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Correlations Between Colposcopy Findings and Histopathological Results from Colposcopy-Directed Biopsy in Cervical Pre-Cancerous Lesions

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Abstract

Background: Cervical cancer remains a significant health burden globally, and early diagnosis of precancerous lesions is paramount in prevention. Colposcopy-directed biopsy has been considered the gold standard to evaluate abnormal cervical cytology, but the correlation of colposcopic impression with histopathological examination has to be revalidated regularly in order to optimize screening programs. This study will correlate colposcopic findings and scoring indices with biopsy results to identify features that predict high-grade cervical lesions. ***Methods:*** 90 women with suspicious cervical findings or abnormal cytology were included in this cross-sectional study, who had received colposcopy and colposcopy-guided biopsy at a tertiary care hospital from July, 2023 to June, 2024. Colposcopic images were captured by routine procedure after acetic acid and Lugol's iodine staining. Reid Colposcopic Index and Swede Score were calculated for each case. Biopsy samples were obtained from the area of abnormality and were histopathologically graded as negative/inflammatory, LSIL (CIN 1), or HSIL (CIN 2-3). Data were analyzed in SPSS, including correlation coefficients, and logistic regression analysis was carried out. ***Results:*** Out of 90 patients, 38 (42.2%) had HSIL and 34 (37.8%) had LSIL, and 18 (20.0%) had negative/inflammatory findings on histopathology. Colposcopy was 81.6% sensitive and 76.9% specific for HSIL detection (AUC=0.85). There were high correlations between the Reid Index and histopathology (r=0.68) and the Swede Score and histopathology (r=0.72). Swede Score ≥8 (AOR=17.3, 95% CI 3.1-95.8), lesion involving ≥2 quadrants (AOR=7.39, 95% CI 2.07-26.3), and atypical vessels (AOR=8.25, 95% CI 1.33-51.2) were independent predictors of HSIL. ***Conclusion:*** Colposcopy has exceptional diagnostic accuracy in the detection of high-grade cervical precancerous lesions, and standardized scoring systems significantly improve predictive performance. These findings support colposcopy-directed biopsy as a safe technique for diagnosis in screening programs for cervical cancer.

Keywords: Colposcopy, Cervical precancer, Reid Index, Swede Score.

INTRODUCTION

Cervical cancer is the fourth most common malignancy in women worldwide, with 604,000 new cases and 342,000 deaths documented in 2020 [1]. Although the disease burden is largely preventable by screening and early treatment, in low- and middle-income nations, the disease burden is still unevenly high, given poor access to full screening programs. Natural

history of cervical cancer has a well-documented cascade of progression from LSIL to HSIL, and there is an important window of opportunity for intervention before invasive cancer occurs [2]. The current standard of practice for cervical cancer screening is multi-level and begins with cytology or human papillomavirus (HPV) testing, followed by colposcopy in triage of screen-positive women. Colposcopy, originally described by Hans Hinselmann in 1925, allows direct visual examination of the cervix on magnification after exposure to acetic acid and Lugol's iodine, enabling observation of acetowhite epithelium, abnormal vascular patterns, and other neoplasia-indicative features [3]. However, colposcopic diagnosis remains operator-dependent and subjective, with reported sensitivity ranging from 58% to 96% and specificity from 72% to 95% in detecting high-grade lesions [4]. To counteract the subjectivity of colposcopic diagnosis, formal scoring systems have been developed to facilitate easier interpretation and improve diagnostic accuracy. The Reid Colposcopic Index (RCI), originally proposed in 1985, uses the four variables of margin features, color tone, vascular features, and iodine staining to yield a quantitative score for histologic severity [5]. Similarly, the Swede Score, proposed in 2008, scores five colposcopic features like acetowhite staining uptake, margins and surface characteristics, vessel patterns, size of the lysis, and iodine staining reaction [6]. A number of studies have demonstrated that these scoring systems enhance diagnostic accuracy and reduce inter-observer variability over subjective impression only [7]. Despite the worldwide use of colposcopy-directed biopsy as the "gold standard" for the diagnosis of cervical precancerous lesions, discordance between colposcopic and histopathological diagnoses remains a clinical challenge. Such discrepancies may be due to sampling error, inadequate visualization of the transformation zone, or misinterpretation of colposcopic features [8]. Previous work has reported varied rates of concordance between colposcopy and histopathology, with 0.40 to 0.85 Kappa coefficients, in keeping with extensive population study heterogeneity, colposcopist experience, and methodology [9]. Recent evidence reports that some colposcopic features, like dense acetowhite epithelium, coarse punctation and mosaicism, atypical vessels, and large size of the lesions, are strongly associated with high-grade histology and may also serve as independent predictors of disease severity [10]. Recognition of the correlation between colposcopic features and histopathological findings is important to rationalize clinical decision algorithms, reduce unnecessary biopsies, and reduce patient anxiety resulting from false-positive results. Furthermore, proper validation of protocol-based scoring systems in diverse clinical settings is necessary for establishing their generalizability and clinical utility [11]. This study was therefore aimed to evaluate the correlation between colposcopic impressions, scoring indices (Reid and Swede) by formal scoring, and histopathological diagnoses in women with abnormal cervical cytology and to identify certain colposcopic features that independently predict high-grade squamous intraepithelial lesions.

METHODS

This cross-sectional study was conducted at Jalalabad Ragib-Rabeya Medical College and Hospital, Sylhet, Bangladesh from July, 2023 to June, 2024. A total of 90 women underwent colposcopy and colposcopy-directed cervical biopsy at a tertiary care hospital. Women with abnormal cytology or suspicious cervical findings were included, while pregnant or previously treated cases were excluded. After informed consent, demographic and clinical data were collected. Colposcopy was performed using a standard procedure after 5% acetic acid and Lugol's iodine application. Findings were classified as normal/benign, minor, major, or suspicious for invasion. Specific features such as acetowhite change, mosaic, punctation, atypical vessels, and lesion size were noted. Reid Colposcopic Index [7] and Swede Score [15] were calculated for each case. Targeted biopsies from abnormal areas were examined histopathologically and categorized as No intraepithelial lesion or malignancy (Negative/Inflammatory change), LSIL (CIN 1), or HSIL (CIN 2–3) [10].

Statistical Analysis

Data were analyzed using SPSS v26.0. Results were expressed as frequency and percentage. Associations between colposcopic findings and histopathology were tested using the Chi-square test, and correlations assessed by Spearman's rank coefficient (r). Diagnostic accuracy was evaluated by calculating sensitivity, specificity, PPV, NPV, and accuracy, with histopathology as the reference standard. ROC curve analysis determined discriminative ability. Binary logistic regression identified independent predictors of HSIL, presented as adjusted odds ratios (AOR 95% CI). Agreement between colposcopy and histopathology was assessed using Cohen's Kappa (κ), with $p < 0.05$ considered significant.

RESULTS

Table 1 represents the baseline characteristics of the study population. The study comprised 90 women with the age distribution having a mean of 40% between 30-39 years and 40% ≥40 years, which depicts the predominant role of perimenopausal and reproductive age groups. The majority of the women (64.4%) were multiparous, while grand-multiparous women contributed 20%. Nearly half the population (46.7%) belonged to middle socioeconomic status, and 35.6% of them were from lower strata. Contraceptive use was dominated by oral contraceptive pills (44.4%), then by intrauterine devices (20%). The reason for presentation was most commonly vaginal discharge (48.9%), followed by post-coital bleeding (28.9%). All of the subjects were HIV-negative, thereby eliminating a significant confounding variable.

Table 1: Baseline characteristics of study population (n = 90)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	< 30 y	18	20.0
	30–39 y	36	40.0
	≥ 40 y	36	40.0
Parity	Nulliparous	14	15.6
	Multiparous (1–3)	58	64.4
	Grand-multiparous (≥ 4)	18	20.0
Socio-economic status	Lower	32	35.6
	Middle	42	46.7
	Upper	16	17.8
Contraceptive use	OCP	40	44.4
	IUCD	18	20.0
	Barrier	10	11.1
	None	22	24.4
Presenting symptom	Post-coital bleeding	26	28.9
	Irregular menstruation	20	22.2
	Vaginal discharge	44	48.9
HIV status	Negative	90	100.0

Table 2 depicts the correspondence between initial cytology and final histopathology. Of 18 NILM (Negative for Intraepithelial Lesion or Malignancy) cases, 77.8% were biopsy positive/inflammatory, and 22.2% were LSIL, resulting in a false negative rate. ASC-US cases agreed with 66.7% of LSIL histology and 16.7% upgradable to HSIL. Among LSIL cytology cases, 33.3% were upgraded to HSIL on histopathology, and this underlines the clinical value of colposcopy-directed biopsy. More importantly, 90% of HSIL cytology cases were histopathologically diagnosed as HSIL, and this indicates a high positive predictive value. Strong statistical significance ($p<0.001$) confirms a strong association between cytological and histopathological diagnoses.

Table 2: Referral cytology vs. histopathology (n = 90)

Cytology	Negative/Inflammation	LSIL (CIN1)	HSIL (CIN2/3)	p-value
NILM (n = 18)	14 (77.8)	4 (22.2)	0 (0.0)	
ASC-US (n = 18)	3 (16.7)	12 (66.7)	3 (16.7)	
LSIL (n = 24)	1 (4.2)	15 (62.5)	8 (33.3)	
HSIL (n = 30)	0 (0.0)	3 (10.0)	27 (90.0)	
Total (n = 90)	**18**	**34**	**38**	**< 0.001**

Table 3 compares colposcopic impressions of normal/benign, Grade 1 (slight changes), Grade 2 (severe changes), and suspicious for invasion with histopathological diagnoses. 38 cases were classified by colposcopy as Grade 2 (severe) and had 71.1% diagnosed as HSIL with excellent predictive accuracy. Grade 1 findings showed 63% concordance with LSIL histology. Benign/normal colposcopic findings were accompanied by 60% negative/inflammatory histology but did not identify 10% of HSIL cases, making liberal biopsy practice a necessity. The suspicious invasion cases detected 80% of HSIL. An extremely low p-value (<0.001) establishes colposcopy as a good triage test, even though discordance calls for histopathological correlation.

Table 3: Colposcopic impression vs. histopathology (n = 90)

Colposcopic impression	Negative/Inflammation	LSIL (CIN1)	HSIL (CIN2/3)	p-value
Normal/Benign (n = 20)	12 (60.0)	6 (30.0)	2 (10.0)	
Grade 1 (Minor) (n = 27)	5 (18.5)	17 (63.0)	5 (18.5)	
Grade 2 (Major) (n = 38)	1 (2.6)	10 (26.3)	27 (71.1)	
Suspicious for invasion (n = 5)	0 (0.0)	1 (20.0)	4 (80.0)	
Total (n = 90)	**18**	**34**	**38**	**< 0.001**

Table 4 reveals the prevalence and predictive value of single colposcopic features for diagnosing HSIL. Dense acetowhite epithelium was noted in 50 cases, 56% of which had HSIL on histopathology ($p=0.006$). Coarse mosaic (68.2%) and coarse punctation (66.7%) had high associations with HSIL. Atypical vessels, being less frequent (8 cases), had the highest specificity with 87.5% correlation with HSIL ($p=0.019$).

Lesion involvement of ≥2 quadrants was highly significant (73.1% HSIL, p<0.001), demonstrating that larger lesion size has more extensive pathology. Inner border sign and ridge sign were also found to be significantly correlated.

Table 4: Association of specific colposcopic signs with histopathological diagnosis (HSIL vs. Non-HSIL, n = 90)

Colposcopic sign	Total N	HSIL Present n (%)	HSIL Absent n (%)	p-value
Dense acetowhite	50	28 (56.0 %)	22 (44.0 %)	0.006
Coarse mosaic	22	15 (68.2 %)	7 (31.8 %)	0.010
Coarse punctation	24	16 (66.7 %)	8 (33.3 %)	0.010
Atypical vessels	8	7 (87.5 %)	1 (12.5 %)	0.019
Lesion ≥ 2 quadrants	26	19 (73.1 %)	7 (26.9 %)	< 0.001
Inner border sign	12	9 (75.0 %)	3 (25.0 %)	0.031
Ridge sign	10	8 (80.0 %)	2 (20.0 %)	0.026

Table 5 classifies the Reid Colposcopic Index score into three groups and cross-matches them with histopathological findings. Low RCI values (0-2) were predominantly suggestive of negative/inflammatory outcomes (48%) and LSIL (44%), with only 8% showing positivity for HSIL. Intermediate scores (3-4) showed increased detection of HSIL at 30.3%. High RCI values (5-8) displayed excellent predictive value with 81.2% correlation for HSIL and a few negative/inflammatory findings (3.1%). The stepwise increase in the prevalence of HSIL across RCI groups and the highly significant p-value (<0.001) validate the scoring system for risk stratification. This corroborates using RCI ≥5 as an optimal cutoff for identification of high-grade lesions for which urgent therapeutic intervention is warranted.

Table 5: Reid Colposcopic Index (RCI) vs. histopathology (n = 90)

RCI score category	Negative/Inflammation	LSIL (CIN1)	HSIL (CIN2/3)	p-value
0–2 (n = 25)	12 (48.0)	11 (44.0)	2 (8.0)	
3–4 (n = 33)	5 (15.2)	18 (54.5)	10 (30.3)	
5–8 (n = 32)	1 (3.1)	5 (15.6)	26 (81.2)	
Total (n = 90)	**18**	**34**	**38**	**< 0.001**

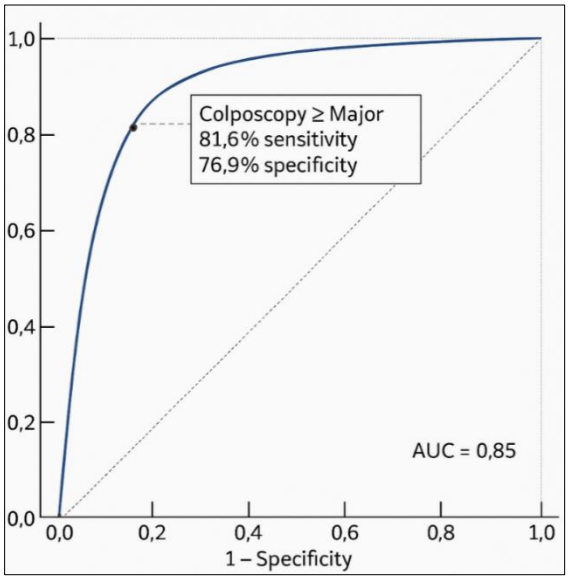

Figure 1

Figure 1: Receiver Operating Characteristic (ROC) curve showing diagnostic performance of colposcopy for HSIL detection. The ROC curve demonstrates that colposcopy has strong discriminative ability in identifying high-grade squamous intraepithelial lesions (HSIL). The optimal threshold, taken at "Colposcopy ≥ Major", yields a sensitivity of 81.6% and a specificity of 76.9%, indicating that colposcopic impression correctly identifies the majority of true HSIL cases while maintaining reasonable exclusion of non-HSIL cases. The Area Under the Curve (AUC = 0.85) further confirms good diagnostic accuracy, supporting the clinical value of colposcopy-directed biopsy as a reliable method for detecting pre-cancerous cervical lesions.

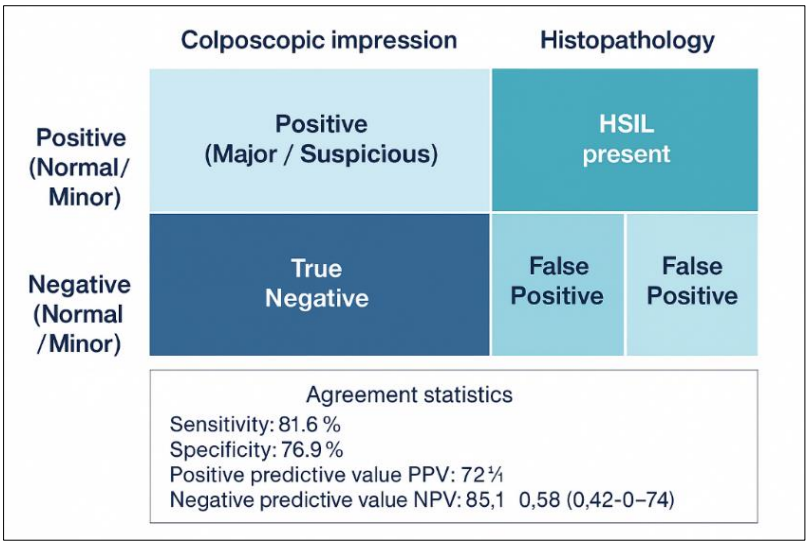

Figure 2: Colposcopic impression and histopathological diagnosis (n = 90)

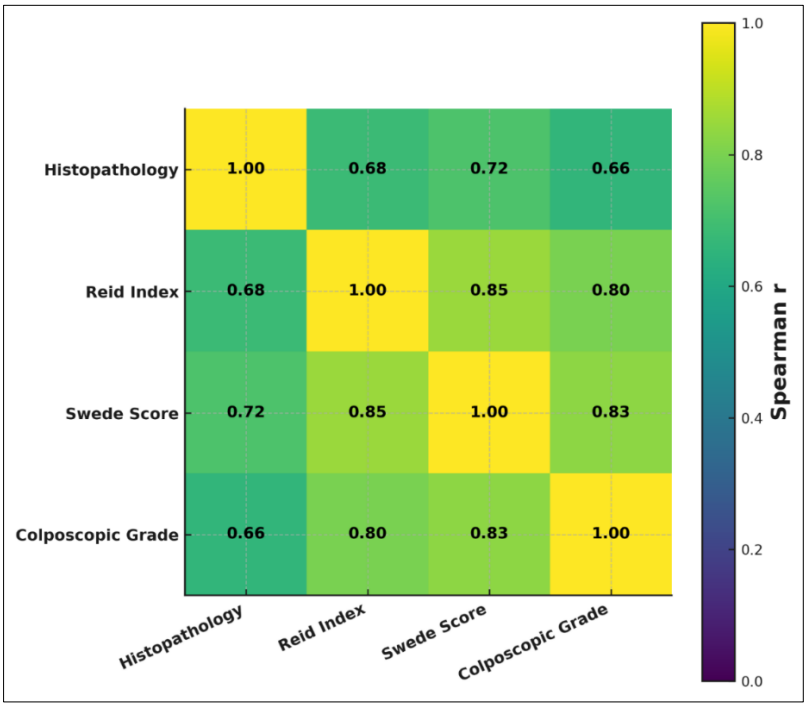

Figure 3

Figure 3: Correlation heatmap showing the correlation between colposcopy indices and histopathological grade. The heatmap demonstrates strong positive correlations among the Reid Colposcopic Index**,** Swede Score**,** overall colposcopic impression**,** and final histopathological grade. The highest correlation is observed between the Swede and Reid scores ($r = 0.85$), indicating excellent internal consistency between the two structured scoring systems. Both indices also show strong correlations with histopathology ($r = 0.68–0.72$), confirming that higher colposcopic scores are consistently associated with more severe cervical epithelial changes on biopsy. This supports the diagnostic reliability of standardized colposcopic scoring in predicting the severity of cervical precancerous lesions.

Table 6 demonstrates a binary logistic regression that identifies independent predictors of HSIL after adjustment for potential confounders. Swede Score ≥8 was the strongest predictor with an adjusted odds ratio of 17.3 (95% CI 3.1-95.8, p<0.001), representing 17 times greater odds of HSIL. Lesion with ≥2 quadrants was significant with AOR of 7.39 (p=0.002), followed by atypical vessels (AOR=8.25, p=0.023). Dense acetowhite change (AOR=4.57), coarse mosaic (AOR=3.98), and coarse punctation (AOR=3.40) were also independently significant.

Table 6: Binary logistic regression for predictors of HSIL on biopsy

Predictor variable	β (SE)	Adjusted OR (95% CI)	p-value
Dense acetowhite	1.52 (0.58)	4.57 (1.45–14.4)	0.009
Coarse mosaic	1.38 (0.63)	3.98 (1.16–13.6)	0.028
Coarse punctation	1.22 (0.59)	3.40 (1.09–10.6)	0.035
Atypical vessels	2.11 (0.92)	8.25 (1.33–51.2)	0.023
Lesion ≥ 2 quadrants	2.00 (0.65)	7.39 (2.07–26.3)	0.002
Swede Score ≥ 8	2.85 (0.89)	17.3 (3.1–95.8)	< 0.001

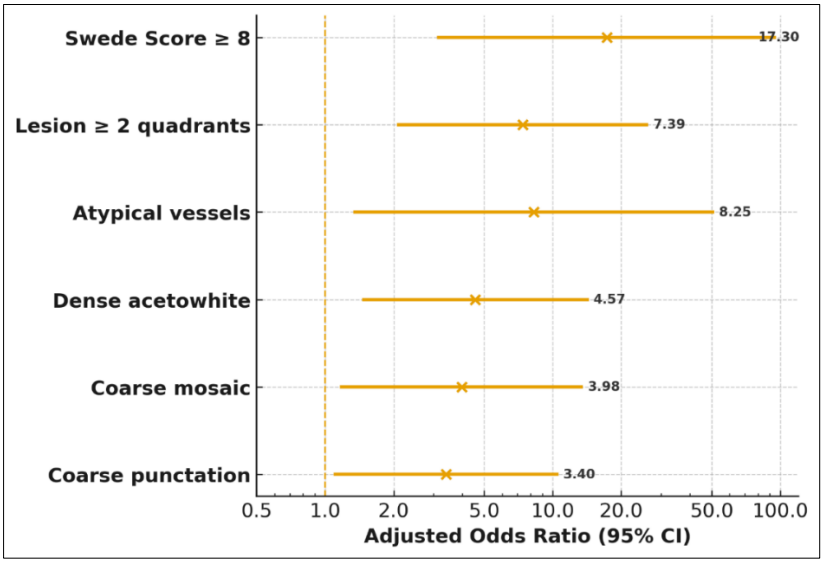

Figure 3

Figure 3: Forest plot showing predictors of HSIL on colposcopy-directed biopsy. The forest plot illustrates the independent predictors of high-grade squamous intraepithelial lesions (HSIL) from multivariable logistic regression. Among all colposcopic signs, a Swede score ≥ 8 (AOR = 17.3, 95% CI 3.1–95.8) and lesion involvement of ≥ 2 quadrants (AOR = 7.39, 95% CI 2.07–26.3) demonstrated the highest odds of HSIL detection. Atypical vascular patterns (AOR = 8.25, 95% CI 1.33–51.2**),** dense acetowhite areas**,** and coarse mosaic/punctation also showed significant associations. All variables have odds ratios greater than 1, confirming that these colposcopic features are strong, independent predictors of high-grade cervical lesions, thereby emphasizing their diagnostic value during real-time assessment.

DISCUSSION

This study demonstrates compelling evidence for the diagnostic accuracy and clinical usefulness of colposcopy-directed biopsy in cervical precancerous lesion detection, with emphasis on systematic scoring systems and some colposcopic characteristics predicting high-grade squamous intraepithelial lesions. Our findings demonstrate overall sensitivity of 81.6% and specificity of 76.9% for HSIL detection, and an AUC of 0.85, indicating superb discriminative power. These results align with recent large multicentric trials reporting colposcopy sensitivity of 78% to 86% for the detection of CIN2+ lesions [12]. Diagnostic performance observed in our series matches the ESTAMPA study, where HPV-positive women's triage based on colposcopy had 86% sensitivity and 72% specificity [13]. One of the strengths of our study is the systematic evaluation of the indices of structured scoring, the Reid Colposcopic Index and Swede Score, both of which showed robust correlation with histopathological outcome. The Reid Index vs. histopathology (r=0.68) and the Swede Score vs. histopathology (r=0.72) correlation coefficient is an expression of the strength of agreement, consistent with Pretorius et al., that has shown correlation coefficients to vary from 0.65 to 0.85 [14]. In addition, the significant intercorrelation between Reid and Swede scores (r=0.85) in the present study testifies to excellent internal consistency between the two standardized tests, as previously documented by Suwanthananon et al., wherein a correlation coefficient value of 0.986 was observed between the two indices [7]. The improved predictive accuracy of the Swede Score for HSIL in our multivariate analysis (AOR=17.3 for score ≥8) supports increasing evidence that this scoring system may yield greater specificity to high-grade lesions than subjective colposcopic impression alone [15]. Our analysis identified several specific colposcopic features as independent predictors of HSIL, of which the size of lesion involving ≥2 quadrants (AOR=7.39) and the presence of atypical vascular patterns (AOR=8.25) were strongest. These findings aligned with Santos et al., suggesting that lesion size is a direct predictor of histopathological severity, with larger lesions having

significantly higher odds of harboring high-grade dysplasia [16]. Strong correlation between atypical vessels and HSIL in our study population (87.5% positive predictive value) underlines the absolute need for careful vascular assessment during colposcopic examination, as abnormal vessel morphology has often been found to indicate stromal invasion or high-grade neoplastic change [17]. Similarly, the tight correlation observed with coarse mosaic and punctation patterns reflects well-entrenched colposcopic principles linking these characteristics with increased metabolic activity and angiogenesis of high-grade lesions [18]. Discordance rate of our study between colposcopic impression and histopathology, preeminently the 10% of normal/benign colposcopic impressions that were HSIL on histopathology, is a harbinger of the inherent disadvantage of visual assessment and highlights the unreplaceable function of histopathological confirmation. This finding agrees with quality assurance studies that demonstrate even experienced colposcopists may fail to identify the appropriate site for biopsy in 5-17% of high-grade lesions [19]. Such failures can be due to a wide range of factors, like inadequate visualization of Type 3 transformation zones, inadequate uptake of acetic acid in certain lesions, or sampling error caused by heterogeneity of lesions. New advances in computer-aided colposcopy have shown promise in avoiding such diagnostic errors, with meta-analyses documenting greater precision than experienced colposcopists [20]. Cytology-histopathology correlation analysis in our study detected an upgrade rate of 33.3% from cytological LSIL to histopathological HSIL, similar to those in other screening groups. This emphasizes the key role of colposcopy-directed biopsy as a terminal diagnostic modality over reliance on cytological interpretation in clinical decision-making. The strong positive predictive value of HSIL cytology (90% confirmed on histopathology) supports current guidelines for the immediate colposcopic assessment for high-grade cytology without further testing [21]. However, the 22.2% LSIL detection rate in cytologically negative cases (NILM) highlights the need for thorough clinical examination and a low threshold for colposcopic referral with abnormal cervical findings, irrespective of cytology. While our study can demonstrate the high level of diagnostic accuracy of colposcopy and systematic scoring systems, several limitations must be considered. The cross-sectional study design precludes analysis of disease progression or clinical outcomes, and the tertiary care single-center environment may not be representative of primary care or resource-limited sites where colposcopy experience and standardized pathways might be less universally accessible. In spite of these limitations, our results contribute valuable evidence in support of the use of structured scoring systems within routine colposcopic practice to optimize diagnostic accuracy and reduce inter-observer variation.

Limitations of the Study

This one-center cross-sectional study with a comparatively modest sample size may limit generalizability to diverse patient populations and practice settings. Analysis of long-term follow-up data or clinical outcomes was not available, which would have enabled assessment of progression rates or treatment efficacy. Systematic testing for inter-observer variability in colposcopic interpretation was not carried out, which may undermine the reproducibility of results.

CONCLUSION

This study demonstrated a strong correlation between colposcopic observation and histopathologic diagnosis of cervical precancerous lesions, and systematic scoring systems highly enhanced the diagnostic accuracy. Reid Colposcopic Index and Swede Score possessed good discriminative power, and distinct characteristics like dense acetowhite epithelium, coarse vascular pattern, atypical vessels, and large lesion size as independent predictors for high-grade squamous intraepithelial lesions. Colposcopy-directed biopsy remains a fundamental method for accurate diagnosis and appropriate management of cervical precancers and maintains its own central role in cervical cancer prevention programs.

RECOMMENDATION

Future studies need to prioritize multi-center prospective trials with larger sample sizes to validate structured scoring algorithms across different populations and levels of resources. Integration of artificial intelligence-enhanced colposcopy with molecular signatures immunostaining may further enhance diagnostic accuracy and reduce inter-observer variability. Long-term clinical outcomes and cost-effectiveness studies to evaluate risk-stratified management algorithms are needed to optimize cervical cancer prevention programs.

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