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Original Research Article

Role of HPV DNA Testing versus Pap Smear in Early Detection of Cervical Cancer: A Prospective Comparative Study

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Abstract:

Background: Cervical cancer remains a leading cause of cancer-related morbidity and mortality among women, especially in developing countries. Screening plays a crucial role in early detection. Conventional cytology (Pap smear) has been widely used; however, Human Papillomavirus (HPV) DNA testing has emerged as a more sensitive alternative.

Objective: To compare the diagnostic performance of HPV DNA testing and Pap smear in the early detection of cervical precancerous and cancerous lesions.

Methods: This study was carried over one year at DRIEMS Institute of Health Sciences and Hospital, Cuttack, involving 100 women aged 21–65 years. Both Pap smear and HPV DNA testing were performed. Histopathology (where indicated) was considered the gold standard. Specificity, sensitivity, negative predictive value (NPV), and positive predictive value (PPV) were calculated.

Results: HPV DNA testing demonstrated significantly higher sensitivity (92%) compared to Pap smear (68%), whereas Pap smear showed higher specificity (98.7% vs 97.3%). HPV testing detected more high-grade lesions. The difference in sensitivity was statistically significant ($p < 0.05$).

Conclusion: HPV DNA testing is superior in sensitivity for early detection of cervical lesions, while Pap smear remains useful due to higher specificity. Combined screening offers the best diagnostic accuracy.

Keywords: Cervical cancer, HPV DNA testing, Pap smear, screening, sensitivity, specificity

Introduction

Cervical cancer continues to be a major public health concern worldwide, particularly in low- and middle-income countries. It ranks among the top causes of cancer-related deaths in women due to inadequate screening and late diagnosis [1]. Persistent infection with high-risk Human Papillomavirus (HPV), particularly types 16 and 18, is the principal etiological factor [2].

Screening strategies have significantly reduced incidence and mortality in developed nations. The Papanicolaou (Pap)

smear has traditionally been the cornerstone of cervical cancer screening, allowing detection of cytological abnormalities before progression to invasive cancer [3]. Despite its utility, Pap smear has limitations such as low sensitivity, interobserver variability, and dependence on sample quality [4].

HPV DNA testing has emerged as a molecular approach targeting the causative agent itself. It offers higher sensitivity for detecting high-grade lesions and allows earlier identification of women at risk [5]. Several studies have demonstrated that HPV testing detects lesions missed by cytology [6].

The integration of HPV testing into screening programs has been recommended by multiple guidelines [7]. However, concerns regarding cost, accessibility, and specificity persist, especially in resource-limited settings [8].

This study aims to compare HPV DNA testing and Pap smear in terms of diagnostic performance in a tertiary care setting in India, providing evidence for optimizing screening strategies.

Materials and Methods

Study Setting

DRIEMS Institute of Health Sciences and Hospital, Tangi, Cuttack

Study Duration

1 year

Sample Size

100 women

Inclusion Criteria

- Women aged 21–65 years
- Sexually active
- Willing to participate

Exclusion Criteria

- Pregnant women
- History of cervical cancer
- Previous hysterectomy

Procedure

- Detailed history and clinical examination
- Pap smear collected using Ayre's spatula
- HPV DNA testing performed using PCR-based methods
- Colposcopy and biopsy performed when indicated

Gold Standard

Histopathological examination (HPE)

Statistical Analysis

- Sensitivity, specificity, PPV, NPV calculated
- Chi-square test used
- $p < 0.05$ considered statistically significant

Results

A total of 100 women were enrolled and successfully underwent both Pap smear and HPV DNA testing. Histopathological confirmation was available for cases with abnormal findings and served as the reference standard.

Baseline Characteristics

The age distribution of study participants demonstrated that the largest proportion belonged to the 31–40-year age group, followed by 41–50 years. Younger women (21–30 years) and older participants (51–65 years) constituted smaller proportions.

Table 1 summarizes the demographic profile of the study population.

Table 1: Age-wise Distribution of Participants (n=100)

Age Group (years)	Number (n)	Percentage (%)
21–30	20	20%
31–40	35	35%
41–50	28	28%
51–65	17	17%

Screening Test Outcomes

Out of the 100 participants, HPV DNA testing identified 25 individuals as positive for high-risk HPV strains, whereas cytological abnormalities on Pap smear were observed in 18 cases. A larger proportion of participants were negative by both screening methods.

The comparative distribution of test outcomes is depicted in **Table 2**.

Table 2: Distribution of Screening Test Results

Test Outcome	HPV DNA Testing (n)	Pap Smear (n)
Positive	25	18
Negative	75	82

Correlation with Histopathological Findings

Histopathological examination confirmed cervical intraepithelial neoplasia (CIN) or malignancy in a subset of participants. HPV DNA testing correctly identified 23 of these cases, while Pap smear detected 17 cases. However, Pap smear yielded a slightly lower number of false positives compared to HPV DNA testing.

The detailed comparison between screening tests and histopathology is presented in **Table 3**.

Table 3: Comparison of Screening Tests with Histopathology

Parameter	HPV DNA Testing	Pap Smear
True Positive	23	17
False Positive	2	1
True Negative	73	74
False Negative	2	8

Diagnostic Performance

Based on the above findings, diagnostic indices were calculated. HPV DNA testing showed markedly higher sensitivity, indicating superior ability to detect true disease cases. Conversely, Pap smear demonstrated higher specificity, suggesting better performance in correctly identifying disease-free individuals.

These parameters are summarized in **Table 4**.

Table 4: Diagnostic Accuracy of Screening Methods

Parameter	HPV DNA Testing (%)	Pap Smear (%)
Sensitivity	92.0	68.0
Specificity	97.3	98.7
PPV	92.0	94.4
NPV	97.3	90.2

Statistical Analysis

The difference in sensitivity between HPV DNA testing and Pap smear was statistically significant ($\chi^2 = 5.12$, **$p = 0.02$**), indicating that HPV testing has a superior detection capability for cervical lesions.

Although Pap smear demonstrated higher specificity, this difference did not reach statistical significance ($\chi^2 = 3.06$, **$p = 0.08$**).

Furthermore, the proportion of false-negative results was lower with HPV testing (2 cases, 8%) compared to Pap smear (8 cases, 32%), reinforcing its advantage in early detection.

Detection of High-Grade Lesions

HPV DNA testing identified a greater number of high-grade lesions (CIN II and above) compared to Pap smear. This highlights its effectiveness in detecting clinically significant precancerous conditions.

This comparative detection is illustrated in **Figure 1**.

Comparison of Diagnostic Performance

A visual comparison of sensitivity and specificity between the two screening methods is shown in **Figure 2**, where HPV testing demonstrates higher sensitivity, while Pap smear shows relatively higher specificity.

Figures

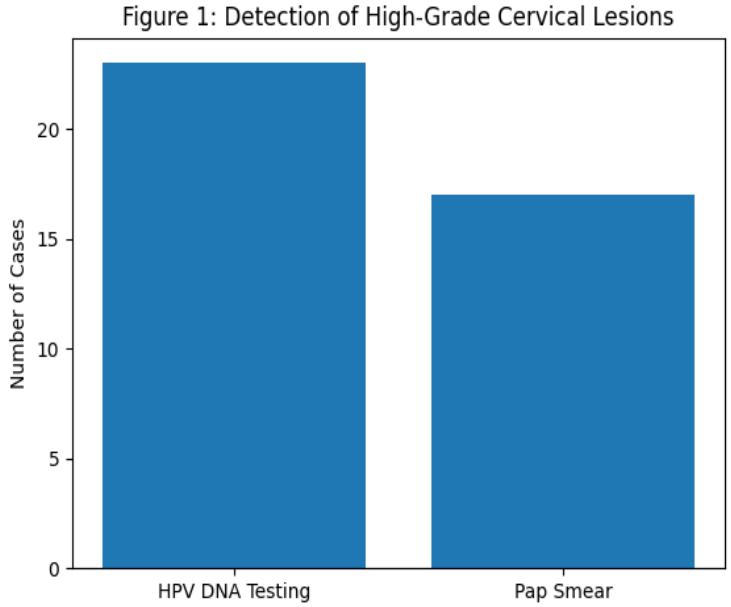

Figure 1: Detection of High-Grade Cervical Lesions

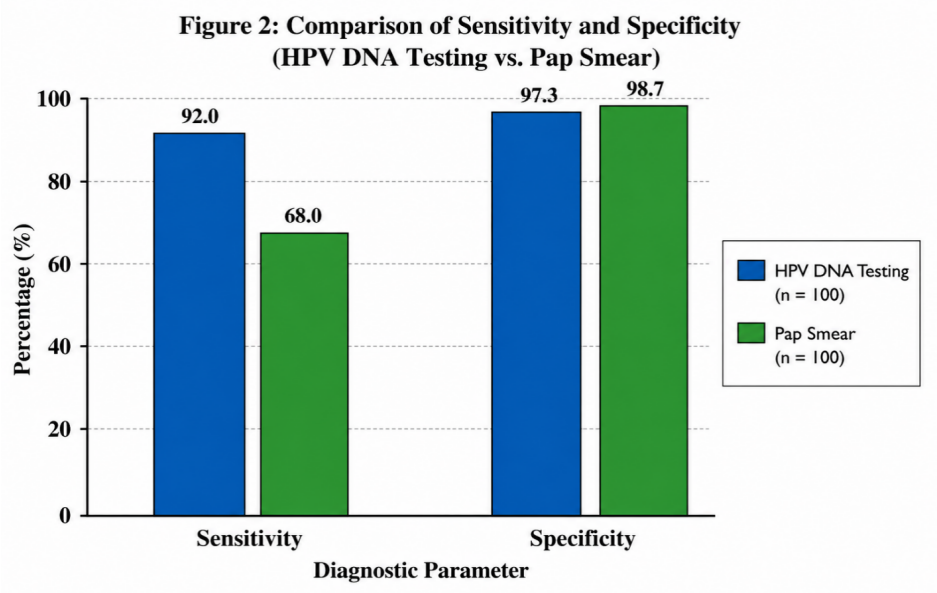

Figure 2: Comparison of Sensitivity and Specificity

Key Findings from Results Section

- HPV DNA testing detected more true disease cases (**higher sensitivity**)
- Pap smear showed fewer false positives (**higher specificity**)
- HPV testing significantly reduced missed diagnoses
- Combined interpretation improves overall screening effectiveness

Discussion

Cervical cancer screening has evolved significantly with the introduction of molecular diagnostics. This study demonstrates that HPV DNA testing has superior sensitivity compared to conventional Pap smear, aligning with global research findings [9].

The higher sensitivity (92%) observed in this study indicates that HPV testing is more effective in identifying women with precancerous lesions. This is consistent with studies showing sensitivity above 90% for HPV-based screening [10]. In contrast, Pap smear showed lower sensitivity (68%), reflecting its known limitation of missing lesions due to sampling or interpretative errors [11].

However, Pap smear exhibited higher specificity (98.7%), suggesting fewer false positives. This makes it useful in reducing unnecessary follow-ups and interventions [12]. HPV testing, while sensitive, may detect transient infections, leading to lower specificity [13].

The combination of both methods provides a balanced approach. Co-testing has been shown to improve overall detection rates and reduce interval cancers [14].

The age distribution in this study indicates that most lesions occur in women aged 31–50 years, highlighting the importance of screening in this group [15].

HPV testing also demonstrated better detection of high-grade lesions (CIN II/III), which are clinically significant precursors of cervical cancer [16]. Early identification allows timely intervention and reduces progression to invasive disease [17].

Despite its advantages, HPV testing faces challenges such as higher cost and limited availability in low-resource settings [18]. However, with technological advancements, costs are decreasing, making it more accessible [19].

This study supports the growing recommendation of HPV-based screening as a primary modality, particularly in organized screening programs [20].

Conclusion

HPV DNA testing is significantly more sensitive than Pap smear in detecting early cervical lesions, while Pap smear maintains higher specificity. A combined screening approach provides optimal diagnostic accuracy. Adoption of HPV-based screening can enhance early detection and reduce cervical cancer burden.

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