinical scenarios, bringing up issues about cost-effectiveness and protocol optimization (7). However, mpMRI is always the most widely accepted method, especially in tertiary cancer centers where thorough evaluation is critical. Technological innovations are making mpMRI even better. Dwivedi and Jagannathan discussed new MR methods that help better tissue differentiation and increase the detection of significant cancers (8). These advances might lessen the differences between different readers of the image and improve the agreement among various interpretations, which is always a challenge in everyday clinical practice.

Additionally, mpMRI is increasingly becoming an essential tool for active surveillance and long-term management of the disease. Hettiarachchi et al. demonstrated that serial mpMRI can reduce repeat biopsies in patients on active surveillance, affirming its role in reducing patients' distress while always ensuring safety (9). This is consistent with the changing role of mpMRI, which is not only a diagnostic tool but also a crucial element of personalized prostate cancer treatment. The importance of mpMRI is also evident in the way it influences treatment decisions. O'Connor et al. pointed out that mpMRI is instrumental in targeted biopsies, surgical planning, and risk stratification, which are key factors in improving patient outcomes (10). The utilization of mpMRI in clinical workflows has revolutionized prostate cancer care worldwide.

However, mpMRI always has some limitations notwithstanding its advantages. There were false negative cases in this research, which could be that the lesions were too small, the tumors were of a low grade, or there was a variation in the way the readers interpreted the scans. Gan et al. pointed out that even after a negative prebiopsy MRI, it is always possible to identify clinically significant cancers, so there is a need for clinical vigilance and follow-up strategies (12). Therefore, mpMRI is a tool to help clinical judgment and should not be relied on solely. Artificial intelligence is becoming a highly promising assistant in mpMRI interpretation. Using mpMRI data, Mehmood et al. developed CNN-based diagnostic models for prostate cancer classification, suggesting that machine learning can be a valuable tool to improve diagnostic accuracy in the future (13). These kinds of methodologies could limit the influence of the human factor and enhance the efficiency of the workflow.

Meta-analyses are also in line with the expanding role of bpMRI, as a recent meta-analysis by Cuocolo et al. reaffirms high detection rates of clinically significant cancers with the use of simplified protocols (14). Similarly, Görmez et al. found that the diagnostic accuracy of bpMRI was on par with that of mpMRI, and they proposed bpMRI as a valid option in certain clinical scenarios (15). Nevertheless, Belue et al. showed that bpMRI is becoming more popular, and mpMRI is always the gold standard because of the larger volume of evidence and comprehensive assessment capabilities (16). In summary, our study demonstrates that mpMRI, when compared to histopathology, is a diagnostic tool with exceptionally high accuracy in prostate cancer detection. Its high sensitivity, specificity, and predictive value warrant the continued adoption of mpMRI in diagnostic algorithms, especially in tertiary care centers such as University Medical and Dental College, Faisalabad, Pakistan. Next investigations should be directed towards the refinement of protocols, use of biomarkers, and leveraging artificial intelligence to not only increase diagnostic accuracy but also to minimize unwarranted biopsies (17).

Conclusion

This research recognizes multiparametric MRI as a very accurate and dependable imaging technique for detecting and locating prostate cancer in comparison to histopathology, which is the gold standard. The results revealed high sensitivity, specificity, and overall diagnostic accuracy, specifically in patients with higher PI-RADS scores, where malignancy detection was significantly increased. Multiparametric MRI was instrumental in uncovering clinically significant prostate cancer, and at the same time helped in avoiding superfluous biopsies in benign cases. By directing targeted biopsy and facilitating better risk stratification, it underlines the pivotal role of mpMRI in contemporary prostate cancer diagnostic algorithms. In clinical use, mpMRI remains a vital non-invasive instrument, but a few false-negative and false-positive cases have been recorded. Therefore, mpMRI must be standardly used in the assessment of patients with suspected prostate cancer to facilitate early diagnosis, guide management decisions effectively, and result in better patient outcomes at tertiary care centers.

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