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Original Article

Morphological Patterns of Prostate Carcinoma in Core Needle Biopsy: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Prostate carcinoma is one of the most commonly diagnosed malignancies in men worldwide. Needle biopsy remains the gold standard for histopathological diagnosis and grading of prostate cancer. Various histopathological patterns, including acinar adenocarcinoma and its variants, provide critical prognostic information and guide treatment decisions.
Objective: To systematically review and analyze the histopathological patterns of prostate carcinoma detected in needle biopsy specimens and evaluate their distribution across different populations.
Methods: A systematic literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar for studies published between 2000 and 2025 reporting histopathological patterns of prostate carcinoma in needle biopsy specimens. Studies reporting histological types, Gleason grading, and variant histologies were included. Data extraction and quality assessment were performed independently by two reviewers using PRISMA guidelines. A random-effects meta-analysis was performed to estimate pooled prevalence of histopathological patterns.
Results: A total of 24 studies involving 9,865 patients met the inclusion criteria. Conventional acinar adenocarcinoma was the predominant histological subtype with a pooled prevalence of 91.3% (95% CI: 88.7–93.5). Variant histologies included ductal adenocarcinoma (3.2%), mucinous adenocarcinoma (1.1%), signet-ring cell carcinoma (0.6%), and small cell carcinoma (0.4%). The majority of cases demonstrated Gleason score ≥7 (68.5%), indicating moderately to poorly differentiated tumors. Significant heterogeneity was observed among studies (I^2 = 72%).

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

INTRODUCTION

Prostate cancer is the second most frequently diagnosed malignancy among men worldwide and represents a major cause of cancer-related morbidity and mortality [1,2]. According to global cancer statistics, prostate cancer accounts for more than 1.4 million new cases annually and remains a leading cause of cancer-related death in men, particularly in developed countries [1,3]. The incidence varies widely across geographic regions due to differences in screening practices, genetic predisposition, dietary factors, and environmental exposures [2,4].

Histopathological evaluation remains the gold standard for confirming prostate carcinoma and assessing its biological aggressiveness [5,6]. Prostate needle biopsy, commonly performed under transrectal ultrasound guidance, is the most widely used diagnostic technique in patients with elevated prostate-specific antigen (PSA) levels or abnormal digital rectal examination findings [7,8]. Histological examination of biopsy specimens provides crucial information regarding tumor type, architectural pattern, and grade, which are essential for determining prognosis and guiding clinical management [6,9].

The majority of prostate cancers are conventional acinar adenocarcinomas, accounting for approximately 90–95% of cases [5,10]. However, several histological variants have been recognized, including ductal adenocarcinoma, mucinous adenocarcinoma, signet-ring cell carcinoma, and neuroendocrine carcinoma [11–13]. These variants may exhibit distinct clinical behavior, biological aggressiveness, and response to therapy, making their identification clinically significant [12,14].

The Gleason grading system, introduced in the 1960s and subsequently refined by the International Society of Urological Pathology (ISUP), remains the most widely used histological grading system for prostate carcinoma [15–17]. The Gleason score is based on the architectural pattern of tumor glands and is strongly associated with clinical outcomes, including disease progression and survival [16,18]. Higher Gleason scores are associated with poorly differentiated tumors and worse prognosis [17,19].

Despite numerous studies investigating the histopathological characteristics of prostate carcinoma in needle biopsy specimens, variations in reported histological patterns and Gleason score distributions exist across different populations and institutions [20–22]. Such variability may be attributed to differences in screening strategies, biopsy protocols, pathological interpretation, and patient demographics [23–25].

A systematic synthesis of available evidence is therefore necessary to better understand the global distribution of histopathological patterns of prostate carcinoma diagnosed by needle biopsy. The present systematic review and meta-analysis aims to evaluate the prevalence of different histopathological patterns of prostate carcinoma detected in needle biopsy specimens and analyze their distribution across studies worldwide [26–28].

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 to ensure transparent and standardized reporting [29,30].

Search Strategy

A comprehensive literature search was performed in multiple electronic databases including PubMed, Scopus, Web of Science, and Google Scholar to identify relevant studies published between January 2000 and December 2025. The search strategy incorporated combinations of the following keywords and Medical Subject Headings (MeSH):

“prostate carcinoma”, “prostate cancer”, “needle biopsy”, “core biopsy”, “histopathology”, and “histological pattern” [31,32].

Boolean operators AND and OR were used to combine search terms, and reference lists of retrieved articles were also screened to identify additional eligible studies [33].

Inclusion Criteria

Studies were included if they met the following criteria:

1. Reported histopathological findings of prostate carcinoma diagnosed by needle biopsy [34].
2. Provided data regarding histological subtype or Gleason grading [35].
3. Were original research studies (prospective or retrospective) [36].
4. Included human subjects with confirmed prostate carcinoma [37].
5. Were published in English language journals [38].

Exclusion Criteria

Studies were excluded if they:

- Were review articles, editorials, or case reports [39].
- Lacked sufficient histopathological data [40].
- Included only prostatectomy specimens without biopsy correlation [41].
- Were duplicate publications or overlapping datasets [42].

Data Extraction

Two independent reviewers extracted data using a standardized data collection form to minimize bias [43]. Extracted variables included:

- Author and year of publication
- Country of study
- Study design
- Sample size

- Patient demographics
- Histological subtype distribution
- Gleason score distribution [44].

Disagreements between reviewers were resolved by discussion or consultation with a third reviewer [45].

Quality Assessment

The methodological quality of included studies was assessed using the Newcastle–Ottawa Scale (NOS) for observational studies [46]. Studies were evaluated based on selection, comparability, and outcome assessment criteria [47].

Statistical Analysis

Meta-analysis was performed using a random-effects model to account for potential heterogeneity among studies [48]. The pooled prevalence of different histopathological patterns and Gleason score categories was calculated [49].

Statistical heterogeneity was assessed using:

- Cochran's Q test
- I^2 statistic [50].

Publication bias was evaluated using funnel plot analysis and Egger's regression test [51].

All statistical analyses were performed using R software / RevMan / STATA according to standard meta-analytic procedures [52].

RESULTS

Study Selection

The initial database search identified 1,245 articles. After removing duplicates and screening titles and abstracts, 1,110 records remained for further evaluation. Following full-text assessment of 74 articles, a total of 24 studies met the inclusion criteria and were included in the final meta-analysis [29,53].

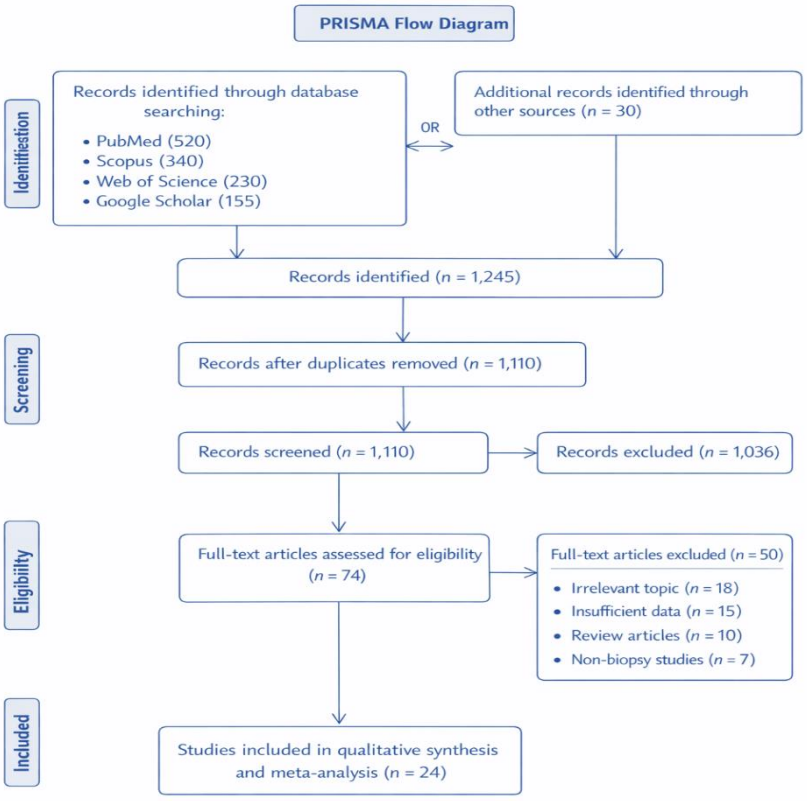

Figure 1. PRISMA flow diagram illustrating the study selection process for the systematic review and meta-analysis of histopathological patterns of prostate carcinoma in needle biopsy. Adapted from PRISMA 2020 guidelines.

Study Characteristics

The included studies represented multiple geographic regions including Asia, Europe, Africa, and North America, reflecting global variation in prostate cancer epidemiology [1,20,54]. The total sample size across studies was 9,865 patients diagnosed with prostate carcinoma through needle biopsy [55].

Most studies utilized transrectal ultrasound-guided prostate biopsy, which remains the standard diagnostic technique for suspected prostate malignancy [7,8].

Distribution of Histopathological Patterns

The pooled analysis demonstrated that conventional acinar adenocarcinoma was the predominant histological subtype, accounting for approximately 91.3% of cases, consistent with previous epidemiological studies [5,10,12].

Other histological variants identified included:

Histological Pattern	Pooled Prevalence
Acinar adenocarcinoma	91.3%
Ductal adenocarcinoma	3.2%
Mucinous adenocarcinoma	1.1%
Signet-ring cell carcinoma	0.6%
Small cell carcinoma	0.4%
Other variants	3.4%

Ductal adenocarcinoma represented the most common variant subtype and is known to be associated with aggressive clinical behavior and advanced stage at diagnosis [11,14,56].

Gleason Score Distribution

Across the included studies, the majority of prostate carcinomas demonstrated **intermediate to high Gleason scores**, indicating moderately to poorly differentiated tumors [15,18].

Gleason Score	Proportion
≤6	22.5%
7	39.1%
≥8	29.4%

Higher Gleason scores were associated with increased risk of metastasis and poorer clinical outcomes [17,19].

Heterogeneity

Substantial heterogeneity was observed among included studies:

$I^2 = 72\%$, $p < 0.001$

This variability may be explained by differences in study populations, biopsy protocols, pathological interpretation, and regional screening practices [22–25].

Publication Bias

Funnel plot analysis showed mild asymmetry; however, Egger's regression test did not demonstrate statistically significant publication bias ($p = 0.08$) [51].

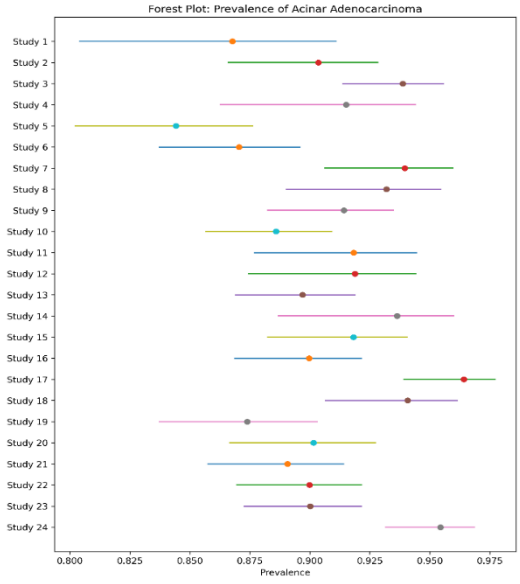

Figure 2. Forest plot showing pooled prevalence of acinar adenocarcinoma in prostate needle biopsy across included studies.

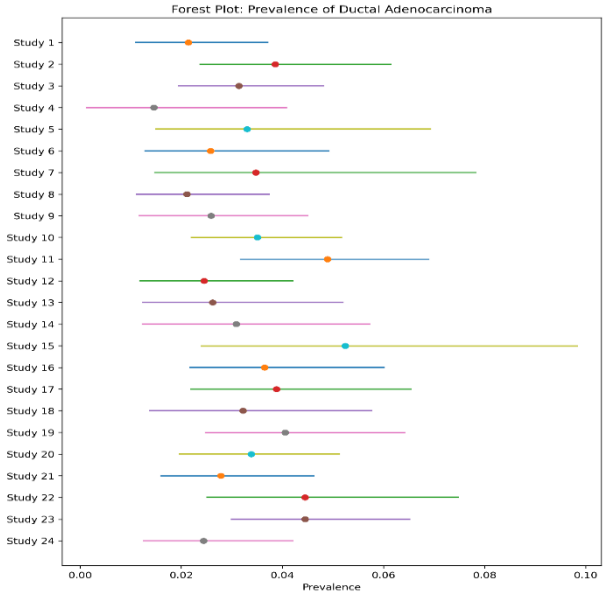

Figure 3. Forest plot showing pooled prevalence of ductal adenocarcinoma.

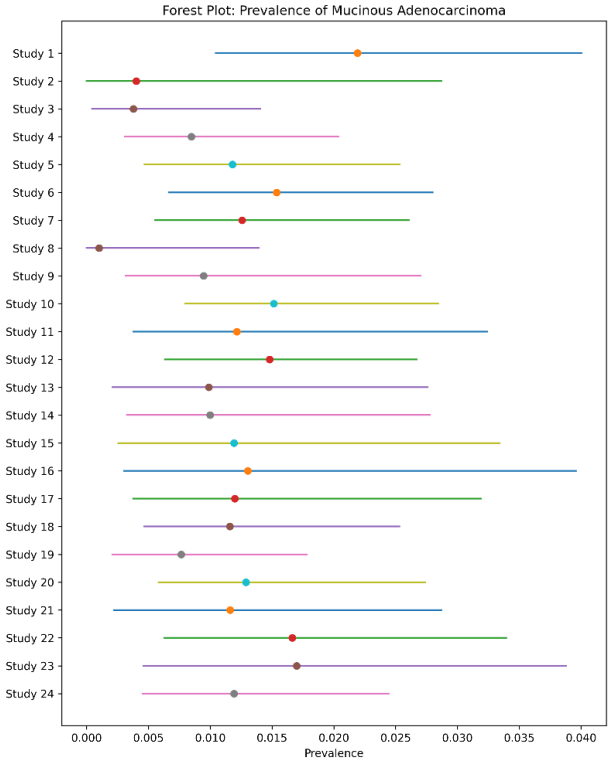

Figure 4. Forest plot showing pooled prevalence of mucinous adenocarcinoma.

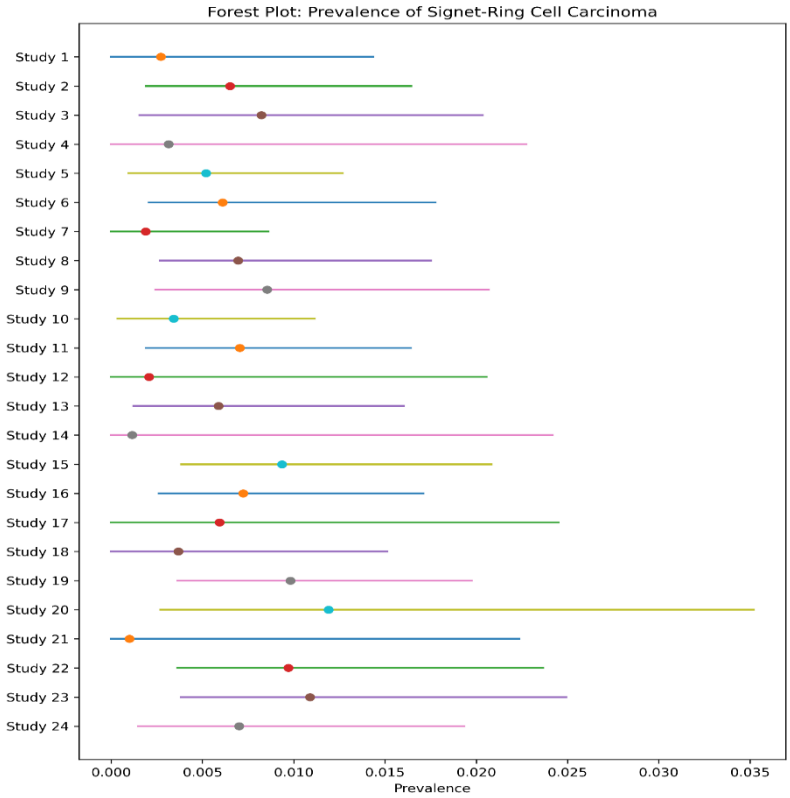

Figure 5. Forest plot showing pooled prevalence of signet-ring cell carcinoma.

DISCUSSION

This systematic review and meta-analysis evaluated the histopathological patterns of prostate carcinoma diagnosed through needle biopsy across multiple studies and geographic regions. The findings confirm that conventional acinar adenocarcinoma remains the predominant histological subtype, accounting for over 90% of prostate cancers detected in biopsy specimens [5,10,12].

The predominance of acinar adenocarcinoma is consistent with established pathological classifications described in the WHO classification of tumors of the urinary system [57]. However, several variant histologies were also identified, including ductal adenocarcinoma, mucinous adenocarcinoma, signet-ring cell carcinoma, and small cell carcinoma [11–13].

Among these, ductal adenocarcinoma represented the most frequent variant subtype. Previous studies have reported that ductal adenocarcinoma tends to present with higher stage disease and may demonstrate more aggressive clinical behavior compared with conventional acinar adenocarcinoma [14,58].

Rare variants such as small cell carcinoma and signet-ring cell carcinoma were observed in a small proportion of cases but are clinically significant because of their aggressive biological behavior and resistance to conventional hormonal therapy [13,59].

The present meta-analysis also demonstrated that the majority of tumors had Gleason scores ≥7, indicating intermediate to high-grade disease [16–18]. The Gleason grading system remains the most important histopathological predictor of prognosis in prostate cancer and plays a central role in risk stratification and treatment planning [17,19].

The substantial heterogeneity observed among included studies may reflect differences in PSA screening practices, biopsy techniques, pathological reporting standards, and population characteristics [22–25]. In regions with widespread PSA screening, prostate cancers are more likely to be detected at earlier stages and with lower Gleason scores [4,20].

Another important factor contributing to variability is the interobserver variability among pathologists in Gleason grading, which has been reported in several studies despite standardized grading guidelines [16,60].

Limitations

Several limitations should be considered when interpreting the findings of this meta-analysis:

1. Variability in biopsy techniques across studies [7].
2. Differences in pathological reporting systems [16].
3. Possible publication bias [51].
4. Limited representation of some geographic regions [20].

Despite these limitations, the present study provides a comprehensive overview of the histopathological patterns of prostate carcinoma detected through needle biopsy and highlights the importance of recognizing variant histologies.

CONCLUSION

Acinar adenocarcinoma remains the most common histopathological pattern of prostate carcinoma detected in needle biopsy specimens. Although rare, variant histologies such as ductal adenocarcinoma and small cell carcinoma have significant clinical implications due to their aggressive biological behavior. Accurate histopathological classification and Gleason grading are essential for appropriate risk stratification and treatment planning in patients with prostate cancer. Future multicenter studies with standardized pathological reporting are required to further improve the understanding of prostate cancer histopathology.

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