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MULTI-PARAMETER DIFFUSION-WEIGHTED MAGNETIC RESONANCE IMAGING FOR PROSTATE CANCER STAGING TAKING HISTOPATHOLOGY AS THE GOLD STANDARD AT ISLAMABAD DIAGNOSTIC CENTER FAISALABAD

Original Research

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ABSTRACT

Background: Prostate cancer is one of the most prevalent malignancies in males and a leading cause of cancer-related mortality worldwide. Early detection and accurate staging are critical for improving outcomes and guiding treatment. Multiparametric MRI (mpMRI), particularly diffusion-weighted imaging (DWI), has emerged as a promising non-invasive diagnostic modality for detecting prostate cancer and assessing tumor aggressiveness. Compared to traditional diagnostic tools like transrectal ultrasound (TRUS), mpMRI offers superior sensitivity and diagnostic accuracy for identifying prostate malignancies.

Objective: To evaluate the diagnostic performance of DWI MRI in detecting and characterizing prostate cancer in comparison with TRUS-guided histopathology. The study also assessed the effectiveness of different b-values and mpMRI sequences in staging and identifying prostate malignancies.

Methods: A prospective cross-sectional study was conducted at Islamabad Diagnostic Center, Faisalabad, from July 2024 to December 2024. A total of 112 male patients, aged 30 years or older, presenting with elevated PSA levels, hematuria, urinary retention, weight loss, prostatitis, or pelvic pain, underwent mpMRI. Imaging sequences, including DWI, ADC mapping, T2-weighted (T2WI), and T1-weighted (T1WI) MRI, were analyzed by independent radiologists. TRUS-guided histopathology was used as the gold standard for correlation. Statistical analysis, including sensitivity, specificity, diagnostic accuracy, and correlation analysis, was performed using SPSS version 22.0.

Results: The mean age of participants was 59.8 years (±1.116 SD), with the 70–80 age group comprising 42 (37.5%) patients. Clinical symptoms included elevated PSA levels in 65 (58%), urinary retention in 83 (74.1%), prostatitis in 70 (62.5%), pelvic pain in 35 (31.3%), hematuria in 30 (26.8%), and weight loss in 9 (8%). DWI and ADC mapping demonstrated the highest sensitivity (92%) compared to T2WI (88.5%) and T1WI (66.7%), while T1WI exhibited the highest specificity (72%). Diagnostic accuracy was highest for DWI (77.6%), followed by T2WI (75.8%), ADC (73.2%), and T1WI (67.8%). DWI demonstrated a significant correlation with TRUS findings (p=0.001) and PSA levels (p=0.038).

Conclusion: DWI MRI proved to be a non-invasive, highly sensitive imaging modality for the early detection and characterization of prostate cancer, surpassing TRUS in diagnostic accuracy. Its ability to assess tumor aggressiveness and guide treatment decisions underscores its indispensable role in prostate cancer diagnosis. The incorporation of mpMRI, alongside PSA testing and TRUS, offers a more comprehensive diagnostic approach for improved outcomes in prostate cancer management.

Keywords: Apparent Diffusion Coefficient, Diffusion-Weighted Imaging, Magnetic Resonance Imaging, Prostate Cancer, Prostatic Neoplasms, Transrectal Ultrasonography, Tumor Staging.

INTRODUCTION

Prostate cancer, clinically referred to as prostate carcinoma, originates in the glandular regions of the prostate, a small, walnut-shaped organ located beneath the bladder in males. It is the second leading cause of malignancy-related deaths in men worldwide and is expected to see a threefold increase in prevalence by 2030 due to the aging global population. Prostate cancer frequently metastasizes to the liver, lungs, lymph nodes, and bones, with bone metastases occurring in approximately 62% of cases. As the disease progresses, bone metastases are observed in nearly 90% of patients, with an overall prevalence rate of 3% across all diagnostic stages (1). Prostate cancer ranks as the second most common cancer and the fifth leading cause of malignancy-related mortality among men, with 1,414,000 new cases and 375,304 deaths reported globally in 2020 (2). Incidence rates vary significantly across South Asia, Europe, and the United States, with men over 50 years of age being particularly susceptible. This incidence is also rising in developing nations (3).

The cancer's prognosis and therapeutic strategy are greatly influenced by its location, whether in the peripheral or transition zone of the prostate. Tumor volume, when combined with Gleason differentiation, serves as a significant predictor of metastasis, although its routine application in clinical practice remains limited (4). Early-stage prostate cancer is frequently asymptomatic, necessitating little to no medical intervention. Symptoms such as nocturia, dysuria, and urinary frequency often emerge later, mimicking benign prostatic hyperplasia. Advanced disease stages are characterized by metastases to the axial skeleton, resulting in symptoms like back pain and urinary complications (5). Detection rates of clinically significant prostate cancer (csPCa) are significantly higher with targeted biopsy techniques compared to systematic approaches. However, systematic prostate-specific antigen (PSA) screening methods often fail to detect clinically insignificant tumors or lead to unnecessary biopsies, highlighting a critical need for enhanced diagnostic accuracy (6).

Traditional diagnostic tools, including transrectal ultrasound (TRUS)-guided biopsies, PSA levels, and digital rectal examinations, have shown limitations in detecting prostate cancer due to the iso-echoic nature of at least 40% of neoplastic foci (7). Although TRUS-guided systematic biopsies remain the standard, they often result in unnecessary sampling of healthy tissue and miss significant malignancies due to multifocal and heterogeneous early lesions. False negatives occur in up to 47% of initial biopsies, underscoring the urgent need to improve early detection methods (6). Random biopsies, while commonly used, are hindered by low precision and a propensity to miss lesions outside standard sampling sites (9).

Magnetic resonance imaging (MRI) has emerged as a promising tool in the diagnostic pathway, especially for patients with PSA levels ≥3.0 ng/ml, reducing unnecessary biopsies while maintaining high sensitivity for clinically significant prostate cancer. Advanced MRI techniques, including diffusion-weighted imaging (DWI), dynamic contrast-enhanced imaging (DCE-MRI), and magnetic resonance spectroscopy (MRS), provide superior diagnostic capabilities compared to traditional T2-weighted imaging (T2WI). Among these, DWI-MRI has shown remarkable accuracy in identifying the location, size, and extent of malignant prostate tumors, offering sensitivity and specificity ranges of 29–94% and 39–100%, respectively (12). Studies suggest that DWI with higher b-values, such as b-2000 s/mm², provides enhanced contrast between malignant and benign tissues, making it a valuable tool for staging and evaluation (13).

The b-value, a critical parameter in DWI, influences image quality and diagnostic accuracy. High b-values, exceeding 2000 s/mm², have demonstrated superior performance in distinguishing prostate tumors, particularly when integrated with ADC mapping. Despite the availability of different MRI configurations, such as 1.5 T and 3 T machines, questions remain regarding the optimal b-value for cancer detection and staging (14). This study employs various b-values and sequences, including T1W, T2W, and ADC maps, to non-invasively evaluate prostate cancer staging, aiming to improve diagnostic precision and treatment outcomes by leveraging the diffusion properties of water molecules within pathological tissues. The objective is to assess the utility of multi-parameter diffusion-weighted MRI, guided by histopathology, as the gold standard for prostate cancer staging at Islamabad Diagnostic Center Faisalabad.

METHODS

This prospective cross-sectional study was conducted in the Radiology Department of Islamabad Diagnostic Center, Faisalabad, from July 2024 to December 2024. A total of 112 male participants, aged 30 years or older, who presented with elevated prostate-specific antigen (PSA) levels, hematuria, urinary retention, weight loss, or prostatitis were included. All participants meeting the inclusion criteria underwent multiparametric magnetic resonance imaging (mpMRI) of the prostate, and their MRI findings were correlated with

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transrectal ultrasound-guided (TRUS) histopathology results for diagnostic confirmation. Patient demographic information, clinical signs and symptoms, and imaging findings were collected using a standardized questionnaire. Data included parameters such as DWI, ADC, T2-weighted (T2W), and T1-weighted (T1W) MRI sequences, zonal distribution of abnormalities, extracapsular findings, Prostate Imaging Reporting and Data System (PIRADS) grading, and TRUS histopathology outcomes categorized as benign, malignant (positive), or normal (negative). MRI findings were similarly categorized as benign, malignant, or normal, and analyzed for their diagnostic accuracy.

MRI imaging was performed using a 1.5 Tesla Philips scanner equipped with a specialized coil. Scans were conducted on all eligible participants, and the resulting images from various sequences were reviewed and interpreted by experienced radiologists. TRUS-guided biopsies were obtained from all participants as the gold standard diagnostic tool for prostate cancer, enabling a direct comparison between MRI results and histopathological findings. Data analysis was carried out using IBM SPSS version 21.0. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated for variables such as age, clinical symptoms, zonal distribution, extracapsular findings, PIRADS grading, and MRI sequence parameters like b-value. Diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of MRI sequences, including DWI, ADC maps, T2W, and T1W, were determined in comparison to TRUS histopathology results using 2×2 contingency tables. Correlations between DWI and clinical symptoms, MRI outcomes, and TRUS histopathology results were also assessed.

RESULT

The study included 112 male participants with a mean age of 59.8 years (±1.116 SD). The majority of patients, 42 (37.5%), were aged between 70-80 years, followed by 35 (31.3%) in the 60-70 age group, and 20 (17.9%) in the 50-60 age group, demonstrating the increased prevalence of prostate cancer in older age groups. Clinical history analysis revealed that elevated PSA levels were present in 65 (58%) patients, hematuria in 30 (26.8%), urinary retention in 83 (74.1%), weight loss in 9 (8%), pelvic pain in 35 (31.3%), and prostatitis in 70 (62.5%) of the participants. These findings underscore the significance of PSA levels and certain clinical symptoms as indicative markers for prostate cancer. The MRI findings, analyzed across sequences such as DWI, ADC, T2-weighted, and T1-weighted imaging, indicated varying diagnostic performance. Prostate cancer lesions appeared hypointense in 28 (25%), 80 (71.4%), 82 (73.2%), and 37 (33%) patients and hyperintense in 84 (75%), 32 (28.6%), 30 (26.8%), and 75 (67%) patients on DWI, ADC, T2W, and T1W sequences, respectively. PIRADS grading classified the lesions into PIRADS-1 (15.2%), PIRADS-2 (16.1%), PIRADS-3 (22.3%), PIRADS-4 (23.2%), PIRADS-5 (21.4%), and PIRADS-6 (1.8%). The zonal distribution of prostate cancer predominantly involved the peripheral-central zone in 63 (56.3%) patients, followed by the peripheral-transition zone in 31 (27.7%), the central-transition zone in 6 (5.4%), and all zones in 12 (10.7%). These findings provided insight into the typical imaging characteristics and anatomical patterns of prostate cancer.

Diagnostic comparisons between MRI and TRUS histopathology results revealed that 87 (77.7%) MRI findings were positive, while TRUS identified 69 (61.6%) positive cases. Among MRI sequences, DWI demonstrated the highest sensitivity (92%) and diagnostic accuracy (77.67%), while T1-weighted imaging exhibited the highest specificity (72%). DWI also showed significant correlations with TRUS histopathology findings (Spearman correlation, p=0.001), confirming its superior role in prostate cancer detection. Additionally, DWI demonstrated the highest sensitivity for prostatitis (63.3%) and PSA levels (60.2%), as well as the highest specificity for weight loss, hematuria, and extra-prostate findings (85.7%). These results establish DWI MRI as a critical imaging modality for accurate prostate cancer diagnosis and staging.

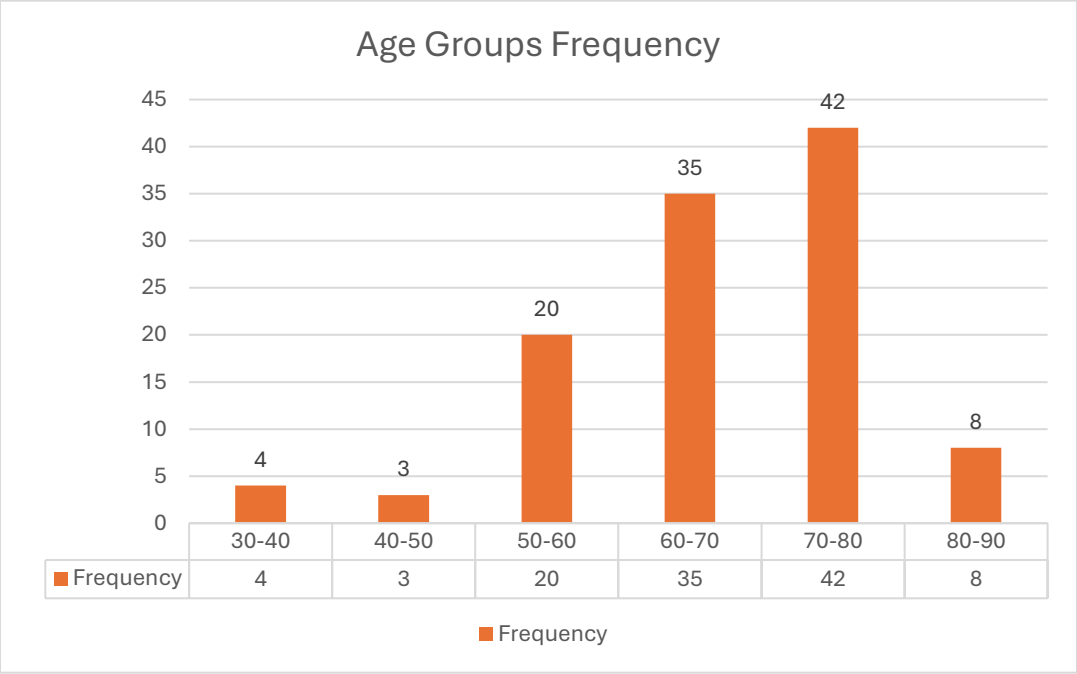

Figure 1 The bar chart represents the different age frequencies

The patient data was categorized based on different age groups and excluded patients below 30 years of age. Patients who were 30 years old or older were the population selected for this study. Figure 4.1 represents that 42/112 patients were aged between 70-80 years as the bar chart showed the highest peak.

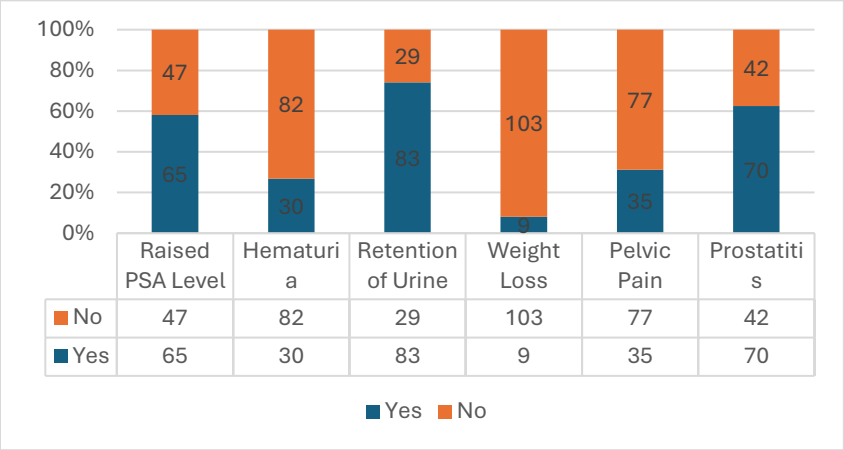

Figure 2 The 3-D 100% stacked column chart represents the clinical history of patients

Data was collected via performa which included the clinical history of patients, MRI prostate findings, zonal distribution, extra prostate findings, results of prostate MRI and TRUS biopsy histopathology results, PIRAD grade distribution & b-value used. Clinical history analysis is performed for more accurate results, such as raised PSA level was present in 65 (58%) of patients, Hematuria was found in 30 (26.8%) of patients, complaints of retention of urine were present in 83 (74.1%) of patients, and weight loss were found in 9 (8%) patients, pelvic pain existed in 35 (31.3%)patients, prostatitis found in 70 (62.5%) patients.

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Table 1: The table represents the different MRI sequence findings

Appearance/Findings	DWI	ADC Map	T2WI	T1WI
Hypo-intense	28 (25%)	80(71.4%)	82(73.2)	37(33%)
Hyper-intense	84 (75%)	32(28.6%)	30(26.8%)	75(67%)

Different MRI sequences were used during the scan of the prostate such as DWI, ADC map, T2, and T1 sequences were used. Each sequence has different characteristics indications and information about prostate abnormalities. Data shows prostate may appear hypointense and hyperintense according to its different pathologies as on DWI, ADC map, T2 & T1 prostate cancer appear as hypointense area in 28 (25%), 80 (71.4%), 82 (73.2%) & 37 (33%), hyperintense area in 84 (75%), 32 (28.6%), 30 (26.8%) & 58 (67%) patients accordingly.

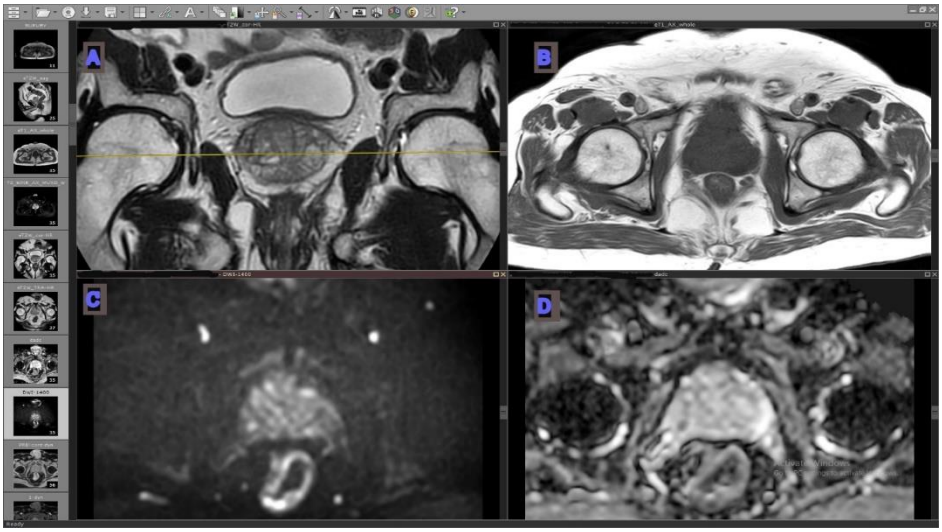

Figure 3 This image Includes T2W (A), T1W (B), DWI (C) & ADC (D) of prostate cancer

Figures include the different sequence images of T2W, T1W, DWI & ADC map which represents the zonal distribution of the prostate lesions which appear differently on different sequences of MRI and DWI 1400 show the minimum noise and maximum image quality.

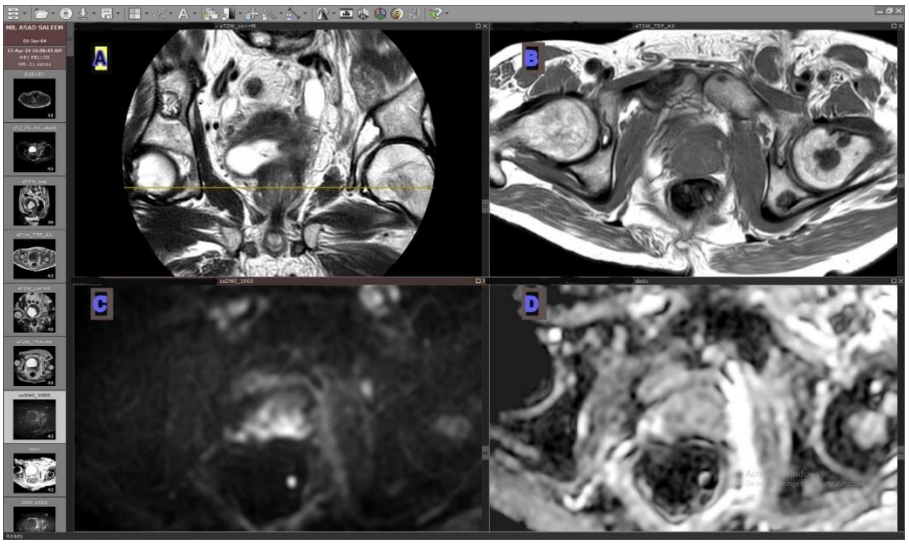

Figure 4 This image Includes T2W (A), T1W (B), DWI (C) & ADC (D) of prostate cancer

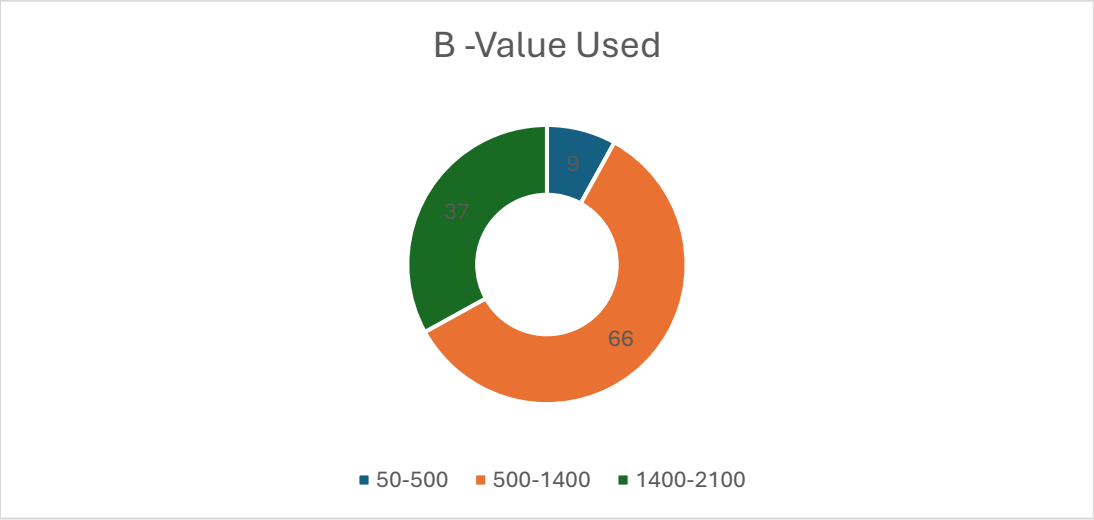

Figure 5 The pie chart represents the various b-values used during DWI MRI

Diffusion weighted images have specific b-values which change the contrast and resolution of the images in this study we used different b-values during DWI MRI scan ranges as 50-500, 500-1400 & 1400-2000. As figure 6 represents most of the scans were performed on the b-value of 500-1400 almost in 66 (58.9%) patients. Which gave the maximum and optimum visualization of the prostate and minimized the noise.

Table 2: Table represents the various b-values used during DWI MRI

PIRADS Grading	Frequency	Percent
PIRAD-1	17	15.2
PIRAD-2	18	16.1
PIRAD-3	25	22.3
PIRAD-4	26	23.2
PIRAD-5	24	21.4
PIRAD-6	2	1.8
Total	112	100.0

According to the DWI MRI findings and appearance of prostate cancer it was graded according to PIRADS grading system and table 4.4 represents PIRAD-1 grade cancer was diagnosed in 17 (15.2%), PIRAD-2 grade prostate cancer was present in 18 (16.1%), PIRAD-3 grade PCa appeared in 25 (22.3%), PIRAD-4 grade PCa showed in 26 (23.2%), PIRAD-5 grade PCa occurred in 24 (21.4%) and PIRAD-6 grade PCa was present in the 2 (1.8%) patients.

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Table 3: The table represents the zonal distribution of prostate cancer

Zonal Distribution		
Zones	Frequency	Frequency
Peripheral-Central Zone	63(56.3%)	56.3
Peripheral-Transition Zone	31(27.7%)	27.7
Central-Transition Zone	06(5.4%)	5.4
Central-Peripheral-Transition Zone	12(10.7%)	10.7
Total	112	100.0

Prostate has different zones peripheral, central, and translational. Prostate cancer distributed differently in these zones which can be visualized by imaging as we used MRI for prostate scanning cancerous deficits are distributed in these zones out of 112 patients 63 (56.3%) patients have peripheral-central zonal distribution, 31 (27.7%) patients have peripheral-transitional zonal distribution,06 (5.4%) patients have central-transitional zonal distribution and 12 (10.7%) patients have transitional zonal distribution of mass. prostate cancer present in 20 (17.9%) patients and absent in 92 (82.1%) patients.

Table 4: The table represents the MRI & TRUS histopathology Findings

Findings				
	MRI Findings		TRUS Histopathological Findings	
Findings	Frequency	Percent	Frequency	Percent
Negative	25	22.3%	43	38.4%
Benign	29	25.9%	26	23.2%
Malignant	58	51.8%	43	38.4%
Total	112	100%	112	100.0%

Prostate cancer diagnosed by using the two most appropriate and easily assessable modalities magnetic resonance imagining sequences and Trans-rectal ultrasound-guided biopsy. Different MRI sequences used to visualize prostate cancer caused by the different hormonal and physiological factors as it progresses and spreads in the prostate. MRI scan shows the different destructive patterns that were caused by prostate cancer. MRI prostate was also used to check the severity and staging of the prostate cancer. From the total patients, (22.3%) patients were showing MRI prostate negative results, (25.9%) of patients had benign prostate cancer and (51.8%) had malignant prostate findings. While (38.4%) of patients showing negative, (23.2%) patients have benign, and (38.4%) patients have malignant TRUS histopathology findings.

Table 5: Table represents the MRI & TRUS histopathology results

Results		
	MRI Results	TRUS Histopathology Results
Positive	87(77.7%)	69(61.6%)
Negative	25(22.3%)	43(38.4%)
Total	112	112

DWI MRI showed 77.7% positive results while the TRUS histopathology showed 61.6% positive results which emphasizes the diagnostic accuracy of DWI MRI is far better than that of TRUS histopathology.

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Table 6: Table represents the diagnostic accuracy of DWI for PCa with different clinical symptoms and findings of MRI

Symptoms	Sensitivity	Specificity	Diagnostic Accuracy
Pelvic Pain	32.7%	78.6%	38.39%
PSA Level	60.2%	57.1%	59.82%
Weight loss	7.1%	85.7%	16.96%
Hematuria	28.6%	85.7%	35.71%
Urinary Retention	74.5%	28.6%	68.75%
Prostatitis	63.3%	42.9%	60.71%
Extra-Prostate Findings	17.3%	85.7%	25.89%

Diagnostic accuracy of DWI in diagnosing prostate cancer was also observed with respect to PSA levels, and different symptoms. Data shows DWI was found to be 32.7% sensitive, 78.6% specific, and 38.39% accurate in regards with pelvic pain in diagnosing prostate cancer. DWI was shown to have 60.2% sensitivity, 57.1% specificity, and 59.82% diagnostic accuracy in regards with PSA level in diagnosing prostate cancer. DWI was shown to have 7.1% sensitivity, 85.7% specificity, and 16.96% diagnostic accuracy regarding weight loss in diagnosing prostate cancer. DWI was demonstrated to have 28.6% sensitivity, 85.7% specificity, and 35.71% diagnostic accuracy about hematuria in diagnosing prostate cancer. DWI was shown to have 74.5% sensitivity, 28.6% specificity, and 68.75% diagnostic accuracy concerning urinary retention in diagnosing prostate cancer. DWI was shown to have 63.3% sensitivity, 42.9% specificity, and 60.71% diagnostic accuracy regarding prostatitis in diagnosing prostate cancer. DWI was shown to have 17.3% sensitivity, 85.7% specificity, and 25.89% diagnostic accuracy in regards to extra prostate findings in diagnosing prostate cancer.

DWI was found to have the highest sensitivity levels for the symptoms of prostatitis and PSA levels with a sensitivity of 63.3% and 60.2% respectively. DWI was found to have the highest specificity levels for the symptoms of weight loss, hematuria, and extra prostate findings with each having a specificity of 85.7%. DWI was found to have the highest diagnostic accuracy levels for the symptoms of urinary retention and prostatitis with a diagnostic accuracy of 68.75% and 60.71% respectively.

Table 7: DWI & ASC Findings

DWI Findings * MRI Results Cross tabulation					
			MRI results		Total
			Positive	Negative	
DWI Findings	Positive	Count	80	18	98
		% within MRI results	92.0%	72.0%	87.5%
	Negative	Count	7	7	14
		% within MRI results	8.0%	28.0%	12.5%
ADC Map Finding * MRI Results Cross tabulation					
			MRI Results		Total
			Positive	Negative	
ADC Map Finding	Positive	Count	80	23	103
		% within MRI results	92.0%	92.0%	92.0%
	Negative	Count	7	2	9
		% within MRI results	8.0%	8.0%	8.0%
Total		Count	87	25	112
		% within MRI results	100.0%	100.0%	100.0%

Data shows the sensitivity and specificity of diffusion-weighted imaging in detecting prostate cancer. DWI was able to correctly identify 80 patients with prostate cancer (true positive). DWI was also able to detect 7 normal people with no disease (true negative). DWI test

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was found to have a 92% sensitivity and 28% specificity level for diagnosing prostate cancer. And the sensitivity and specificity of the apparent diffusion coefficient map in detecting prostate cancer. ADC mapping was able to correctly identify 80 patients with prostate cancer (true positive). ADC mapping was also able to detect 2 normal people with no disease (true negative). ADC mapping was found to have a 92% sensitivity and 8% specificity level for diagnosing prostate cancer.

Table 8: T2 & T1 Findings

T2 Findings * MRI Results Cross tabulation					
			MRI Results		Total
			Positive	Negative	
T2_Findings	Positive	Count	77	17	94
		% within MRI results	88.5%	68.0%	83.9%
	Negative	Count	10	8	18
		% within MRI results	11.5%	32.0%	16.1%
T1 Findings * MRI Results Cross tabulation					
			MRI results		Total
			Positive	Negative	
T1 Findings	Positive	Count	58	7	65
		% within MRI results	66.7%	28.0%	58.0%
	Negative	Count	29	18	47
		% within MRI results	33.3%	72.0%	42.0%
Total		Count	87	25	112
		% within MRI results	100.0%	100.0%	100.0%

Data shows the sensitivity and specificity of T2 weighted imaging MRI in detecting prostate cancer. T2 weighted imaging MRI was able to correctly identify 77 patients with prostate cancer (true positive). T2 weighted imaging MRI was also able to detect 8 normal people with no disease (true negative). T2 weighted imaging MRI was found to have 88.5% sensitivity and 32% specificity level for diagnosing prostate cancer. T1 Data shows the sensitivity and specificity of T1 weighted imaging MRI in detecting prostate cancer. T1 weighted imaging MRI was able to correctly identify 58 patients with prostate cancer (true positive). T1 weighted imaging MRI was also able to detect 18 normal people with no disease (true negative). T1 weighted imaging MRI was found to have 66.7% sensitivity and 72% specificity level for diagnosing prostate cancer.

Table 9: Specificity of DWI, ADC map, T2, and T1, MRI in detecting prostate cancer

MRI Variable	**Sensitivity**	**Specificity**	**Diagnostic Accuracy**
DWI	92.0%	28.0%	77.67%
ADC	92.0%	8.0%	73.21%
T2	88.5%	32.0%	75.89%
T1	66.7%	72.0%	67.85%

The study demonstrated that among MRI sequences, diffusion-weighted imaging (DWI) exhibited the highest sensitivity (92%) and diagnostic accuracy (77.67%) for detecting prostate cancer, though its specificity was relatively low (28%). Apparent diffusion

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coefficient (ADC) mapping also had high sensitivity (92%) but the lowest specificity (8%) and a diagnostic accuracy of 73.21%. T2-weighted MRI showed a sensitivity of 88.5%, specificity of 32%, and diagnostic accuracy of 75.89%, while T1-weighted MRI had the highest specificity (72%) but the lowest sensitivity (66.7%) and diagnostic accuracy (67.85%). Significant correlations were found between patient age and PSA levels with MRI results ($p=0.002$ and $p=0.038$, respectively), while other symptoms like pelvic pain, weight loss, hematuria, and urinary retention showed no significant associations. DWI MRI not only provided superior sensitivity and diagnostic accuracy but also demonstrated a strong correlation with TRUS results (Spearman correlation $p=0.001$), underscoring its critical role in prostate cancer diagnosis.

DISCUSSION

Prostate cancer is one of the most common malignant tumors in males, ranking as the second leading cause of cancer-related deaths following lung cancer. The present study observed that the majority of patients were between 60 to 80 years of age, with the highest prevalence (37.5%) noted in the 70–80 age group, and a mean age of 59.8 years. These findings align with previous research indicating that prostate cancer incidence significantly increases with age, particularly after 60 years. While several risk factors, such as family history and racial predisposition, are known to influence prostate cancer development, no definitive preventive measures have been established, making early detection vital for improving outcomes (16, 17). Prostate-specific antigen (PSA) testing, though widely used, has shown limitations in specificity and predictive value. This study demonstrated a significant relationship between PSA levels and prostate cancer diagnosis, but MRI emerged as a superior diagnostic modality, particularly with diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) mapping, which exhibited higher sensitivity and diagnostic accuracy compared to PSA levels and TRUS-guided biopsies.

The integration of DWI and ADC mapping in prostate cancer detection proved instrumental in identifying cellular-level changes associated with malignancy. Tumors with higher cell density restrict water diffusion, resulting in lower ADC values, which were significantly associated with aggressive cancer types and higher Gleason scores (19). The study utilized b-values ranging up to 1400 s/mm², achieving optimal image quality and contrast. These findings support previous research demonstrating that higher b-values enhance lesion characterization by improving contrast-to-noise ratios, enabling the accurate detection of malignant lesions and extracapsular involvement. However, the low specificity (8%) of ADC mapping limits its utility as a standalone diagnostic tool, emphasizing the need for multiparametric MRI approaches that combine T2-weighted imaging (T2WI) and T1-weighted imaging (T1WI). This combination improves sensitivity and specificity, ensuring accurate staging and guiding treatment decisions (12, 20). While DWI demonstrated high sensitivity (92%) and diagnostic accuracy (77.67%), its specificity (28%) was comparatively lower than T1WI, which showed the highest specificity (72%).

Despite the promising results, the study had several limitations that may have influenced the outcomes. The use of a 1.5 Tesla MRI system restricted the potential for achieving higher resolution imaging, which may have improved diagnostic accuracy with advanced equipment. Additionally, the study duration was relatively short, limiting the ability to assess long-term trends in prostate cancer diagnosis and management. The findings are consistent with previous studies, but variations in demographics, MRI protocols, and data analysis methods make direct comparisons with other research challenging. Strengths of the study include its use of multiparametric MRI sequences, which allowed for comprehensive evaluation of prostate cancer lesions, and its inclusion of both diagnostic and prognostic parameters. A comparative study conducted by Woo et al. (2021) evaluated the diagnostic performance of multiparametric MRI (mpMRI) versus transrectal ultrasound (TRUS) in detecting clinically significant prostate cancer. The study included 300 patients with elevated PSA levels and utilized targeted biopsies based on mpMRI findings alongside systematic TRUS biopsies. The results demonstrated that mpMRI had a significantly higher sensitivity (88.9%) compared to TRUS (65.2%) for detecting clinically significant prostate cancer ($p<0.001$). Furthermore, mpMRI achieved a higher negative predictive value (NPV) of 91.7%, indicating its reliability in ruling out significant disease. However, TRUS biopsies showed slightly better specificity (82.5% vs. 79.3%) in identifying benign lesions, which may reflect the variability of interpreting mpMRI. Notably, combining mpMRI with TRUS-guided biopsies resulted in improved overall diagnostic accuracy ($p=0.005$), emphasizing the complementary role of both modalities. The study concluded that mpMRI is a superior diagnostic tool for identifying clinically significant prostate cancer and reducing unnecessary biopsies, but integration with TRUS could enhance specificity and overall diagnostic precision. These findings further support the need for incorporating advanced imaging techniques, such as DWI and ADC mapping, in routine prostate cancer diagnostic workflows for more reliable outcomes (24).

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MRI, particularly DWI, demonstrated substantial diagnostic utility for prostate cancer detection, providing a non-invasive alternative with high sensitivity and diagnostic accuracy. While TRUS remains a valuable tool, the addition of MRI enhances early detection, tumor characterization, and treatment planning. The combination of PSA testing, MRI, and TRUS biopsies offers a more accurate and minimally invasive diagnostic approach. Future studies incorporating higher-field MRI systems and longitudinal data are essential to further refine diagnostic protocols and improve prostate cancer outcomes. This study emphasizes the critical role of advanced imaging techniques in addressing the limitations of conventional diagnostic methods while highlighting the potential for improved clinical practices in prostate cancer management.

CONCLUSION

This study highlights the critical role of multiparametric MRI, particularly diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) mapping, in the accurate detection and characterization of prostate cancer. By providing detailed insights into tumor biology and zonal distribution, these imaging modalities enable earlier diagnosis and more precise staging of prostate cancer compared to traditional methods such as PSA testing and TRUS-guided biopsies. The findings underscore the potential of MRI as a first-line, non-invasive diagnostic tool that minimizes unnecessary interventions while guiding clinical decisions with greater reliability. While limitations such as technological constraints and the variability of results across different imaging parameters were noted, the study reinforces the importance of integrating advanced imaging techniques into routine diagnostic workflows to enhance the overall management and outcomes of prostate cancer. This approach paves the way for improved diagnostic precision, better patient outcomes, and a more comprehensive understanding of prostate cancer progression and treatment planning.

AUTHOR CONTRIBUTIONS

Author	Contribution
Ahmad Mehmood*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Tasra Bibi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Adeel Shah	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Umer Nazir	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Khalid Nazir	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sibghatullah	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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