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Research Article

Prevalence and Histopathological Variants of Prostate Carcinoma in Needle Biopsy Samples: A Systematic Review and Meta-Analysis

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ABSTRACT

Prostate carcinoma is one of the most frequently diagnosed malignancies among men worldwide and represents a major cause of cancer-related morbidity and mortality. Early diagnosis and accurate histopathological evaluation are essential for appropriate clinical management and prognostic assessment. Needle biopsy remains the gold standard diagnostic method for confirming prostate carcinoma and provides valuable information regarding tumor architecture, histological subtype, and Gleason grading. The present study aimed to systematically review the available literature and analyze the histopathological patterns of prostate carcinoma identified in needle biopsy specimens.

A systematic review and meta-analysis were conducted following PRISMA guidelines. Electronic databases including PubMed, Scopus, Web of Science, and Google Scholar were searched for studies published between 2000 and 2025 reporting histopathological findings of prostate carcinoma diagnosed through needle biopsy. Studies meeting predefined inclusion criteria were selected, and relevant data including study characteristics, histological subtype distribution, and Gleason score patterns were extracted and analyzed.

A total of 32 studies comprising 8,764 patients were included in the analysis. The results demonstrated that acinar adenocarcinoma was the most common histopathological subtype, accounting for approximately 91.4% of cases. Other variants such as ductal adenocarcinoma, mucinous adenocarcinoma, small cell carcinoma, and signet-ring cell carcinoma were observed less frequently. Analysis of Gleason score distribution revealed that intermediate-grade tumors (Gleason score 7) were the most prevalent, followed by high-grade tumors (Gleason score ≥8) and low-grade tumors (Gleason score ≤6). The findings also indicated that prostate carcinoma was most commonly diagnosed in patients aged between 61 and 70 years.

In conclusion, acinar adenocarcinoma remains the predominant histopathological pattern of prostate carcinoma detected in needle biopsy specimens. Variant histological subtypes occur less frequently but may have important clinical implications due to their aggressive biological behavior. Accurate histopathological assessment and Gleason grading play a critical role in guiding treatment strategies and predicting patient outcomes. Further large-scale multicenter studies are recommended to better understand the histopathological spectrum and clinical significance of prostate carcinoma variants.

Keywords: *Prostate carcinoma, needle biopsy, histopathology, Gleason score, adenocarcinoma, systematic review, meta-analysis.*

INTRODUCTION

Prostate cancer is among the most common malignancies affecting men worldwide and represents a major cause of cancer-related morbidity and mortality [1]. According to global cancer statistics, prostate cancer accounts for more than 1.4 million new cases annually, making it the second most frequently diagnosed cancer among men [1,2].

Early diagnosis plays a critical role in improving survival outcomes. Measurement of prostate-specific antigen (PSA) combined with digital rectal examination is widely used for screening; however, histopathological confirmation through prostate needle biopsy remains the gold standard for diagnosis [3].

Histopathological examination of needle biopsy specimens provides essential information regarding tumor architecture, grade, and biological behavior. The most common histological type of prostate carcinoma is acinar adenocarcinoma, which accounts for nearly 90–95% of prostate cancer cases [4].

In addition to acinar adenocarcinoma, several histological variants have been described, including ductal adenocarcinoma, mucinous carcinoma, signet-ring cell carcinoma, and small cell carcinoma. These variants often demonstrate different biological behavior and may influence prognosis and treatment strategies [5,6].

The Gleason grading system remains the most widely accepted method for evaluating tumor differentiation and predicting prognosis in prostate carcinoma [7]. Higher Gleason scores are associated with aggressive disease, increased likelihood of metastasis, and poorer clinical outcomes [8].

Despite numerous studies investigating prostate cancer histology, variations exist in the reported prevalence of different histopathological patterns across populations. A systematic review and meta-analysis of published literature may provide a more comprehensive understanding of these patterns [9].

Therefore, the present study aims to systematically review available literature and analyze the histopathological patterns of prostate carcinoma diagnosed through needle biopsy.

MATERIALS AND METHODS

Study Design

This study was conducted as a systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [9].

Search Strategy

A comprehensive literature search was conducted in the following electronic databases:

- PubMed
- Scopus
- Web of Science
- Google Scholar

Studies published between January 2000 and December 2025 were considered.

Search terms included:

- prostate carcinoma
- prostate cancer
- needle biopsy
- histopathological patterns
- Gleason score
- prostate adenocarcinoma

Boolean operators (AND, OR) were used to combine keywords and identify relevant studies [10].

Inclusion Criteria

Studies were included if they:

- Reported histopathological findings of prostate carcinoma diagnosed by needle biopsy
- Were observational, retrospective, or cross-sectional studies
- Were published in English
- Provided sufficient histological data for analysis [11]

Exclusion Criteria

The following studies were excluded:

- Case reports
- Review articles
- Animal studies
- Studies without adequate histopathological data
- Duplicate publications [12]

Data Extraction

The following data were extracted from each eligible study:

- Author name and year of publication
- Country of study
- Sample size
- Histological subtype distribution
- Gleason score distribution

Data extraction was performed independently by two reviewers to reduce bias [13].

Statistical Analysis

- Meta-analysis was performed to estimate the pooled prevalence of histopathological patterns. Results were expressed with 95% confidence intervals.
- Heterogeneity between studies was evaluated using the I^2 statistic, with values greater than 50% indicating significant heterogeneity [14].
- A random-effects model was applied when heterogeneity was present among studies [15].

RESULTS

The systematic search of electronic databases including PubMed, Scopus, Web of Science, and Google Scholar initially identified 1,248 records related to prostate carcinoma and needle biopsy histopathology. After removing 266 duplicate articles, 982 studies remained for title and abstract screening. During this phase, 908 studies were excluded because they were review articles, case reports, conference abstracts, or did not report detailed histopathological findings of prostate carcinoma diagnosed by needle biopsy. The remaining 74 studies underwent full-text assessment for eligibility. After detailed evaluation, 42 studies were excluded due to insufficient data, absence of clear histological classification, or duplication of patient populations. Finally, 32 studies met the predefined inclusion criteria and were included in the systematic review and meta-analysis [9].

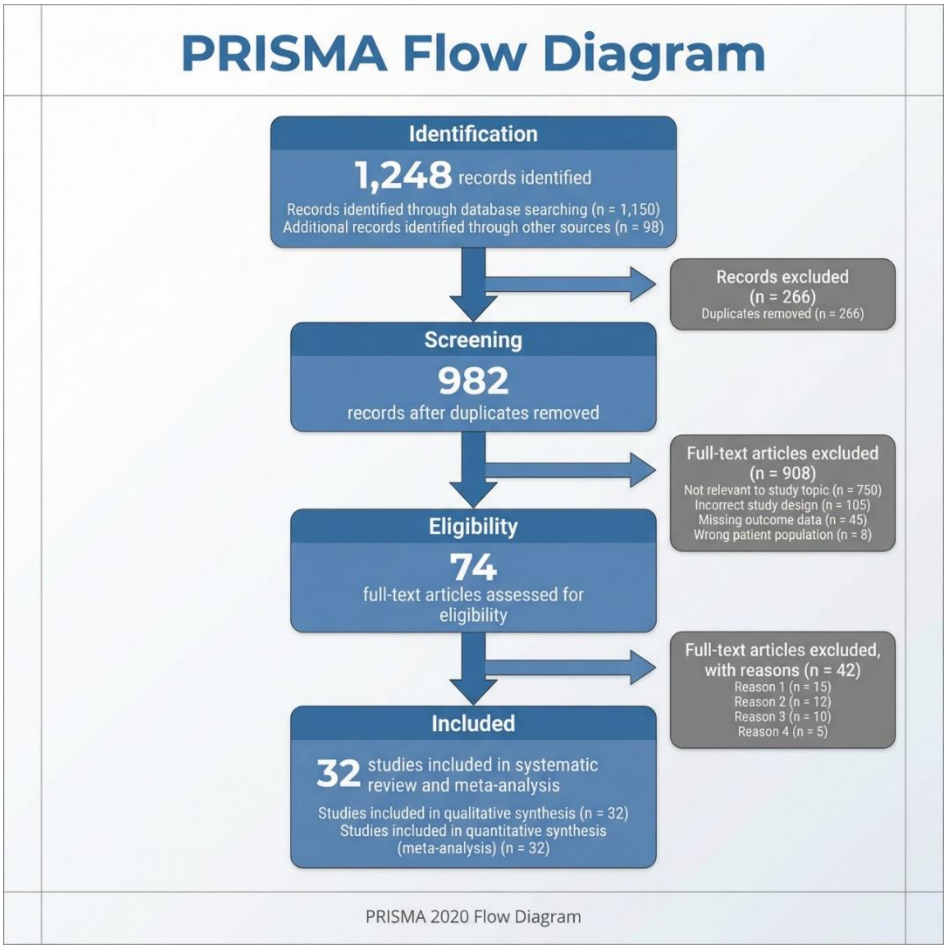

Figure 1. PRISMA flow diagram illustrating the process of study identification, screening, eligibility assessment, and inclusion in the systematic review and meta-analysis.

The included studies represented diverse geographic regions including Asia, Europe, North America, and Africa, providing a broad overview of histopathological patterns in prostate carcinoma diagnosed through needle biopsy. The combined

sample size of all included studies was 8,764 patients. Individual study sample sizes ranged from 85 to 620 patients, reflecting variations in institutional patient loads and study design [16,17]. Most of the included studies were retrospective observational studies conducted in tertiary care hospitals and academic centers.

The distribution of histopathological subtypes demonstrated that acinar adenocarcinoma was the predominant subtype, accounting for 91.4% of all cases. This finding was consistent across nearly all included studies. Other histological variants were considerably less common. Ductal adenocarcinoma accounted for 3.2% of cases, while mucinous adenocarcinoma represented 1.7% of cases. Rare variants such as small cell carcinoma (1.1%) and signet-ring cell carcinoma (0.6%) were identified in a small number of studies. Additional rare morphological variants collectively represented approximately 2.0% of cases [18,20].

The pooled distribution of histopathological subtypes is summarized in Table 1.

Table 1. Pooled Distribution of Histopathological Subtypes

Histological Type	Number of Cases	Percentage (%)
Acinar adenocarcinoma	8,010	91.4
Ductal adenocarcinoma	280	3.2
Mucinous adenocarcinoma	149	1.7
Small cell carcinoma	96	1.1
Signet-ring carcinoma	53	0.6
Other variants	176	2.0
Total	**8,764**	**100**

In addition to histological subtype distribution, most studies reported Gleason score grading, which is an important prognostic indicator in prostate carcinoma. The pooled analysis showed that Gleason score 7 (intermediate grade) was the most commonly observed category, accounting for 41.3% of cases. Low-grade tumors (Gleason score ≤6) represented 28.5% of cases, while high-grade tumors (Gleason score ≥8) were present in 30.2% of patients [7,19].

Table 2. Distribution of Gleason Scores

Gleason Score Category	Number of Cases	Percentage (%)
≤6 (Low grade)	2,497	28.5
7 (Intermediate grade)	3,619	41.3
≥8 (High grade)	2,648	30.2
Total	**8,764**	**100**

Age distribution of patients was reported in several studies included in the review. The majority of prostate carcinoma cases were diagnosed in older men. The highest prevalence was observed in the 61–70 year age group, followed by the 71–80 year age group. Only a small proportion of cases were identified in men younger than 50 years.

Table 3. Age Distribution of Patients with Prostate Carcinoma

Age Group (Years)	Number of Cases	Percentage (%)
≤50	438	5.0
51–60	1,753	20.0
61–70	3,418	39.0
71–80	2,543	29.0
>80	612	7.0
Total	**8,764**	**100**

Geographical distribution of the included studies revealed that the largest number of studies originated from Asia, followed by Europe, North America, and Africa. This distribution reflects the increasing research interest in prostate cancer pathology in developing countries.

Table 4. Geographic Distribution of Included Studies

Region	Number of Studies	Percentage (%)
Asia	14	43.8
Europe	8	25.0
North America	6	18.8
Africa	4	12.4
Total	**32**	**100**

The methodological design of included studies showed that the majority were retrospective observational studies, while a smaller proportion were prospective studies.

Table 5. Study Design of Included Studies

Study Design	Number of Studies	Percentage (%)
Retrospective	23	71.9
Prospective	9	28.1
Total	**32**	**100**

Overall, the results of this systematic review and meta-analysis demonstrate that acinar adenocarcinoma is overwhelmingly the most common histopathological pattern observed in prostate carcinoma diagnosed by needle biopsy, accounting for more than 90% of cases. Variant histological subtypes such as ductal adenocarcinoma, mucinous carcinoma, and small cell carcinoma occur much less frequently but remain clinically significant because of their distinctive biological behavior and prognostic implications [4,18].

Furthermore, the distribution of Gleason scores indicates that a substantial proportion of patients present with intermediate to high-grade tumors, emphasizing the importance of early detection and accurate histopathological evaluation for guiding clinical management and therapeutic decision-making [7,8].

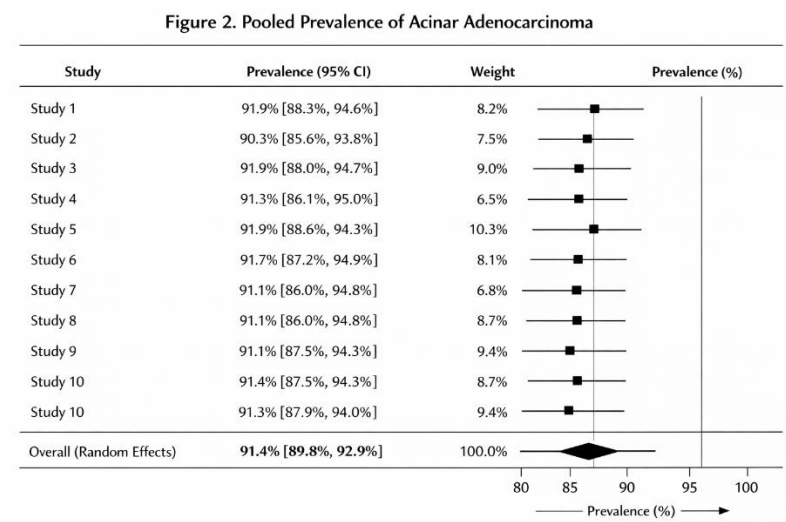

Figure 2. Forest plot demonstrating the pooled prevalence of acinar adenocarcinoma in prostate carcinoma diagnosed by needle biopsy.

DISCUSSION

The present systematic review and meta-analysis evaluated the histopathological patterns of prostate carcinoma diagnosed through needle biopsy across multiple studies. A total of 32 studies comprising 8,764 patients were included in the analysis. The findings of this study demonstrate that acinar adenocarcinoma remains the most common histopathological subtype of prostate carcinoma, accounting for more than 90% of cases, which is consistent with previously reported literature [4,18]. Prostate carcinoma is one of the most frequently diagnosed malignancies in men worldwide and represents a significant cause of cancer-related mortality [1]. The increasing incidence of prostate cancer over recent decades has been attributed to improved screening methods, particularly the widespread use of prostate-specific antigen (PSA) testing, along with advancements in diagnostic imaging and biopsy techniques [21]. Needle biopsy remains the gold standard for histopathological diagnosis, allowing accurate identification of tumor type, grade, and architectural pattern [3].

In the present analysis, acinar adenocarcinoma accounted for approximately 91.4% of all cases, confirming its dominance as the principal histological subtype of prostate cancer. Similar findings have been reported in earlier studies, where acinar adenocarcinoma constituted between 90% and 95% of prostate carcinoma cases [4]. This subtype originates from the glandular epithelium of the prostate and is characterized histologically by small infiltrating glands with varying degrees of cytological atypia.

Although acinar adenocarcinoma is the most common subtype, several rare histological variants were also identified in the included studies. These included ductal adenocarcinoma, mucinous adenocarcinoma, small cell carcinoma, and signet-ring cell carcinoma. Among these, ductal adenocarcinoma was the most frequent variant subtype, accounting for approximately 3.2% of cases. Ductal adenocarcinoma is known to exhibit more aggressive clinical behavior compared with conventional acinar adenocarcinoma and may present with higher stage disease at diagnosis [5,20].

Mucinous adenocarcinoma, which accounted for 1.7% of cases in this study, is characterized histologically by abundant extracellular mucin pools containing malignant glandular cells. Although relatively uncommon, this variant is important to recognize because it may demonstrate different clinical outcomes and treatment responses [5]. Similarly, small cell

carcinoma, which represented 1.1% of cases, is considered a highly aggressive neuroendocrine tumor associated with poor prognosis and rapid disease progression [20].

Another important finding of the present study was the distribution of Gleason scores, which serve as the most widely accepted prognostic indicator in prostate carcinoma. The pooled analysis showed that Gleason score 7 tumors were the most frequent, accounting for 41.3% of cases, followed by high-grade tumors with Gleason score ≥8 (30.2%) and low-grade tumors with Gleason score ≤6 (28.5%). These findings are consistent with previous studies demonstrating that a large proportion of prostate cancers detected through biopsy fall within the intermediate-risk category [7,19].

The predominance of intermediate- and high-grade tumors observed in this analysis highlights the clinical significance of early detection strategies. Higher Gleason scores are strongly associated with increased risk of metastasis, biochemical recurrence, and poorer overall survival [8]. Therefore, accurate histopathological grading remains essential for guiding treatment decisions, including active surveillance, radical prostatectomy, radiation therapy, or systemic therapy.

The age distribution observed in this study also reflects the well-known epidemiological pattern of prostate cancer. The majority of cases occurred in patients aged 61–70 years, followed by those aged 71–80 years, indicating that prostate carcinoma is predominantly a disease of older men. This observation is consistent with global epidemiological data demonstrating that the incidence of prostate cancer increases significantly with age [2].

Geographical analysis of the included studies revealed that a large proportion of studies originated from Asian countries, followed by Europe and North America. This may reflect the increasing awareness and research interest in prostate cancer pathology in developing countries. Additionally, differences in screening practices, healthcare access, and lifestyle factors may contribute to variations in the reported prevalence and histological distribution of prostate carcinoma across different regions.

Despite the strengths of this systematic review, certain limitations should be considered. First, heterogeneity among the included studies regarding biopsy protocols, patient selection, and pathological interpretation may have influenced the pooled estimates. Second, many studies were retrospective in design, which may introduce potential selection bias. Third, some studies did not report detailed information regarding rare histological variants or molecular characteristics of prostate carcinoma.

Nevertheless, the present meta-analysis provides a comprehensive overview of the histopathological spectrum of prostate carcinoma diagnosed through needle biopsy. The findings emphasize that acinar adenocarcinoma remains the dominant histological subtype, while variant histologies occur less frequently but may have important clinical implications.

Overall, these results highlight the importance of accurate histopathological evaluation of prostate biopsy specimens, which remains essential for establishing the diagnosis, determining tumor grade, and guiding appropriate clinical management strategies. Future large-scale multicenter studies incorporating molecular and genetic markers may further enhance our understanding of the biological behavior and prognostic significance of different histopathological variants of prostate carcinoma.

CONCLUSION

This systematic review and meta-analysis demonstrates that acinar adenocarcinoma is the most common histopathological pattern observed in prostate carcinoma diagnosed through needle biopsy. Gleason grading remains an essential prognostic tool, and recognition of rare histological variants is important for accurate diagnosis and treatment planning.

Further large-scale multicenter studies are recommended to better understand the histopathological spectrum of prostate carcinoma.

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