Correlation between Ultrasound Features and Histopathological Findings in Prostate Cancer at Tertiary Care Hospital

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ABSTRACT

Background: Prostate cancer is one of the most commonly diagnosed malignancies in men worldwide and a major cause of morbidity and mortality. Despite the widespread use of imaging modalities like transrectal ultrasound, histopathological confirmation remains the gold standard, and local data correlating ultrasound features with tumor pathology are limited. **Objective:** The aim of the study was to evaluate the correlation between ultrasound features and histopathological findings in patients with prostate cancer at a tertiary care hospital. **Methods & Materials:** This cross-sectional observational study was conducted at the Department of Radiology and Imaging, Bangladesh Medical University, and the National Institute of Kidney Diseases and Urology, Dhaka, Bangladesh, from January to June 2021, including 200 male patients aged ≥50 years with indications for prostate biopsy. TRUS was performed to assess hypoechoic lesions, irregular margins, increased vascularity, and calcifications, followed by histopathology and Gleason scoring. Associations between ultrasound features and histopathology, diagnostic performance, and Gleason scores were analyzed using chi-square tests ($p < 0.05$). **Results:** In 200 patients (mean age 65.1 ± 7.5 years), hypoechoic lesions (72.5%), irregular margins (55.0%), and increased vascularity (47.5%) were common. Prostate adenocarcinoma was diagnosed in 160 cases (80.0%), mostly intermediate grade (43.8%). Ultrasound features were significantly associated with malignancy and Gleason score, with hypoechoic lesions showing highest sensitivity (81.3%) and PPV (89.7%) and increased vascularity highest specificity (75.0%). **Conclusion:** Transrectal ultrasound features, particularly hypoechoic lesions, irregular margins, and increased vascularity, reliably correlate with histopathology and tumor grade, making them valuable for detecting and assessing prostate cancer.

Keywords: *Correlation, Ultrasound, Histopathology*

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INTRODUCTION

Prostate cancer ranks among the most frequently diagnosed malignancies in men worldwide. Globally, it is the second most prevalent cancer in males, following lung cancer. In 2018, over 1.6 million men were newly diagnosed with prostate cancer, and more than 366,000 deaths were attributed to the disease [1]. It continues to be a major contributor to morbidity and mortality among men, representing the second most common solid tumor and the fifth leading cause of cancer-related death globally, with an estimated incidence of around 1.41 million cases annually [2,3].

Timely identification and precise diagnosis are essential for optimizing patient management and improving clinical outcomes [4,5]. Prostate biopsy remains the definitive method for establishing a diagnosis, while advances in imaging technologies have enhanced the capacity for early detection of prostate malignancies [6].

Transrectal ultrasound (TRUS), introduced in 1968, serves as an important imaging modality for evaluating suspected prostate cancer [7]. The TRUS-guided systematic prostate biopsy is regarded as the gold standard for definitive diagnosis [8], providing real-time visualization of lesions and facilitating targeted sampling [9].

Despite widespread application, conventional diagnostic tools such as serum prostate-specific antigen (PSA) measurement and digital rectal examination (DRE) have limitations in distinguishing malignant from benign prostate conditions. This can lead to unnecessary biopsies or missed clinically significant tumors [10]. On TRUS, hyperechoic lesions are generally considered benign, often corresponding to benign prostatic hyperplasia, prostatitis, or infarction [9]. Malignant lesions typically appear as hypoechoic in 60–70% of cases and isoechoic in 30–40%, whereas hyperechoic lesions are rare, accounting for about 1.5% of cases [11].

Histopathological evaluation remains the definitive method for confirming prostate cancer. The Gleason scoring system is the primary tool used to grade tumors, providing valuable prognostic information based on the architectural patterns and differentiation of carcinoma cells in H&E-stained sections [1,12]. Gleason grade continues to serve as an established predictor of tumor aggressiveness and patient outcomes.

Although multiple studies have explored the relationship between ultrasound findings and histopathological outcomes, data specific to Bangladeshi patients, particularly in tertiary care centers like BSMMU, are scarce. With an increasing burden of prostate cancer in Bangladesh due to aging, lifestyle changes, and enhanced diagnostic capabilities, local

evidence on the correlation between imaging features and histopathology is limited and warrants further investigation [13,14]. Therefore, this study was conducted to assess the correlation between ultrasound features and histopathological findings in patients with prostate cancer at a tertiary care hospital.

OBJECTIVE

To evaluate the correlation between ultrasound features and histopathological findings in patients with prostate cancer at a tertiary care hospital.

METHODS & MATERIALS

This cross-sectional observational study was conducted at the Department of Radiology and Imaging, Bangladesh Medical University, and the National Institute of Kidney Diseases and Urology, Dhaka, Bangladesh, from January 2021 to June 2021. A total of 200 male patients suspected of having prostate pathology were included, selected based on clinical evaluation, prostate-specific antigen (PSA) levels, and digital rectal examination (DRE). Data were collected to evaluate the correlation between ultrasound features and histopathological findings in prostate cancer.

Inclusion Criteria:

- Male patients aged 50 years and above
- Patients with clinical indications for prostate biopsy, including abnormal PSA levels or suspicious findings on DRE

Exclusion Criteria:

- History of prior prostate surgery
- Known metastatic prostate disease
- Incomplete imaging or histopathological data

All participants underwent transrectal ultrasound (TRUS) performed by experienced radiologists using a high-frequency transducer. Key ultrasound features—including hypoechoic lesions, irregular margins, increased vascularity on color Doppler imaging, and calcifications—were systematically evaluated and documented along with lesion size and location. Following imaging, patients underwent histopathological evaluation via needle biopsy or surgical specimens as indicated. Reports were reviewed to determine the presence of malignancy and tumor type, and Gleason scoring was applied to classify prostate cancer as low grade (≤6), intermediate grade (7), or high grade (8–10).

Data analysis included descriptive statistics for demographic and ultrasound variables, while correlations between ultrasound findings and histopathology were assessed using chi-square tests. Diagnostic performance metrics, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated for each ultrasound feature. Associations with Gleason score were also evaluated to assess predictive value for tumor aggressiveness. A p-value < 0.05 was considered statistically significant. Written informed consent was obtained from all participants prior to enrollment.

RESULTS

Table I presents the age distribution of the study participants (N = 200). The majority of patients were aged 61 to 70 years (88/200, 44.0%), followed by 51 to 60 years (60/200, 30.0%) and above 70 years (52/200, 26.0%). The mean age was 66.8 ± 7.4 years, with an age range of 51 to 84 years.

Table I
Age Distribution of the Study Participants (*n* = 200).

Age Group (years)	Number of Patients	Percentage (%)
51–60	60	30.0
61–70	88	44.0
>70	52	26.0
Total	200	100.0
Mean Age ± SD (years)	65.1 ± 7.5	
Age Range (years)	51–80	

Table II presents the distribution of ultrasound features among the study participants (N = 200). Hypoechoic lesions were the most common finding (145/200, 72.5%), followed by irregular margins (110/200, 55.0%), increased vascularity (95/200, 47.5%), and calcifications (40/200, 20.0%).

Table II
Distribution of Ultrasound Features Among Study Participants (*n* = 200).

Ultrasound Feature	Number of Patients	Percentage (%)
Hypoechoic lesion	145	72.5
Irregular margins	110	55.0
Increased vascularity	95	47.5
Calcifications	40	20.0

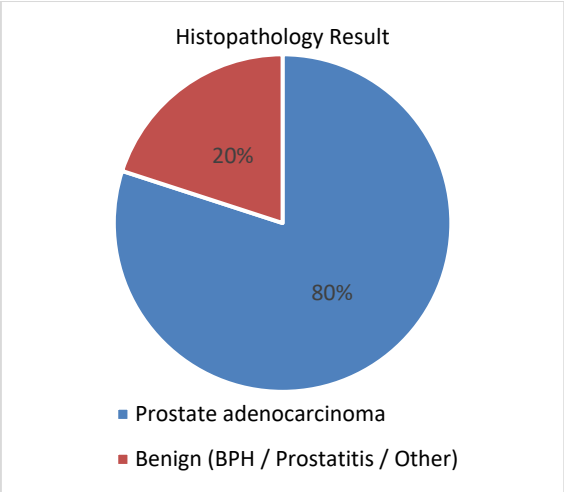

Figure I: Distribution of Histopathological Diagnoses Among Study Participants (*n* = **200).**

Figure I illustrates the distribution of histopathological diagnoses among the study participants (N = 200). Prostate adenocarcinoma was identified in 160 out of 200 patients (80.0%), while benign conditions, including benign prostatic hyperplasia and prostatitis, were observed in 40 patients (20.0%).

Table III shows the distribution of Gleason scores among malignant cases (n = 160). Most patients had intermediate grade tumors (70/160, 43.8%), followed by high grade (50/160, 31.2%) and low grade tumors (40/160, 25.0%).

Table-III
Distribution of Gleason Scores Among Malignant Cases (*n* = 160).

Gleason Score	Number of Patients	Percentage (%)
≤6 (Low grade)	40	25.0
7 (Intermediate grade)	70	43.8
8–10 (High grade)	50	31.2
Total	160	100.0

Table IV demonstrates the correlation between ultrasound features and histopathology (N = 200). Hypoechoic lesions, irregular margins, and increased vascularity were significantly more frequent in malignant cases compared to benign cases (130/160, 81.3% vs 15/40, 37.5%; 95/160, 59.4% vs 15/40, 37.5%; and 85/160, 53.1% vs 10/40, 25.0%, respectively). Calcifications were more commonly observed in benign lesions (20/40, 50.0%) than malignant cases (20/160, 12.5%).

Table-IV
Correlation Between Ultrasound Features and Histopathological Findings (*n* = 200).

Ultrasound Feature	Cancer Present (n=160)	Benign (n=40)	p-value
Hypoechoic lesion	130 (81.3%)	15 (37.5%)	<0.001
Irregular margins	95 (59.4%)	15 (37.5%)	0.013
Increased vascularity	85 (53.1%)	10 (25.0%)	0.001
Calcifications	20 (12.5%)	20 (50.0%)	<0.001

Table V summarizes the diagnostic performance of ultrasound features for detecting prostate cancer. Hypoechoic lesions showed the highest sensitivity (81.3%) and positive predictive value (89.7%), while increased vascularity demonstrated the highest specificity (75.0%).

Table V
Diagnostic Performance of Ultrasound Features for Detecting Prostate Cancer.

Ultrasound Feature	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Hypoechoic lesion	81.3	62.5	89.7	45.5
Irregular margins	59.4	62.5	86.4	27.8
Increased vascularity	53.1	75	89.5	28.6

Table VI shows the correlation between ultrasound features and Gleason score among malignant cases (n = 160). The frequency of hypoechoic lesions increased from low grade (20/40, 50.0%) to intermediate grade (61/70, 87.1%) and high grade tumors (49/50, 98.0%). Similar increasing trends were observed for irregular margins (30.0%, 64.3%, and 76.0%) and increased vascularity (20.0%, 60.0%, and 70.0%), with all associations being statistically significant ($p < 0.001$).

Table VI
Correlation Between Ultrasound Features and Gleason Score Among Malignant Cases (*n* = 160).

Ultrasound Feature	Low Grade (≤6) (n=40)	Intermediate (7) (n=70)	High Grade (8–10) (n=50)	p-value
Hypoechoic lesion	20 (50.0%)	61 (87.1%)	49 (98.0%)	<0.001
Irregular margins	12 (30.0%)	45 (64.3%)	38 (76.0%)	
Increased vascularity	8 (20.0%)	42 (60.0%)	35 (70.0%)	

DISCUSSION

Prostate cancer is a prevalent malignancy in men that can result in significant morbidity and mortality if not accurately diagnosed and managed. Transrectal ultrasound (TRUS) serves as a key imaging modality for the evaluation of suspected prostate lesions, providing real-time visualization and guiding targeted biopsy. The findings of this study demonstrate that specific TRUS features, including hypoechoic lesions, irregular margins, and increased vascularity, are significantly associated with malignant histopathology and higher Gleason scores. These results highlight the clinical importance of carefully assessing ultrasound features in patients with suspected prostate cancer to support early diagnosis, risk stratification, and informed management decisions.

In the present study, the mean age of the study participants was 65.1 ± 7.5 years, with the majority of patients aged 61 to 70 years (88/200, 44.0%), followed by 51 to 60 years (60/200, 30.0%) and above 70 years (52/200, 26.0%). This age distribution indicates that prostate cancer predominantly affects older adults, which aligns with findings from previous studies. Albasri et al. reported that prostate adenocarcinoma occurred mainly in older men, with a mean age of 70.9 years and peak prevalence in the 80–89-year age group, highlighting the age-dependent nature of the disease [15]. Similarly, Jia et al., in a large retrospective study of prostate biopsies (n≈1022), observed a mean age of 71.28 ± 8.39 years (range 41–92), with most cases occurring in men over 60 years [16]. These findings collectively support the observation that advancing age is a significant risk factor for prostate cancer, and our results are consistent with the global trend of higher incidence in men above 50 years, particularly in the sixth and seventh decades of life.

In this study, hypoechoic lesions were the most frequent ultrasound finding, observed in 145 of 200 patients (72.5%), followed by irregular margins (55.0%), increased vascularity (47.5%), and calcifications (20.0%). These results are in agreement with previous reports emphasizing the predominance of hypoechoic areas in prostate cancer detection. Griffiths et al. reported that ill-defined hypoechoic lesions were the most common ultrasound appearance in a cohort of 221 histologically confirmed prostate cancer patients, highlighting the reliability of this feature in identifying malignancy [17]. Similarly, Sharma et al. demonstrated that patients with hypoechoic lesions on transrectal ultrasound (TRUS) had significantly higher cancer detection rates and were more likely to harbor higher Gleason grade tumors compared to those without such lesions [18]. The observed frequencies of irregular margins and increased vascularity in our cohort further support their role as significant ultrasound predictors of malignancy, while the lower prevalence of calcifications aligns with literature indicating that calcifications are less specific and may be seen in both benign and malignant prostatic conditions. Overall, these findings corroborate existing evidence that hypoechoic lesions, irregular margins, and increased vascularity are important ultrasound features associated with prostate cancer.

Histopathological analysis revealed that prostate adenocarcinoma was the predominant diagnosis, accounting for 160 of 200 cases (80.0%), whereas benign conditions, including benign prostatic hyperplasia and prostatitis, were observed in 40 patients (20.0%). These findings are consistent with prior reports emphasizing the predominance of malignant adenocarcinoma in prostate biopsy series. Singh et al., in a recent systematic review and meta-analysis of needle biopsy series across multiple populations, reported that acinar adenocarcinoma accounted for more than 90% of prostate carcinoma cases, with other subtypes being much less frequent [19]. The high proportion of adenocarcinoma in our cohort aligns with this global pattern, underscoring that malignant lesions constitute the majority of clinically significant prostate pathology identified on histopathology, whereas benign conditions are less frequent but still clinically relevant.

The distribution of Gleason scores among malignant cases (n = 160) showed that intermediate grade tumors (Gleason score 7) were the most frequent, observed in 70 patients (43.8%), followed by high grade tumors (8–10) in 50 patients (31.2%) and low grade tumors (≤6) in 40 patients (25.0%). These findings are in line with existing literature reporting similar patterns of Gleason score distribution in prostate cancer. Singh et al., in a large systematic review and meta-analysis of 8,764 prostate cancer cases, reported that low grade tumors constituted 28.5%, intermediate grade 41.3%, and high grade 30.2% of cases [19]. Similarly, Taborelli et al., analyzing a population-based cohort of over 19,000 prostate cancer patients, observed that low grade tumors accounted for 40.7%, intermediate grade 37.0%, and high grade 22.3% of cases [20]. The predominance of intermediate grade tumors in our cohort reflects the common epidemiological pattern seen in both large-scale meta-analyses and population-based studies, highlighting the relevance of Gleason score 7 as the most frequently encountered tumor grade in clinical practice.

Hypoechoic lesions were observed in 81.3% of malignant cases compared to 37.5% of benign cases ($p < 0.001$), highlighting their strong association with prostate cancer. This finding is consistent with the prospective study by Sharma et al., which reported that hypoechoic lesions on TRUS were significantly associated with higher cancer detection rates and more aggressive tumors, confirming their value as a predictive marker [18]. Similarly, irregular margins and increased vascularity were significantly more common in malignant cases (59.4% vs 37.5%, $p = 0.013$; 53.1% vs 25.0%, $p = 0.001$, respectively), aligning with the observations of Lee et al., who found that shape, margin irregularity, and asymmetrical vascularity on TRUS were strong predictors of malignancy and could help differentiate malignant from benign lesions [21]. In contrast, calcifications were more frequently observed in benign lesions (50.0% vs 12.5%, $p < 0.001$), supporting the notion that while calcifications can occur in both benign and malignant conditions, they are often associated with non-malignant prostatic pathology. These results collectively reinforce the diagnostic value of hypoechoic lesions, margin irregularity, and increased vascularity on TRUS as reliable indicators for identifying prostate cancer in clinical practice.

The diagnostic performance of ultrasound features in detecting prostate cancer was notable in this study. Hypoechoic lesions demonstrated the highest sensitivity at 81.3% and a positive predictive value of 89.7%, with a specificity of 62.5% and a negative predictive value of 45.5%, indicating strong predictive capacity for malignancy. Irregular margins showed moderate sensitivity (59.4%) and specificity (62.5%), with a PPV of 86.4% and an NPV of 27.8%, while increased vascularity exhibited lower sensitivity

(53.1%) but higher specificity (75.0%), with a PPV of 89.5% and NPV of 28.6%. These findings are in line with the prospective study by Khanduri et al., where the combined use of TRUS and color Doppler achieved high sensitivity (100%) and specificity (92.6%) along with elevated PPV and NPV for detecting prostate malignancy [22], highlighting that integrating multiple ultrasound features can improve diagnostic accuracy. Similarly, the study by Yang et al. demonstrated that hypoechoic lesions on TRUS significantly enhanced predictive accuracy, with substantial sensitivity, specificity, PPV, and NPV across different patient subgroups, supporting our observation that hypoechoic lesion detection has robust diagnostic performance [23]. Overall, these results reinforce that hypoechoic lesions, margin irregularity, and increased vascularity are valuable ultrasound markers for identifying prostate cancer, providing both practical and clinically relevant information for guiding further diagnostic evaluation.

The analysis revealed a significant correlation between ultrasound features and Gleason score among malignant cases, with the prevalence of hypoechoic lesions increasing from 50.0% in low grade tumors to 87.1% in intermediate grade and 98.0% in high grade tumors ($p < 0.001$). Similarly, irregular margins were observed in 30.0% of low grade, 64.3% of intermediate, and 76.0% of high grade tumors ($p < 0.001$), while increased vascularity was noted in 20.0%, 60.0%, and 70.0% of low, intermediate, and high grade tumors, respectively ($p < 0.001$). These findings are consistent with Sharma et al., who reported that hypoechoic lesions on TRUS were significantly associated with higher cancer detection rates and more aggressive disease, with a clear tendency for higher Gleason grades among patients with such lesions [18]. In addition, the results align with Zhu et al., who demonstrated that malignant lesions with higher Gleason scores exhibited significantly richer microvascularity compared to lower grade tumors, supporting the observation that increased vascularity on ultrasound correlates with tumor aggressiveness [24]. Collectively, these results underscore the value of specific TRUS features, particularly hypoechoic lesions, irregular margins, and vascularity, as reliable indicators of tumor grade in prostate cancer.

LIMITATIONS

The study was limited to two tertiary care centers in Dhaka, which may reduce the generalizability of the findings to other regions or healthcare settings in Bangladesh. The study relied on conventional TRUS features without incorporating newer imaging techniques or contrast-enhanced methods, which might improve detection and characterization of prostate lesions.

CONCLUSION

Prostate cancer predominantly affects older men and is often associated with characteristic ultrasound features that can aid in its detection. This study demonstrates that hypoechoic lesions, irregular margins, and increased vascularity are strongly associated with both the presence and aggressiveness of prostate cancer. Hypoechoic lesions showed the highest sensitivity and positive predictive value, while increased vascularity was the most specific. These features also correlated with Gleason score, increasing progressively from low- to high-grade tumors. Histopathology confirmed that prostate adenocarcinoma was the predominant diagnosis, with intermediate-grade tumors being most common. Overall, the results support the utility of transrectal ultrasound as a valuable, non-invasive tool for detecting prostate cancer and estimating tumor aggressiveness, providing important guidance for clinical decision-making and patient management.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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