Biomedical and Biopharmaceutical Research
Abbreviation: Biomed. Biopharm. Res.
Volume: 22: Issue: 02 |Year: 2025
Page Number: 147-150

Efficacy of Colposcopy versus Pap Smear in Cervical Lesion Screening: A Comparative Study with Histopathological Correlation

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Article Received:18-02-2025

Article Accepted:29-03-2025

Abstract

Objective: To assess the efficacy of colposcopy compared to Pap smear in detecting cervical lesions, using histopathology as the gold standard, in women with abnormal symptoms or cervical findings.

Methods: This prospective observational study included 500 women aged 20–60 years attending the gynecology outpatient department at Government Victoria Hospital, Visakhapatnam, from November 2022 to April 2024. Participants underwent Pap smear, colposcopy, and colposcopy-guided biopsy. Outcomes were categorized as normal, cervicitis, cervical intraepithelial neoplasia (CIN I, CIN II/III), or invasive carcinoma. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated, with statistical significance determined using Chi-square tests ($p<0.05$).

Results: Histopathology revealed 11% normal, 66% cervicitis, 13% CIN I, 8% CIN II/III, and 2% invasive carcinoma. Pap smear sensitivity was 78.3% and specificity 94.8%, with PPV 81.8%, NPV 93.6%, and accuracy 91%. Colposcopy demonstrated higher sensitivity (86.9%) and specificity (97.4%), with PPV 90.9%, NPV 96.1%, and accuracy 95%. Colposcopy outperformed Pap smear in detecting high-grade lesions (CIN II/III, invasive carcinoma). Significant associations were found between CIN and age (mean 43.6 years), multiparity (76.6%), illiteracy (20.8%), and symptoms like vaginal discharge (77.4%).

Conclusion: Colposcopy exhibits superior sensitivity and specificity compared to Pap smear, enhancing the detection of cervical lesions, particularly high-grade abnormalities. Combining both modalities optimizes screening accuracy in high-risk populations.

Keywords: Cervical lesions, colposcopy, Pap smear, histopathology, CIN, screening..

INTRODUCTION

Cervical cancer remains a significant global health burden, ranking as the second most common malignancy among women in India, where it accounts for approximately 25% of cervical cancer deaths worldwide [1]. The age-standardized incidence rate in India is 22 per 100,000 women annually, with a mortality rate of 12.4 per 100,000, reflecting disparities in screening and treatment access [2]. The 5-year survival rate hinges on early detection, plummeting from over 90% in preinvasive stages to less than 50% in advanced disease [3]. In industrialized nations, cervical cancer affects 1 in 100 women, whereas in India, the lifetime risk rises to 1 in 53, largely due to limited precancerous lesion management [4,5].

The concept of preinvasive cervical disease emerged in 1947, describing cellular changes confined to the cervical epithelium, now termed cervical intraepithelial neoplasia (CIN) [6]. CIN progresses from mild (CIN I) to severe (CIN III) dysplasia and carcinoma in situ (CIS), potentially culminating in invasive squamous cell carcinoma (SCC) or adenocarcinoma over 7–20 years [7]. This protracted preinvasive phase offers a window for screening and intervention, drastically reducing invasive cancer rates. Risk factors include early sexual debut (<16 years), multiple partners, smoking, high parity, low socioeconomic status, and human papillomavirus (HPV) infection, the latter being a well-established etiological agent [8]. Histologically, SCC predominates, though adenocarcinoma has risen in incidence over recent decades, possibly due to improved squamous lesion detection [9].

The Pap smear, introduced by Papanicolaou in 1943, is the cornerstone of cervical screening, detecting CIN and invasive cancer through exfoliative cytology [10]. However, its false-negative rate ranges from 10–70%, attributed to sampling errors, processing issues, and interpretive variability [11]. In resource-limited settings like India, cytology-based programs face challenges including inadequate infrastructure, trained personnel, and follow-up logistics [12]. The Bethesda System (2001) standardizes Pap smear reporting, categorizing findings as negative for intraepithelial lesion or malignancy (NILM), atypical squamous cells of undetermined significance (ASCUS), low-grade squamous intraepithelial lesion (LSIL), high-grade squamous intraepithelial lesion (HSIL), or invasive carcinoma [13].

Colposcopy, a magnified visual inspection of the cervix, enhances diagnostic precision, particularly for abnormal cytology or suspicious lesions. Using acetic acid and Lugol's iodine, it identifies acetowhite epithelium, punctation, mosaicism, and atypical vessels indicative of CIN or malignancy [14]. Its sensitivity ranges from 60–75% alone, rising above 90% when paired with cytology, making it pivotal for guiding biopsies [15]. Histopathology remains the gold standard, classifying lesions as CIN I (lower third undifferentiated cells), CIN II (middle third), CIN III (near-full thickness), or invasive carcinoma [16]. Despite its diagnostic utility, colposcopy's subjectivity and resource demands limit its widespread use in low-income settings.

In India, where cervical cancer incidence remains high, optimizing screening strategies is critical. The Pap smear's variable sensitivity necessitates adjunctive tools like colposcopy, yet comparative efficacy studies in symptomatic populations are scarce. Previous research, such as Shalini et al. (1998), reported Pap smear sensitivity at 56% and specificity at 90%, while colposcopy ranged from 87–99% sensitivity in meta-analyses [17,18]. However, regional data integrating both modalities with histopathology are limited, particularly in tertiary care contexts serving diverse demographics.

This study addresses these gaps by evaluating the efficacy of colposcopy versus Pap smear in 500 symptomatic women at Government Victoria Hospital, Visakhapatnam, from November 2022 to April 2024. Conducted in a high-burden region, it compares diagnostic accuracy against histopathological outcomes, focusing on sensitivity, specificity, and predictive values. The cervix's accessibility for direct observation and sampling underscores its suitability for such investigations, aligning with historical insights that preinvasive lesions precede invasive cancer [19]. By correlating findings with risk factors like age, parity, and education, this study aims to refine screening protocols, potentially reducing missed diagnoses and improving outcomes in resource-constrained settings.

AIMS

To evaluate the sensitivity and specificity of colposcopy versus Pap smear in detecting cervical dysplasias, compare their findings, and assess colposcopy's reliability through correlation with histopathological results.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at the Gynecology Outpatient Department, Government Victoria Hospital, Visakhapatnam, India, from November 2022 to April 2024. Ethical approval was granted by the Institutional Ethics Committee (Serial No: 168/IEC AMC/JUL 2023), and informed consent was obtained.

Participants

A total of 500 women aged 20–60 years were enrolled based on inclusion criteria: abnormal symptoms (e.g., vaginal discharge, post-coital bleeding, intermenstrual bleeding, postmenopausal bleeding) or clinically unhealthy cervix (e.g., erosion, cervicitis, polyps) identified via speculum examination. Exclusion criteria included age <20 or >60 years, active bleeding, frank invasive cancer, prior hysterectomy, or pregnancy.

Procedures

Participants underwent Pap smear using an Ayre's spatula, fixed in 95% alcohol, and stained via the Papanicolaou method. Colposcopy was performed with a video colposcope (40x magnification, green filter), applying 5% acetic acid and Lugol's iodine to identify abnormal findings (acetowhite areas, punctation, mosaicism). Colposcopy-guided biopsies were taken from suspicious sites, processed, and examined histopathologically, categorized as normal, cervicitis, CIN I, CIN II/III, or invasive carcinoma.

Statistical Analysis

Data were analyzed using Chi-square tests to assess associations between screening results and histopathology ($p<0.05$). Sensitivity, specificity, PPV, NPV, and accuracy were calculated. Analyses were performed using SPSS version 25.

RESULTS

Of 500 participants (mean age 43.6 years), histopathology revealed 55 (11%) normal, 330 (66%) cervicitis, 65 (13%) CIN I, 40 (8%) CIN II/III, and 10 (2%) invasive carcinoma.

Table 1: Diagnostic Accuracy of Pap Smear

	Positive by HPE (CIN + Cancer)	Negative by HPE	Total
Positive	90 (TP)	20 (FP)	110
Negative	25 (FN)	365 (TN)	390
Total	115	385	500

- Sensitivity: 78.3%, Specificity: 94.8%, PPV: 81.8%, NPV: 93.6%, Accuracy: 91% ($X^2=275.5$, $p<0.0001$).

Table 2: Diagnostic Accuracy of Colposcopy

	Positive by HPE (CIN + Cancer)	Negative by HPE	Total
Positive	100 (TP)	10 (FP)	110
Negative	15 (FN)	375 (TN)	390
Total	115	385	500

- Sensitivity: 86.9%, Specificity: 97.4%, PPV: 90.9%, NPV: 96.1%, Accuracy: 95% (X^2=367.2, p<0.0001).

Colposcopy detected 100/115 CIN/invasive cases (86.9%) versus Pap smear's 90/115 (78.3%). CIN prevalence peaked in the 41–50 age group (mean 43.6 years), with 46% para 2 and 30.6% para 3. Illiteracy was noted in 20.8% of CIN cases. Symptoms included vaginal discharge (77.4%), post-coital bleeding (6%), intermenstrual bleeding (8.4%), and postmenopausal bleeding (8.2%).

DISCUSSION

Cervical cancer's preventable nature stems from its prolonged preinvasive phase, enabling early detection via screening [1]. This study of 500 symptomatic women confirms colposcopy's superior diagnostic performance over Pap smear, with histopathology as the reference standard. Colposcopy's sensitivity (86.9%) and specificity (97.4%) outstripped Pap smear's (78.3% and 94.8%), aligning with meta-analyses reporting colposcopy sensitivity of 87–99% versus Pap smear's variable 20–56% [18,20]. The higher accuracy (95% vs. 91%) underscores colposcopy's role in reducing false negatives, particularly for high-grade lesions (CIN II/III, invasive carcinoma), where Pap smear missed 25 cases compared to colposcopy's 15.

The 23% prevalence of CIN/invasive carcinoma (115/500) reflects a high-risk cohort, consistent with India's elevated cervical cancer burden [2]. Age distribution (mean 43.6 years) mirrors Kushtagi and Fernandez (>35 years) and Shalini et al. (41 years), suggesting peak CIN incidence in perimenopausal women due to cumulative exposures [21,17]. Multiparity (76.6% with ≥2 pregnancies) as a risk factor aligns with Vaidya et al., where parity >4 increased CIN prevalence, likely due to hormonal and mechanical stress [22]. Illiteracy (20.8%) correlates with delayed healthcare access, echoing national trends linking education to disease burden [5].

Symptomatically, vaginal discharge (77.4%) predominated, exceeding Durdi et al. (66%) and Bharati et al. (52%), suggesting a role in dysplasia progression, possibly via chronic inflammation or HPV persistence [23,24]. Post-coital bleeding (6%) matched Bharati et al. (6.28%), often signaling advanced lesions [24]. Clinical findings like cervical erosion (42%) reinforce speculum examination's value in identifying at-risk cases, supporting biopsy justification beyond symptoms alone.

Pap smear's moderate sensitivity (78.3%) exceeds Basu et al. (29.5%) and Pete et al. (47%), possibly due to standardized sampling and staining, yet falls below colposcopy's 86.9% [25,26]. Its high specificity (94.8%) aligns with Londhe et al. (96.3%), reflecting reliability in ruling out disease [27]. False negatives (25/115) highlight limitations in detecting subtle dysplasias, consistent with global ranges of 10–70% [11]. Colposcopy's enhanced sensitivity reflects its ability to visualize acetowhite changes and vascular patterns, corroborated by Massad et al. (89%) and Sukhpreet Singh (95%) [28,29]. Specificity (97.4%) exceeds Olaniyan's meta-analysis (26–87%), likely due to experienced colposcopists and standardized criteria [18].

The PPV (90.9% vs. 81.8%) and NPV (96.1% vs. 93.6%) favor colposcopy, emphasizing its confirmatory role post-Pap smear. Combining both modalities, as advocated by Shalini et al., maximizes detection, reducing missed high-grade lesions critical in India's context [17]. Risk factors like early marriage (<20 years) and prolonged OCP use, noted in our cohort, align with Kushtagi et al. and Duggan, reinforcing HPV's synergistic role [21,30]. Smoking (3.6%) as a cofactor echoes Schuman et al., though its low prevalence limits statistical power [31].

Limitations include the tertiary hospital setting, potentially skewing toward symptomatic or severe cases, and exclusion of rural populations. Future studies should incorporate community-based screening and HPV testing to enhance generalizability. The justification for biopsying white discharge cases, supported by Vaidya et al., underscores comprehensive evaluation's necessity given India's rising cervical cancer trends [22].

CONCLUSION

This study demonstrates colposcopy's superior efficacy over Pap smear in detecting cervical lesions, with sensitivity (86.9% vs. 78.3%), specificity (97.4% vs. 94.8%), and accuracy (95% vs. 91%) favoring colposcopy. Histopathological correlation confirms its reliability, particularly for high-grade lesions, in a high-risk cohort with 23% CIN/invasive carcinoma. Key risk factors—age (mean 43.6 years), multiparity (76.6%), illiteracy (20.8%), and vaginal discharge (77.4%)—highlight vulnerable populations. Pap smear's moderate sensitivity necessitates adjunctive colposcopy to minimize false negatives, optimizing early detection during CIN's prolonged preinvasive phase. Integrating both modalities enhances screening precision, critical in India's resource-limited, high-burden context. Broader implementation of colposcopy in medical institutions is recommended to improve cervical cancer prevention.

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