Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 480-490.

GYNAECOLOGY

The New Scoring System for Predicting Positive Surgical Margins of High-grade Cervical Intraepithelial Neoplasia after Loop Electrosurgical Excision Procedure

Nuttha Sangsitong, M.D.*,
Nopporn Rodpenpear, M.D.*

** Department of Obstetrics and Gynecology, Faculty of Medicine, Srinakharinwirot University, Ongkharak, Nakornnayok, Thailand*

ABSTRACT

Objectives: To develop prediction score for positive surgical margins after loop electrosurgical excision procedure (LEEP) in women with high-grade cervical intraepithelial neoplasia.

Materials and Methods: A diagnostic predictive model study was conducted during January 2025 to December 2026. Medical records of women with histologically confirmed cervical intraepithelial neoplasia 2/3 who underwent primary LEEP at HRH Princess Maha Chakri Sirindhorn Medical Center were reviewed between January 2017 and December 2023. Independent predictors identified by multivariable logistic regression were converted into a risk score based on regression coefficients. Model performance was assessed using area under the curve (AUC), calibration belt, and bootstrap internal validation.

Results: A total of 207 women were included. Four independent predictors were incorporated into the final model: endocervical gland involvement, transformation zone type, high-grade cytology, and cone depth. The total score ranged from 0 to 7. At a cutoff score of ≥ 4, the model yielded a sensitivity of 83.18%, specificity of 58%, positive predictive value of 67.9%, and negative predictive value of 76.3%. The model showed acceptable discrimination with AUC of 0.739 (95% confidence interval 0.672-0.807), with satisfactory calibration and good internal validity following bootstrap validation.

Conclusion: The prediction model can assist clinicians in estimating positive margin risk and optimizing surgical planning.

Keywords: cervical intraepithelial neoplasia, loop electrosurgical excision procedure, positive surgical margin, prediction model.

Correspondence to: *Nopporn Rodpenpear, M.D., Department of Obstetrics and Gynecology, Faculty of Medicine, Srinakharinwirot University, Ongkharak, Nakornnayok, Thailand. E-mail: noppornr@g.swu.ac.th*

Received: 6 September 2026, **Revised:** 28 September 2026, **Accepted:** 2 October 2026

ดัชนีใหม่ทำนายความเสี่ยงในการพบรอยโรคบริเวณขอบชิ้นเนื้อหลังการตัดปากมดลูกด้วยห่วงลวดไฟฟ้า

ณัฏฐา แสงสีทอง, นพพร โรจน์เพ็ญเพียร

บทคัดย่อ

วัตถุประสงค์: *เพื่อสร้างดัชนีใหม่ทำนายความเสี่ยงในการพบรอยโรคบริเวณขอบชิ้นเนื้อหลังการตัดปากมดลูกด้วยห่วงลวดไฟฟ้าในสตรีที่พบรอยโรคของปากมดลูกก่อนเป็นมะเร็งขั้นสูง*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาเพื่อพัฒนาดัชนีการทำนาย โดยการศึกษาทบทวนเวชระเบียนของสตรีที่พบรอยโรคของปากมดลูกก่อนเป็นมะเร็งขั้นสูง (cervical intraepithelial neoplasia 2/3) และได้รับการรักษาด้วย loop electrosurgical excision procedure เป็นครั้งแรก ณ ศูนย์การแพทย์สมเด็จพระเทพรัตนราชสุดาฯ สยามบรมราชกุมารี ระหว่างเดือนมกราคม 2560 ถึงเดือนธันวาคม 2566 ตัวแปรทำนายที่ได้จากการวิเคราะห์การถดถอยโลจิสติกพหุตัวแปร (multivariable logistic regression) ถูกนำมาพัฒนาเป็นคะแนนความเสี่ยงตามค่าสัมประสิทธิ์ ประเมินประสิทธิภาพของแบบจำลองด้วยพื้นที่ใต้โค้ง (area under the curve; AUC) และประเมินการสอบเทียบของดัชนีด้วย calibration belt และการตรวจสอบความเที่ยงตรงภายในด้วยวิธี bootstrap*

ผลการศึกษา: *มีสตรีเข้าร่วมการศึกษาทั้งหมด 207 ราย พบตัวแปรทำนาย 4 ตัวแปรที่นำมาใช้ในดัชนีทำนาย ได้แก่ การตรวจพยาธิวิทยาพบ endocervical gland involvement ชนิดของ transformation zone ผลตรวจเซลล์วิทยาปากมดลูกระดับ high-grade และระดับความลึกของการตัดปากมดลูก คะแนนรวมอยู่ในช่วง 0-7 คะแนน เมื่อใช้จุดตัดที่มากกว่าเท่ากับ 4 คะแนน ดัชนีทำนายมีความไวร้อยละ 83.18 ความจำเพาะร้อยละ 58 ค่าทำนายผลบวกร้อยละ 67.9 และค่าทำนายผลลบร้อยละ 76.3 ดัชนีทำนายมีความสามารถในการจำแนกอยู่ในระดับที่ยอมรับได้ โดยมีพื้นที่ใต้โค้งเท่ากับ 0.739 (95% CI 0.672-0.807) มีการประเมินการสอบเทียบที่ดีและความเที่ยงตรงภายในที่ดีหลังการตรวจสอบด้วยวิธี bootstrap*

สรุป: *ดัชนีทำนายนี้สามารถช่วยแพทย์ในการประเมินความเสี่ยงของการพบรอยโรคบริเวณขอบชิ้นเนื้อหลังการตัดปากมดลูกด้วยห่วงลวดไฟฟ้าและเป็นประโยชน์ในการวางแผนผ่าตัดต่อไป*

คำสำคัญ: *รอยโรคก่อนมะเร็งปากมดลูก, การตัดปากมดลูกด้วยห่วงลวดไฟฟ้า, การพบรอยโรคบริเวณขอบชิ้นเนื้อ, ดัชนีการทำนาย*

Introduction

Cervical cancer remains the fourth most common cancer among women worldwide[1], with an estimated 661,021 new cases and 348,189 deaths reported in 2022. Despite substantial reductions in disease burden following the implementation of cervical cancer screening programs, cervical cancer continues to represent a major public health problem, particularly in low- and middle-income countries[2]. In Thailand, cervical cancer remains one of the leading malignancies among women[3], highlighting the importance of effective screening and timely treatment of cervical precancerous lesions[4].

High-grade cervical intraepithelial neoplasia grades 2 and 3 (CIN2/3) are well-established precursor lesions with significant malignant potential if left untreated. American Society for Colposcopy and Cervical Pathology recommend excisional treatment for most women with histologically confirmed high-grade squamous intraepithelial lesion, particularly when the transformation zone is not fully visualized, endocervical involvement is suspected, or invasive disease cannot be excluded[5]. Loop electrosurgical excision procedure (LEEP) has become the most widely used excisional treatment because it is effective, minimally invasive, cost-effective, and can be performed safely in an outpatient setting[6]. In addition to providing definitive treatment, LEEP allows histopathological evaluation of the excised specimen, including assessment of surgical margin status, which is an important predictor of treatment success.

Positive surgical margins after LEEP have consistently been associated with an increased risk of residual or recurrent cervical intraepithelial neoplasia, persistent high-risk human papillomavirus infection, repeat excisional procedures, and subsequent hysterectomy in selected patients[7]. A previous Thai study evaluating hysterectomy specimens after LEEP or cold-knife conization demonstrated that residual disease remained an important finding following excisional treatment, highlighting the importance of adequate lesion removal and subsequent surveillance[8]. Although not all women with positive margins develop recurrent disease, margin status remains one of the strongest pathological predictors guiding postoperative surveillance and further management[9, 10]. Several clinical and pathological factors associated with positive surgical margins have been reported, including advanced age, menopausal status, abnormal cervical cytology, extensive lesion involvement, transformation zone type, endocervical gland involvement, lesion extension into the endocervical canal, and inadequate cone depth[11-14]. Based on these predictors, Zhu et al developed a clinical scoring system to estimate the risk of positive margins after cervical excision[15]. However, their model incorporated endocervical curettage (ECC) findings, a procedure not routinely performed in all women undergoing LEEP, thereby limiting its applicability in routine clinical practice. Furthermore, the model has not been externally validated in Thai women, whose clinical characteristics and treatment practices may differ from those of the original study population.

To date, no clinical prediction model has been developed specifically for the Thai population to estimate the risk of positive surgical margins following LEEP. Therefore, this study aimed to develop and internally validate a simple clinical prediction score, using routinely available variables, to predict positive surgical margins after LEEP in women with high-grade cervical intraepithelial neoplasia (CIN2/3). Additionally, we evaluated its diagnostic performance.

Materials and Methods

This diagnostic predictive model study was conducted at Her Royal Highness Princess Maha Chakri Sirindhorn Medical Center, Faculty of Medicine, Srinakharinwirot University, Thailand. Medical records of women who underwent LEEP between January 2017 and December 2023 were reviewed. The study protocol was approved by the Institutional Ethics Committee of Srinakharinwirot University (Approval No. SWUEC-673062) and was registered on the Thai Clinical Trials Registry (TCTR20250801001).

Women aged 18 years or older with histologically confirmed cervical intraepithelial neoplasia grade 2 or grade 3 (CIN2/3) who underwent their first LEEP and had all required data in medical record were eligible for inclusion. Patients were excluded if they had a previous diagnosis of invasive cervical cancer or other malignancies, invasive carcinoma identified on the final LEEP specimen, pregnancy at the time of treatment, or incomplete pathological reports that precluded evaluation of surgical margin status.

Demographic and clinical data were retrieved from medical records. The collected variables included age, parity, menopausal status, preoperative cervical cytology, transformation zone (TZ) type, satisfactory colposcopy, lesion quadrant involvement, cone depth, pathological margin status and endocervical gland involvement. Cervical cytology was categorized as low-grade group (atypical squamous cells of undetermined significance (ASC-US), low-grade squamous intraepithelial lesion (LSIL), atypical glandular cells, not otherwise specified (AGC-NOS)) or high-grade group (atypical squamous cells, cannot exclude HSIL (ASC-H), high-grade squamous intraepithelial lesion (HSIL), atypical glandular cells, favor neoplasia (AGC-FN)), adenocarcinoma, squamous cell carcinoma) according to the Bethesda System[16]. The transformation zone was classified as type 1, type 2, or type 3 according to the International Federation for Cervical Pathology and Colposcopy (IFCPC) nomenclature[17]. Endocervical gland involvement was determined from histopathological examination of pre-LEEP cervical biopsy. Cone depth was obtained from the final pathology report. Because the pathological measurement was performed after formalin fixation, the reported cone depth was adjusted for potential tissue shrinkage by adding 15% to the measured value. The adjusted cone depth was used in the statistical analysis and prediction model[18].

The primary outcome was the presence of a positive surgical margin after LEEP. A positive margin was defined as the presence of CIN involving either the ectocervical or endocervical or deep resection margin on the final histopathological report. A negative margin was defined as the absence of dysplastic epithelium at all surgical margins.

The sample size calculation was based on the area under the receiver operating characteristic curve (AUC) from a previous predictive index. The study by Zhu et al reported an AUC of 0.769 for predicting margin positivity. We hypothesized that our newly developed index would demonstrate superior predictive performance, with an anticipated AUC of 0.88. Given the observed ratio of positive to negative surgical margins (1:3) at Her Royal Highness Princess Maha Chakri Sirindhorn Medical Center, the sample size was calculated using the MedCalc online tool for ROC curve analysis(19). With a two-sided alpha error of 5% ($\alpha = 0.05$) and a statistical power of 80%, the minimum required sample size was determined to be 196 participants. Accounting for an estimated 5% rate of incomplete data, the total required sample size was adjusted to 207 participants, comprising 155 patients in the negative margin group and 52 patients in the positive margin group. Continuous variables were summarized as mean ± standard deviation (SD) and compared using the independent student's t-test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate. Variables with $p < 0.20$ in the univariable analysis were included in the multivariable logistic regression model to identify independent predictors of positive surgical margins. Adjusted odds ratio (aOR) with 95% confidence intervals (CIs) were reported.

A clinical prediction score was subsequently developed based on the final multivariable logistic regression model. The regression coefficient of each independent predictor was divided by the smallest coefficient in the model and rounded to the nearest integer to generate an assigned score for practical clinical use (final model). The total score was calculated by summing the assigned scores of all predictors. The predictive performances of the original regression model (original model) and the simplified prediction score model (final model) were then compared using the area under the receiver operating

characteristic curve (AUC). As there were no missing data among the variables included in the analysis, no imputation was required.

The discriminative ability of the prediction model was assessed using the AUC with a 95% CI. The cutoff score was selected by examining the receiver operating characteristic (ROC) curve and identifying the threshold that provided an appropriate balance between sensitivity and specificity. Calibration was evaluated using the calibration belt, and internal validation was performed using 1,000 bootstrap resampling. The diagnostic performance of different cutoff values was assessed by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). All statistical analyses were performed using Stata version 14 (StataCorp LP, College Station, TX, USA). A two-sided p value of < 0.05 was considered statistically significant.

Results

A total of 237 women with histologically confirmed CIN 2/3 who underwent LEEP between January 2017 and December 2023 were initially identified. After applying the exclusion criteria, 30 women were excluded: 27 with invasive cervical cancer identified on final histopathology and 3 with a history of prior malignancy. The remaining 207 women were included in the final analysis (Fig. 1). Among the 207 eligible women, 107 (51.7%) had positive surgical margins, whereas 100 (48.3%) had negative surgical margins following LEEP.

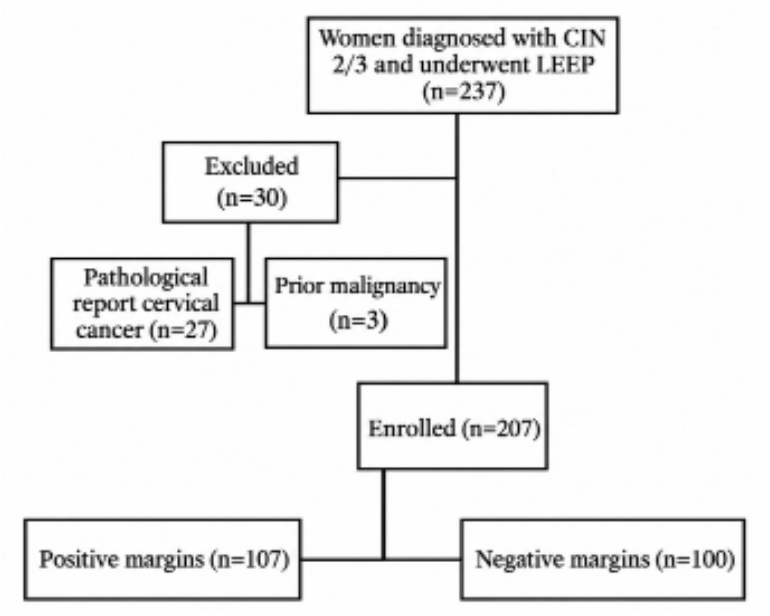


Fig. 1. Consort flow diagram.

CIN: cervical intraepithelial neoplasia, LEEP: loop electrosurgical excision procedure

The baseline demographic and clinicopathological characteristics of the study population are summarized in Table 1. Compared with women with negative surgical margins, those with positive surgical margins were older (40.47 ± 9.92 vs 37.42 ± 8.66 years, $p = 0.019$), had a lower mean cone depth (7.08 ± 2.67 vs 8.79 ± 3.49 mm, $p < 0.001$), and were more likely to have high-grade cytology, endocervical gland involvement, and a non-type 1 (type 2 or 3) transformation zone. Conversely, parity, menopausal status, satisfactory colposcopy, and lesion quadrant involvement were not significantly different between the two groups.

Table 1. Demographic characteristics of the patients.

Clinical characteristics	Positive margin (n = 107)	Negative margin	p value
Age (years), mean ± SD	40.47 ± 9.92	37.42 ± 8.66	0.019
Parity, n (%)			0.155
0	22 (48.89)	23 (51.11)	
1	30 (42.25)	41 (57.75)	
2	39 (62.9)	23 (37.1)	
3	13 (59.09)	9 (40.91)	
4	2 (33.33)	4 (66.67)	
5	1 (100)	0 (0)	
Menopausal status, n (%)			0.147
Pre-menopause	93 (50)	93 (50)	
Post-menopause	14 (66.67)	7 (33.33)	
Cone depth (mm), mean ± SD	7.08 ± 2.67	8.79 ± 3.49	
Cytology, n (%)			< 0.001
Low grade	16 (30.19)	37 (69.81)	
High grade	91 (59.09)	63 (40.91)	
Endocervical gland involvement, n (%)			< 0.001
Yes	88 (61.11)	56 (38.89)	
No	19 (30.16)	44 (69.84)	
Satisfactory colposcopy, n (%)			0.085
Yes	93 (49.73)	94 (50.27)	
No	14 (70)	6 (30)	
Type of transformation zone, n (%)			0.001
Type 1	70 (44.59)	87 (55.41)	
Type 2	24 (77.42)	7 (22.58)	
Type 3	13 (68.42)	6 (31.58)	
Quadrant of lesion, n (%)			0.182
No lesson	11 (45.83)	13 (54.17)	
1	38 (44.19)	48 (55.81)	
2	32 (55.17)	26 (44.83)	
3	14 (70)	6 (30)	
4	12 (63.16)	7 (36.84)	

SD: standard deviation

Multivariable logistic regression analysis identified four factors independently associated with positive surgical margins after LEEP: endocervical gland involvement on pre-LEEP biopsy (aOR 2.98, 95% CI 1.504, 5.914), non-type 1(type 2 or 3) versus type 1 transformation zone (aOR 3.13, 95% CI 1.484, 6.609), high-grade versus low-grade cytology (aOR 2.402, 95% CI 1.166, 4.945), and cone depth < 7.21 versus ≥ 7.21 mm (aOR 2.06, 95% CI 1.124, 3.784). Based on the regression coefficients, assigned scores were 2, 2, 2, and 1 point, respectively, yielding a total score ranging from 0 to 7 points (Table 2). The optimal cone depth cutoff of 7.21 mm was based on the study by Srijarusith and Rodpenper, which recommended this depth to achieve a higher likelihood of negative surgical margins[13]. The original model demonstrated an AUC of 0.747 (95% CI 0.681, 0.814), while the final simplified model achieved an AUC of 0.739 (95% CI 0.672, 0.807), with no statistically significant difference between the two (p = 0.114). Thus, the predictive performance of the final model was comparable to that of the original model (Fig. 2).

Table 2. Multivariable analysis and assigned score.

Predictive variable	Adjusted odds ratio	95%CI	p value	Coefficient	Assigned score
Endocervical gland involvement on pre-LEEP biopsy: Yes vs No	2.98	1.504-5.914	0.002	1.092832	2
Type of transformation zone: non-Type 1 vs type 1	3.13	1.484-6.609	0.003	1.14184	2
Cytology: high grade vs low grade	2.402	1.166-4.945	0.017	0.8761978	2
Cone depth < 7.21 vs ≥7.21 mm*	2.06	1.124-3.784	0.019	0.7239634	1

*Appropriate cone depth was at least 7.21 mm. to achieve negative margin
CI: confidence intervals, LEEP: loop electrosurgical excision procedure

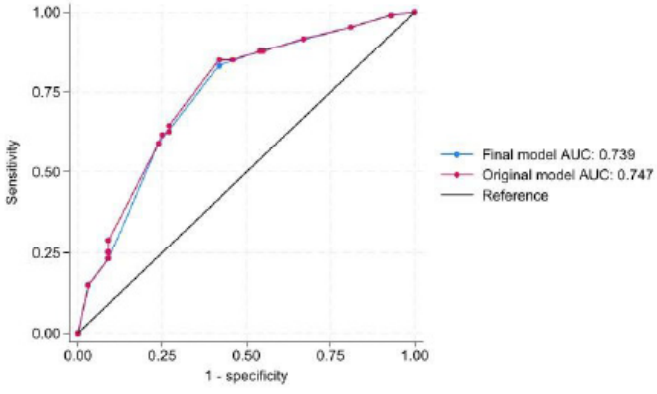


Fig. 2. Compare performance between original model and final model.
AUC: area under the curve

The diagnostic performance of the prediction score at different cutoff values is shown in Table 3. An optimal cutoff score of 4 yielded a sensitivity of 83.18%, specificity of 58.0%, positive predictive value of 67.9%, and negative predictive value of 76.3%. This cutoff was selected based on the optimal balance between sensitivity and specificity on the ROC curve, as well as the overall diagnostic accuracy of the model. The prediction model demonstrated acceptable discrimination, with an apparent AUC of 0.739 (95% CI 0.672, 0.807) (Fig. 3). After internal validation using 1,000 bootstrap resamples, the corrected AUC was 0.732 (95% CI 0.669, 0.803). The calibration belt showed no significant evidence of model miscalibration (p = 0.535), no observed data deviating above or below the bisector, and maintaining a narrow and consistent width across the entire predicted risk spectrum (Fig. 4).

Table 3. The diagnostic performance of the prediction score.

Cut-off point	Sensitivity	Specificity	Positive predictive value	Negative predictive value
≥ 0	100.00%	0.00%	51.6%	-
≥ 1	99.07%	7.00%	53.3%	87.5%
≥ 2	95.33%	19.00%	55.7%	79.2%
≥ 3	87.85%	46.00%	63.5%	78.0%
≥ 4*	83.18%	58.00%	67.9%	76.3%
≥ 5	58.88%	76.00%	72.4%	63.3%
≥ 6	23.36%	91.00%	73.5%	52.6%
≥ 7	14.95%	97.00%	84.2%	51.6%

* Optimal cut-off point

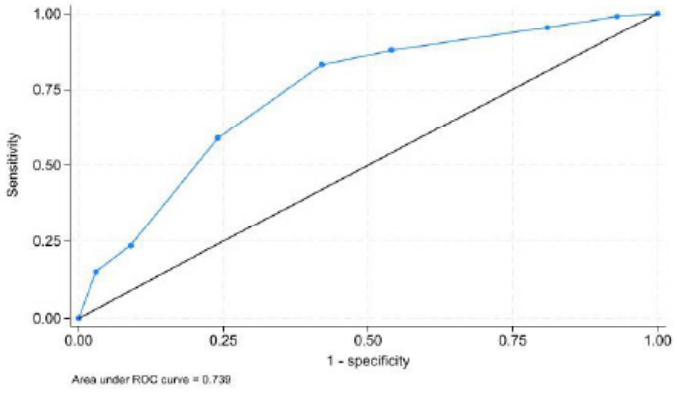


Fig. 3. The ROC curve of prediction model.
ROC: receiver operating characteristic

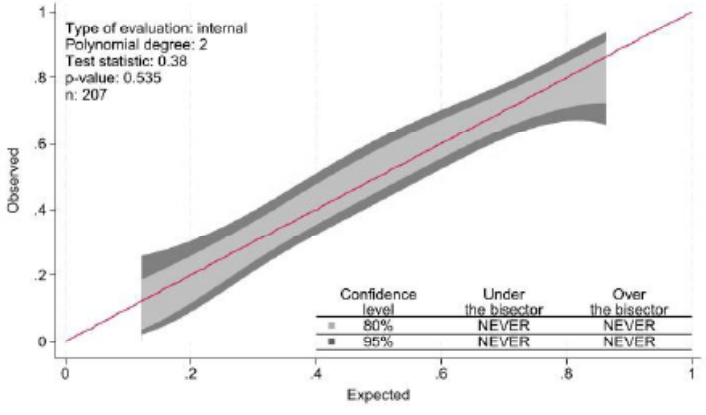


Fig. 4. The calibration belt.

Discussion

This study identified a combination of clinical, cervical cytology, cervical pathology, and procedural factors associated with positive surgical margins after LEEP. The resulting prediction model demonstrated acceptable discriminatory performance, suggesting that combining these routinely available factors may help identify women at increased risk of margin involvement. Achieving negative surgical margins remains clinically important because positive margins have consistently been associated with an increased risk of residual and recurrent cervical intraepithelial neoplasia[7]. Although not all women with positive margins develop recurrent disease, identifying factors associated with margin positivity may improve understanding of incomplete excision and inform future development of prediction tools that can be applied before or during the procedure[15].

Several prediction models for positive surgical margins have previously been proposed. Compared with the previously proposed model by Zhu et al[15], our model does not require routine endocervical curettage (ECC). This may facilitate its application in settings where ECC is not routinely performed before LEEP, as the prediction score can be calculated without requiring additional ECC findings. This feature may improve the practical applicability of the model within our clinical setting. Notably, all predictors in our proposed model can be determined prior to or during the LEEP procedure.

The positive margin rate in our study was higher than that reported in previous Thai studies. Champawong et al[20] reported a positive margin rate of 24.8% after LEEP, whereas Tanompongchat et al[21] reported margin involvement in 35.3% of women undergoing LEEP, which was consistent with prior institutional records. This elevated rate may partly reflect differences in temporal and geographical settings, as well as our institution's role as a tertiary care center receiving complex referral cases from diverse regions. Despite the difference in margin positivity, the factors identified in our model were broadly consistent with previous reports[13, 14, 22]. Endocervical gland involvement, transformation zone characteristics, high-grade cytology, and inadequate excision depth have all been associated with positive margin after excision. In our cohort, a type 2 transformation zone was significantly associated with margin positivity when compared with a type 1 transformation zone (aOR 3.59, 95% CI 1.35, 9.57, p = 0.011), whereas a type 3 transformation zone showed no significant association (aOR 1.95, 95% CI 0.66, 5.80, p = 0.228). This finding contrasts with previous studies that identified type 3 transformation zones as a primary risk factor[22], which may be attributed to the small number of participants with a type 3 transformation zone in our study. Consequently, the final model categorized transformation zones as type 1 versus non-type 1 (types 2 or 3).

An important potential application of the model relates to cone depth. Although actual cone depth was measured from the final pathological specimen in this study, the 7.21-mm threshold may serve as a practical reference for procedural planning. Surgeons could consider this threshold when selecting an appropriate loop size before LEEP and could measure the excised specimen immediately after the procedure. If the achieved depth is < 7.21 mm, particularly in women with a higher predicted risk based on the other model components, additional excision may be considered intraoperatively. This approach allows the scoring system to guide real-time decision-making during the pre- and intraoperative phases, rather than relying solely on postoperative pathological evaluation. The strengths of this study included, to our knowledge, the development of the first clinical prediction score for positive surgical margins after LEEP derived from a Thai population, the use of routinely available variables, and assessment of both discrimination and calibration. Internal validation using bootstrap resamples yielded a corrected AUC of 0.732, close to the apparent AUC of 0.739. Several limitations should be acknowledged. First, the retrospective, single-center design may limit the generalizability of our findings and introduced selection bias. Second, external validation was not performed, and long-term clinical outcomes, such as residual or recurrent disease, were unavailable. Third, the model is unable to predict site-specific margin positivity, namely ectocervical, endocervical, or deep surgical margins. Furthermore, this model is not applicable to the 'see-and-treat' approach, as pre-procedure histopathological confirmation of CIN 2/3 is required. Future prospective multicenter studies should externally validate the model. Incorporating additional predictors, such as high-risk human papillomavirus genotype or persistence, should be considered in future research. Furthermore, site-specific margin prediction would necessitate three distinct models requiring a significantly larger study population.

Conclusion

The prediction model comprising endocervical gland involvement, transformation zone type, cervical cytology, and cone depth can assist clinicians in estimating positive margin risk and optimizing surgical planning. It is user-friendly for routine clinical practice and demonstrates acceptable predictive performance and calibration.

Acknowledgement

This study was based on a dataset from HRH Princess Maha Chakri Sirindhorn Medical Center provided and produced by the Obstetric and Gynecological Department, Srinakharinwirot University.

Author contributions

Data curation, Formal analysis, Investigation, Methodology, Writing – first draft, **NS**, Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Methodology Funding acquisition, Writing – review and editing, **NR**.

Potential conflicts of interest

The authors declare no competing interests.

References

1. Bhatla N, Aoki D, Sharma DN, Sankaranarayanan R. Cancer of the cervix uteri: 2021 update. Int J Gynaecol Obstet 2021;155:28-44.
2. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2024;74:229-63.
3. Wongpratate M, Bumrungthai S. Cervical cancer in Thailand: 2023 update. Obstet Gynecol Sci 2024;67:261-9.
4. Ploysawang P, Rojanamatin J, Prapakorn S, Jamsri P, Pangmuang P, Seeda K, et al. national cervical cancer screening in Thailand. Asian Pac J Cancer Prev 2021;22:25-30.
5. Perkins RB, Guido RS, Castle PE, Chelmow D, Einstein MH, Garcia F, et al. 2019 ASCCP risk-based management consensus guidelines for abnormal cervical cancer screening tests and cancer precursors. J Low Genit Tract Dis 2020;24:102-31.
6. Tillmanns TD, Falkner CA, Engle DB, Wan JY, Mannel RS, Walker JL, et al. Preoperative predictors of positive margins after loop electrosurgical excisional procedure-Cone. Gynecol Oncol 2006;100:379-84.
7. Oh SH, Lee KB, Shin JW, Lee SH. Risk factors for recurrence of cervical intraepithelial neoplasia after loop electrosurgical excisional procedure in patients with positive margins. J Obstet Gynaecol Res 2023;49:2102-8.
8. Kumpasano T, Triratanachat S. Residual disease in hysterectomy specimens after loop electrosurgical excision or cold knife conization in high grade squamous intraepithelium lesion and microinvasive cervical carcinoma. Thai J Obstet Gynaecol 2017;19:67-73.
9. Ding T, Li L, Duan R, Chen Y, Yang B, Xi M. Risk factors analysis of recurrent disease after treatment with a loop electrosurgical excision procedure for high-grade cervical intraepithelial neoplasia. Int J Gynaecol Obstet 2023;160:538-47.
10. Suprasert P, Panyaroj W, Kietpeerakool C. Recurrent rates with cervical intraepithelial neoplasia having a negative surgical margin after the loop electrosurgical excision procedure in Thailand. Asian Pac J Cancer Prev 2009;10:587-90.
11. Ikeda M, Mikami M, Yasaka M, Enomoto T, Kobayashi Y, Nagase S, et al. Association of menopause, aging and treatment procedures with positive margins after therapeutic cervical conization for CIN 3: a retrospective study of 8,856 patients by the Japan Society of Obstetrics and Gynecology. J Gynecol Oncol 2021;32:e68.
12. Kanjanasirirut P, Pataradool K, Manusirivithaya S, Phaloprakarn C, Chavanisakun C. Prevalence and risk factors for positive surgical margin after loop electrosurgical excision procedure (LEEP) in patients with high grade squamous intraepithelial lesion. Thai J Obstet Gynaecol 2015;23:240-5.
13. Srijarusith N, Rodpenpear N. The appropriate of cone depth in loop electrical excision procedure (LEEP) for negative pathological margin from high grade precancerous lesion of cervix, retrospective study. Asian Pac J Cancer Prev 2022;23:659-64.
14. Cong Q, Yu Y, Xie Y, Li Y, Sui L. Risk factors of LEEP margin positivity and optimal length of cervical conization in cervical intraepithelial neoplasia. Front Oncol 2023;13:1209811.
15. Zhu M, Yu M, Chen Z, Zhao W. Construction and evaluation of a clinical prediction scoring system for positive cervical margins under colposcopy. Front Med (Lausanne) 2022;9:807849.
16. The Bethesda System for reporting cervical cytology. Definitions, criteria, and explanatory notes. Third dition. Anticancer Research 2015;35:5708.
17. Bornstein J BJ, Bosze P, Girardi F, Haefner H, Menton M, Perrotta M, et al. IFCPC colposcopic nomenclature. 2011.
18. Boonstra H, Oosterhuis JW, Oosterhuis AM, Fleuren GJ. Cervical tissue shrinkage by formaldehyde fixation, paraffin wax embedding, section cutting and mounting. Virchows Arch A Pathol Anat Histopathol 1983;402:195-201.
19. MedCalc Software Ltd. Sample size for area under ROC curve. https://www.medcalc.org/en/calc/sample-size-area-under-roc-curve.php (Version 23.7.1; accessed 30 November 2024)
20. Champawong R, Tangmanowuthikul S, Saenpoch S, Songthamwat S, Songthamwat M. Prevalence

and associated factors of positive margins of cervical tissue from loop electrosurgical excision procedure. Thai J Obstet Gynaecol 2019;27:187-94.
21. Tanompongchat R, Sangkarat S, Padungsutt P. Prevalence and risk factors of LEEP margin involvement. Thai J Obstet Gynaecol 2017;15:153-9.
22. Chen Y, Zhou JD. Application value of different transformation zone types and its genetic relationship with high-risk HPV type in diagnosis and therapy of cervical disease. Int J Clin Exp Med 2015;8:2447-52.