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RESEARCH ARTICLE

A Comparative Study of Cervicography and Histopathology Reports from Colposcopic-Directed Biopsies at a Tertiary Care Hospital in Pathum Thani, Thailand

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Abstract

Introduction: This study aimed to evaluate the diagnostic performance of cervicography (CG) in detecting cervical intraepithelial neoplasia (CIN) grade 2 or higher (CIN2+) and to compare the diagnostic performance among examiners with different levels of clinical experience. **Materials and Methods:** We conducted a retrospective descriptive study at Thammasat University Hospital in Pathum Thani, Thailand, from October 2023 to November 2024. Participants included women who underwent colposcopy and colposcopy-directed biopsy. CG images were independently interpreted by a gynecologic oncologist (expert) and two Obstetrics and Gynecology residents (R1, R2), all of whom were blinded to clinical and histopathologic data. The interpretations from the expert, R1, and R2 were compared to the histopathologic reports of cervical biopsy. **Results:** A total of 160 participants were recruited for the study. The mean age of participants was 42.5 years. High-risk HPV was detected in 96.3% (104/108) of participants. Histopathology confirmed CIN2/3 in 24.4% (39/160) and cancer in 0.6% (1/160) of participants. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for detecting CIN2+ among expert, R1, and R2 were 47.5/45.0/47.5, 95.0/85.8/78.3, 76.0/51.4/42.2, and 84.4/82.4/81.7 percent, respectively. Specificity and PPV were significantly higher for the expert, while sensitivity and NPV were similar across examiners. **Conclusion:** CG demonstrated acceptable diagnostic performance in detecting CIN2+. While specificity and PPV increased with examiner experience, sensitivity stayed consistent across different training levels.

Keywords: Cervical cancer- Cervicography- Colposcopy-directed biopsy- Cervical intraepithelial neoplasia

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Introduction

Cervical cancer (CC) is the fourth most common cancer among women worldwide, reporting 13.3 cases per 100,000 women each year [1]. In Thailand, it is the second most common cancer among women, with approximately 14.4 cases per 100,000 women annually. The early stage of CC showed excellent results from either surgery or radiation, while advanced cases required a combination of chemotherapy and radiation [2, 3]. The incidence has been decreasing mainly due to organized and effective preventive strategies, especially high-coverage cervical screening programs [4].

CC screening methods included cervical cytology, high-risk human papillomavirus (HPV) testing, and a combination of HPV with cervical cytology (Co-testing). According to the 2019 American Society for Colposcopy and Cervical Pathology (ASCCP) risk-based management consensus guidelines, women with an immediate risk of at least 4 percent and a 5-year cumulative risk of 5 percent for cervical intraepithelial neoplasia (CIN) grade 3 or higher (CIN3+) were recommended for colposcopy-directed biopsy (CDB) [5].

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The high sensitivity of the primary human papillomavirus (HPV) test requires many CDB requirements [6, 7]. CDB demands expertise and a significant learning curve for proper training. Obstacles such as long wait times, inefficient referral systems, and transportation problems cause delays in diagnosing and treating high-grade CIN [8, 9].

Telemedicine involves capturing images of the cervix after applying 5 percent acetic acid and then sending them to a gynecologic oncologist (expert) for interpretation. A previous study demonstrated strong agreement between cervicography (CG) and colposcopy when histopathology was used as the standard reference [10]. Additionally, CG has been shown to be capable of distinguishing high-grade CIN from other conditions [11, 12]. Therefore, CG can serve as an adjunct to colposcopy, enabling telemedicine links between patients and experts, and effectively reducing delays in diagnosing and treating high-grade CIN. The current study aimed to evaluate the diagnostic performance of CG in women who underwent colposcopy, using histopathologic findings from CDB as the reference standard. Diagnostic agreement was compared across various levels of clinical training to assess the potential of CG as an adjunct or alternative to colposcopy in regions with limited access to experts.

Materials and Methods

Study Design and populations

This retrospective descriptive study was conducted at the colposcopic clinic in the Department of Obstetrics and Gynecology at Thammasat University Hospital (TUH), Pathum Thani, Thailand, from October 2023 to November 2024. This study received approval from the Human Research Ethics Committee at Thammasat University (037/2024) in 2024.

The study included women with an indication for colposcopy. They underwent both colposcopy and CG imaging, along with histopathological reports. Participants with incomplete medical records, poor-quality CG images, missing histopathological results, prior hysterectomy, or previous CC treatments were excluded. All underwent colposcopy, performed using a standardised technique with a Leisegang colposcope (model 1DF, Germany), under proper illumination and magnification. All cervical biopsies were sent for histopathology examination using the standard Hematoxylin and Eosin (H&E) staining method.

During a colposcopy, participants were positioned in the lithotomy position, and a vaginal speculum was inserted to examine the cervix. The cervix was gently cleaned with normal saline to remove mucus, and then 5 percent acetic acid was applied for approximately 60 seconds to highlight any abnormal epithelial changes. Lugol's iodine was used to help visualize abnormal glycogen levels within epithelial cells. The colposcopic findings were documented, including the type of transformation zone (TZ) and the severity of the lesions.

TZ was classified according to the 2011 International Federation for Cervical Pathology and Colposcopy (IFCPC) nomenclature. TZ types 1, 2, and 3 were fully, partially, and not fully visible at the SCJ [13]. The severity of the lesion was assessed based on the color of acetowhite areas, margin features, vascular patterns, and iodine uptake. Cervical images were captured during the exam. When necessary, CDB was performed on the most suspicious area for histopathological confirmation [14]. CG interpretations were classified as high-grade lesions (HGL: CIN2+) and low-grade lesions (LGL: < CIN2) [15, 16].

Sample Size

According to Buderer's 1996 study, the sample size was calculated using a Z-distribution of 1.96 and a 5 percent margin of error. [17]. The estimated prevalence of abnormal colposcopic findings and the sensitivity of colposcopy reports were 45.8 percent and 95.15 percent, respectively, based on data from an institutional pilot study. As stated, at least 155 cases were needed for an adequate sample size. Fifty percent compensation was included for data loss. The total sample size was 230 cases.

Data Collection

Data were collected from the electronic hospital information system (e-PHIS), including CC screening results, CG images, CDB histopathology, and participants' demographic data such as age, parity, history of sexually transmitted diseases (STDs), menopausal status, and HPV vaccination status. CG images taken during colposcopic examination were independently reviewed by two Obstetrics and Gynecology residents (R1, R2) and one expert at TUH. Each image was evaluated separately by R1, R2, and the expert. Examiners were blinded to clinical history and real-time colposcopic findings to minimize bias.

Data analysis

Statistical analysis was conducted using IBM SPSS Statistics for Windows, version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were reported as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Interpretations were categorized as HGL or LGL. The results were compared to CDB histopathology, the reference standard for diagnosing CIN2+. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each examiner. Receiver operating characteristic (ROC) curve analysis was used to assess the ability to differentiate between HGL (≥ CIN2) and LGL (< CIN2). The area under the ROC curve (AUC) was calculated to evaluate the diagnostic performance of the index test, indicating its acceptability.

Comparisons of diagnostic performance between examiners were conducted using McNemar's test to evaluate differences in paired proportions of sensitivity, specificity, PPV, and NPV. A p-value less than 0.05 was deemed statistically significant.

Results

During the study, a total of 160 participants were included, as shown in Figure 1. The average age was 42.5 years. Most participants (107/160) were multiparous. About ten percent had received the HPV vaccine. One-third (45/160) of the participants were menopausal. Regarding screening methods, two-thirds (108/160) of the participants underwent HPV-based testing. Most subjects (104/108) had positive tests for high-risk HPV types.

Cervical cytology results before colposcopy showed atypical cytology, including atypical squamous cells of undetermined significance (ASC-US), atypical squamous cells cannot exclude high-grade squamous intraepithelial lesion (ASC-H), and atypical glandular cells (AGC). It also showed high-grade squamous intraepithelial lesion (HSIL) and cancer, with respective percentages of 53.1, 10.6, and 1.9.

One-third (57/160) of all participants had TZ types 2 and 3 in colposcopy findings. A quarter of cases (40/160) had histopathology of CIN2+ from CDB. Three participants showed abnormal cervical cytology, indicating CC. All were confirmed as CIN2/3 through final histopathology. The only case of CC in this study was associated with a positive high-risk HPV test without a cytology result. Her final diagnosis was CC stage IA2. According to the CG interpretation, all three operators reported the HGL. She underwent a radical hysterectomy and pelvic node dissection (RHND), as shown in Table 1.

Sensitivity to detect CIN2+ for the expert, R1, and R2 was 47.5, 45.0, and 47.5 percent, respectively, with no statistically significant differences. Meanwhile, the specificity of the expert, R1, and R2 in detecting CIN2+ was 95.0, 85.8, and 78.3 percent, respectively, with statistically significant differences. PPV was 76.0, 51.4, and 42.2 percent for the expert, R1, and R2, respectively, with significant differences observed. Conversely, the NPV was 84.4 percent for the expert, 82.4 percent for R1, and 81.7 percent for R2, without statistically significant differences among examiners, as shown in Table 2. The expert, R1, and R2 showed AUCs of 0.71, 0.65, and 0.63, respectively, as shown in Figure 2. According to widely accepted standards, an AUC between 0.70 and 0.80 was considered fair. Therefore, the expert's performance was classified as fair, whereas R1 and R2 demonstrated poor discrimination in identifying CIN2+.

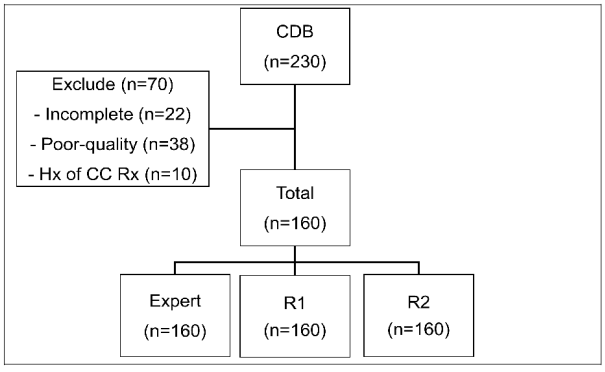

Figure 1. Flow Chart of the Study. CDB: colposcopic-directed biopsy; Expert: gynecologic oncologist; R1: First Obstetrics and Gynecology residents; R2: Second Obstetrics and Gynecology residents; Incomplete: incomplete data; Poor-quality: poor-quality of cervicographic images; Hx of CC Rx: History of cervical cancer treatment or hysterctomy.

Table 1. Demographic Characteristics of Subjects who Underwent Colposcopy and Cervicography (n=160)

Characteristics	n (%)
Age (years)*	42.5 ± 14.5
Multiparity	107 (66.9)
History of STD	10 (6.3)
Menopause	45 (28.1)
HPV vaccination	22 (13.8)
Testing	
Cytology	52 (32.5)
HPV testing	12 (7.5)
Co-testing	96 (60.0)
Positive HPV testing	104 (96.3)
Cytology	
None	12 (7.5)
NILM	13 (8.1)
LSIL	30 (18.8)
Atypical cytology	85 (53.1)
HSIL	17 (10.6)
Cancer	3 (1.9)
Transformation zone	
Type 1	103 (64.4)
Type 2	54 (33.8)
Type 3	3 (1.8)
Pathology of cervical biopsy	
< CIN2	120 (75.0)
CIN2+	40 (25.0)

*mean ± standard deviation (SD); STD: Sexually Transmitted Diseases; HPV: Human Papillomavirus; Co-testing: combination of HPV testing and cervical cytology; NILM: Negative for Intraepithelial Lesion or Malignancy; LSIL: Low-grade squamous intraepithelial lesion; HSIL: High-grade squamous intraepithelial lesion; CIN: Cervical Intraepithelial Neoplasia; < CIN2: Cervical Intraepithelial Neoplasia grade 1or lower; CIN2+: Cervical Intraepithelial Neoplasia grade 2 or higher.

Discussion

The sensitivity of CG for detecting CIN2+ ranged from 45.0 to 47.5 percent across examiners. The sensitivity was similar between the expert and the residents. When comparing with previous studies, the sensitivity of the current study aligned with de Castro Hillmann's and Ularnwong's studies (52.5 and 56.0 percent) [10, 18]. However, Song and colleagues from Korea in 2020 reported that the sensitivity of CG for diagnosing CIN1+ was 81.3 percent [19]. Subjects in Song's study had an average age of 36.9 years, with a diagnosis threshold of CIN1+. The average age in the current study was 41 years, with a cutoff point at CIN2+. Singhakum from Thailand reported that the sensitivity of CG for detecting

Table 2. Performance of Cervicography to Detect HGL (n = 40)

	CDB					
	HGL	LGL	Sensitivity*	Specificity*	PPV*	NPV*
Ex			47.5 (31.5-63.9)	95.0 (89.4-98.1)	76.0 (54.9-90.6)	84.4 (77.2-90.1)
HGL	19	6				
LGL	21	114				
R1			45.0 (29.3-61.5)	85.8 (78.3-91.5)	51.4 (34.0-68.6)	82.4 (74.6-88.6)
HGL	18	17				
LGL	22	103				
R2			47.5 (31.5-63.9)	78.3 (69.9-85.3)	42.2 (21.7-57.8)	81.7 (73.5-88.3)
HGL	19	26				
LGL	21	94				
P1			1	0.02	< 0.01	0.51
P2			1	< 0.01	< 0.01	0.38
P3			1	0.06	0.02	0.82

*: 95% confidence interval; CDB: colposcopic-directed biopsy; Ex: gynecologic oncologist; R1: first Obstetrics and Gynecology residents; R2: Second Obstetrics and Gynecology residents; HGL: high-grade squamous epithelial lesion or more; LGL: low-grade squamous epithelial lesion or less; PPV: positive predictive value; NPV: negative predictive value; AUC: Area Under the Receiver Operating Characteristic curve; P1: p-value comparison between Ex and R1; P2: p-value comparison between Ex and R2; P3: p-value comparison between R1 and R2.

Table 3. Comparison of Present and Previous Studies of Cervicography

	Kittiniyom	Ularnwong	Song	de Castro Hillmann	Singhakum	Longatto-Filho
Year	2025	2025	2020	2019	2018	2012
Country	Thailand	Thailand	Korea	Canada	Thailand	BRA&ARG
Age (years)	41	42.5	36.9	35.4	46.6	37.9
TZ type1 (%)	64.4	100	-	71.9	64.6	-
Nulliparity (%)	53	-	-	36.8	-	-
Device	Colpo	MB	Handheld	Camera	MB	Handheld
Threshold	CIN2+	CIN2+	CIN1+	CIN2+	CIN2+	CIN2+
Cases (n)	160	450	4117	228	325	12,114
Percent CIN2+	25	10.2	5.4			1.4
Sense	47.5	56	81.3	52.5	72.4	28.6
Spec	95	87.7	60.3	91.9	97	96.6
PPV	76	53.7	55.8	60	84	15.4
NPV	84.4	88.7	83.9	89.3	94.2	98.4

Year: Publication year. Country: Country of study; BRA&ARG: Brazil and Argentina. Age: Mean age in each study. TZ type 1: Transformation zone type 1. Device: Cervicography equipment; Colpo: Colposcope; MB: Mobile phone camera with small USB pen camera; Handheld: Commercial cervical camera. CIN1+: cervical intraepithelial neoplasia grade 1 or higher; CIN2+: cervical intraepithelial neoplasia grade 2 or higher. Sense: Sensitivity; Spec: Specificity; PPV: positive predictive value; NPV: negative predictive value.

CIN2+ was 72.4 percent [11]. The high sensitivity observed by Singhakum was based on two examiners reaching mutual agreement using Reid's colposcopic Index. Ularnwong and Singhakum used self-developed CG tools consisting of a small USB pen camera with a magnification range of 4 to 15 times [11, 18]. The camera was attached to a smartphone for image recording [11, 18]. In contrast, the current study used pictures taken from a standard colposcope. A large study by Longatto-Filho et al. from Brazil and Argentina reported that the sensitivity of CG for diagnosing CIN2+ was only 28.6 percent [20]. The commercial CG used in Song's and Longatto-Filho's studies was developed by NTL, Korea [19, 20]. One operator interpreted all images from the CG. The limitations of CG primarily depended on the quality of TZ visualization. In the current study, TZ type 1 was observed in 64.4 percent, while Singhakum's, de Castro Hillmann's, and Ularnwong's studies reported TZ type 1 rates of 64.6, 74.9, and 100 percent, respectively [10, 11, 18]. The low sensitivity (47%) was observed in the current study. It indicated that CG missed more than half of the HGL cases. However, this was not the primary screening tool. CG was only an adjunctive tool for prioritization of cases to undergo colposcopy. To improve sensitivity, we recommended using a high-resolution camera and focusing on TZ type 1 subjects.

In the present study, the expert achieved a specificity of 95 percent, which was among the highest reported values. This aligned with Singhakum's (97.0%) and Longatto-Filho's (96.6%) studies [11, 20]. The specificity of the current study was slightly higher than that of de Castro Hillmann's (91.0%) and Ularnwong's (87.7%) studies

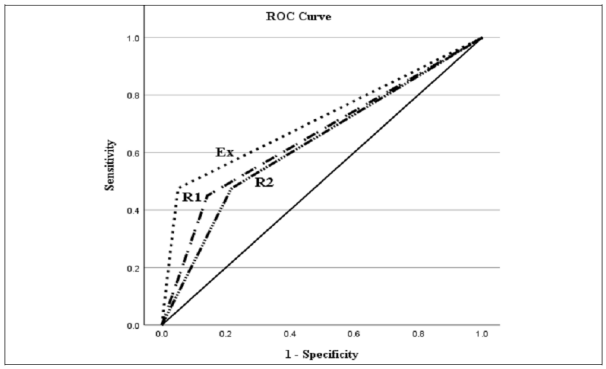

Figure 2. AUC for Cervicography Interpretation by Examiners. AUC: Area Under the Receiver Operating Characteristic curve; Ex: gynecologic oncologist; R1: First Obstetrics and Gynecology residents; R2: Second Obstetrics and Gynecology residents

[10, 11, 18, 20]. Conversely, the Song study used a CIN1+ cutoff, resulting in lower specificity (60.3%) [19].

While the current study reported a PPV of 76.0 percent from the expert, it also aligns with previous literature [10, 11, 18, 19]. The reports by Ularnwong, Song, de Castro, and Singhakum indicated that the PPV ranged from 53.7 to 84.0 percent [10, 11, 18, 19]. However, Longatto-Filho reported that the PPV for CIN2+ detection was only 15.4 percent [20]. The CG camera used in Longatto-Filho's study was an older version than the one used in Song's study [19, 20]. The PPV from the current study is consistent with those reported by Ularnwong, Song, de Castro, and Singhakum [10, 11, 18, 19]. A high PPV from CG (76%) might be an effective tool for clinics lacking experienced colposcopists. Real-time CG from remote clinics to expert colposcopists could serve as an alternative method to guide remote operators in performing cervical biopsies with expert oversight via online communication. This approach could assist patients with abnormal CC screening results who undergo colposcopy in urban areas. NPV for detecting CIN2+ remained consistent across examiners, ranging from 81.7 to 84.4 percent. These findings demonstrated that CG could reliably exclude high-grade lesions regardless of the examiner's training level.

A large study by Longatto-Filho in 2012 showed that the NPV of CG for detecting CIN2+ was 98.4 percent [20]. The prevalence of CIN2+ in that study was only 1.4 percent. Another large study, conducted in Korea in 2020 by Song, found that the NPV of CG for detecting CIN1+ was 83.9 percent [19]. The prevalence of CIN2+ in Song's study was only 5.4 percent [19]. As previously mentioned, CG in both Song's and Longatto-Filho's studies used commercial CG from NTL, Korea, with different versions [19, 20]. Studies by Ularnwong, de Castro Hilman, and Singhakum reported NPVs of 88.7, 89.3, and 94.2 percent for detecting CIN2+, respectively [10, 11, 18]. The prevalence of CIN2+ in these studies was 10.2, 22, and 20 percent, respectively [10, 11, 18]. The diagnostic performance of the screening test varied according to the prevalence of positive results, with the prevalence of CIN2+ in Longatto-Filho's and current studies being 1.4 and 25.0 percent, respectively [20]. The prevalence of CIN2+ in the current study was comparable to that in Ularnwong's, de Castro Hilman's, and Singhakum's studies, which also showed similar NPV [10, 11, 18]. The prevalence of CIN2+ in Song's study was only 5.4 percent, with the test threshold set at CIN1+ [19]. The NPV of 83.9 percent in Song's study was probably lower than expected [19]. In the current study, the NPV of CG for detecting CIN2+ among experts and OB-GYN residents was comparable. In settings lacking experienced colposcopists, CG performed by general OB-GYN physicians could be an alternative test after abnormal screening to rule out CIN2+ initially.

The rate of abnormal cervical screening results has increased, mainly due to the widespread adoption of primary HPV testing [21]. Consequently, the demand for colposcopy services has increased because current guidelines recommend CDB for women at high short-term or cumulative risk of CIN2+ based on HPV and cytology results [5]. The high sensitivity of HPV testing results in an increased number of colposcopy referrals. Using simple tools to assess risk might help prioritize colposcopic investigations. CG interpreted by OB-GYN physicians can serve as an effective triage tool before colposcopy or biopsy. Evidence from Thailand shows that CG can achieve acceptable accuracy in detecting CIN2+, with sensitivity similar to that of expert-read colposcopy [11, 18]. CG may help prioritize or balance limited resources with appropriate investigations to reduce unnecessary procedures. Anxiety among women with abnormal cervical cancer screening results can increase when scheduled for a colposcopy [22, 23]. Rapid assessment through standard colposcopy or a preliminary CG report might help lessen anxiety among women waiting for colposcopy. A summary of previous literature was presented in Table 3.

The study's strength was the blinded review of CG images by examiners with different levels of clinical experience, which helped minimize potential bias. Additionally, CG utilized standard colposcopy images, making the method easy to integrate into routine practice without requiring additional equipment. The single-center design, retrospective approach, and limited number of CIN2+ cases could be limitations of this study. Variation in physician performance only influenced the specificity and PPV for detecting CIN2+. The sensitivity and NPV of CG remained consistent across different levels of physician performance. The sensitivity and NPV were sufficient for initial interpretation. Moving forward, prospective multicenter cohorts and the evaluation of artificial intelligence (AI)-aided interpretation are necessary to strengthen the evidence base and improve the clinical usefulness of CG.

In conclusion, CG shows high specificity and acceptable sensitivity for the initial detection of CIN2+. In this study, expert interpretation achieved the highest diagnostic performance, including specificity and PPV. NPV and sensitivity were not affected by the physician's experience. Notably, all examiners demonstrated similar ability to rule out the disease, with comparable NPV across groups, supporting the potential of CG as a reliable triage

tool. When used alongside experienced readers, CG can enhance the detection of CIN2+ in cases where colposcopy is challenging and multiple procedures are needed. CG can also be incorporated into telemedicine pathways to allow prompt biopsy or treatment decisions. Although CG could not replace colposcopy, it serves as another practical screening test to prioritize cases with abnormal cervical cancer screening results.

Declarations

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Clinical trial registration

Not applicable

Conflicts of interest

The authors declare that they have no conflicts of interest to disclose.

Availability of data and material

The data sets used and/or analyzed in this study are available from the corresponding authors upon reasonable request.

Code availability

The custom code has been used.

Authors' contributions

Kanokwan Promchit and Sawanya Benchahong contributed to the conception, design, and final drafting of the manuscript. Pitchapong Kittiniyom contributed to data collection and took the lead in drafting the initial version of the manuscript. Nop Khongthon contributed to the study concept and provided statistical consultation and data analysis support. Komsun Suwannarurk supervised the study. All authors approved the final version for submission.

Ethics approval

This study received approval from the Human Research Ethics Committee at Thammasat University (037/2024) in 2024.

Consent to participate

Not applicable

Consent for publication

Not applicable

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