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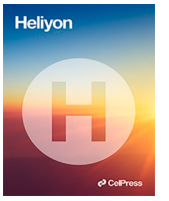

Research article

The application of magnifying endoscopy in the diagnosis of cervical lesions

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ABSTRACT

Objective: This study aimed to assess the sensitivity and specificity of magnifying endoscopy in the examination of patients with high-risk factors for cervical lesions.
Methods: Two equally skilled colposcopy specialists examined 59 patients admitted to the Obstetrics and Gynecology Hospital of Fudan University between March 14, 2023, and April 15, 2023. These patients underwent both colposcopy and magnifying endoscopy examinations. Preliminary diagnoses were then made by the two colposcopy specialists using colposcopy and magnifying endoscopy. The sensitivity and specificity of these methods were then evaluated compared to the postoperative pathology diagnosis for a better understanding of their efficacy.
Results: Colposcopy exhibited sensitivity rates of 23.08 % for diagnosing normal tissue, 10 % for low-grade squamous intraepithelial lesions (LSIL), 90 % for high-grade squamous intraepithelial lesions (HSIL), and 84.62 % for cervical cancer, with specificity rates of 93.94 %, 67.35 %, 71.43 %, and 100 %, respectively. In contrast, magnifying endoscopy demonstrated sensitivity rates of 42.31 %, 40 %, 90 %, and 92.31 % for normal tissue, LSIL, HSIL, and cervical cancer, respectively. The corresponding specificity rates for these categories were 87.88 %, 77.55 %, 83.67 %, and 100 %.
Conclusion: Magnifying endoscopy exhibits higher sensitivity and specificity compared to colposcopy in detecting cervical lesions. With the ability to magnify lesions up to 520 times, magnifying endoscopy facilitates precise visualization of cellular-level lesions, as well as associated anatomical features and vascular signals.

1. Background

Even with the role of vaccines [1,2], cervical cancer is one of the most prevalent cancers among women globally, ranking as the second leading cause of cancer-related death in women aged 20–39 years [3]. Although colposcopy-guided cervical biopsy remains the primary method for diagnosing cervical cancer [4], conventional colposcopy has limitations in identifying and diagnosing subtle lesions, highlighting the need for advanced technologies in clinical practice. Recent advancements in microscopy technologies [3]

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have improved image resolution and vascular visualization, thereby facilitating non-invasive pathological diagnosis. As an emerging imaging technique, magnifying endoscopy shows promise in addressing the limitations of conventional colposcopy. However, few studies have investigated the potential impact of magnifying endoscopy on the diagnosis of cervical cancer. To evaluate its clinical value in diagnosing cervical lesions, magnifying endoscopy was employed and its efficacy was compared with that of conventional colposcopy and biopsy pathology results.

2. Methods

This study included 59 patients who provided consent and underwent colposcopy examinations at the Obstetrics and Gynecology Hospital of Fudan University between March 14, 2023, and April 15, 2023. Eligible women presented with one of the following conditions: a) positive high-risk HPV (types 16/18) testing; b) cervical cytology classified as Atypical Squamous Cells of Undetermined Significance (ASCUS), accompanied by positivity for other high-risk HPV types, or persistent infection with other high-risk HPV types for over one year; c) abnormal cervical cytology, including Low-grade Squamous Intraepithelial Lesion (LSIL), High-grade Squamous Intraepithelial Lesion (HSIL), Atypical Squamous Cells, Cannot Exclude High-grade Squamous Intraepithelial Lesion (ASC-H), Low-grade Squamous Intraepithelial Lesion and Atypical Squamous Cells, Cannot Exclude High-grade Squamous Intraepithelial Lesion (LSIL, ASC-H), Atypical Glandular Cells (AGC), Adenocarcinoma In Situ (AIS), or Squamous Cell Carcinoma (SCC); d) clinical suspicion of cervical malignancy that could not be ruled out. Patients with acute or subacute infections in the lower genital tract, or with wounds, contusions, or active bleeding in the lower genital tract were excluded from the study. Additionally, individuals with a history of previous cervical surgery, pelvic radiation, or hysterectomy, as well as those who were pregnant, were also excluded.

Two experienced colposcopists, Dr. Li and Dr. Chen, each performing over 2,000 colposcopic procedures annually and possessing more than five years of expertise in colposcopy, were selected as the primary examiners. Dr. Li received training from Dr. Sun, a skilled endoscopist at a tertiary hospital, to enhance proficiency in utilizing magnifying endoscopy. Dr. Li conducted the initial examination using the endoscope, which was subsequently followed by Dr. Chen's colposcopy examination. The study employed the Olympus Endocytoscopy System (Type: CF-H290ECI), an advanced category of endoscope known as super magnifying endoscope or EC. This system integrates a 520× contact-type optical microscope at the distal end of the endoscope. To ensure stable observation, a prominent soft silicone cap was affixed to the lens, maintaining an optimal focal distance between the lens and the mucosa. This cap minimized potential damage to the mucosa and lesion surfaces while facilitating rapid and precise focusing for image acquisition. The study received approval from the Ethics Committee of the Obstetrics and Gynecology Hospital of Fudan University (2022-202).

In a typical colposcopy examination, the participant assumed the lithotomy position for the evaluation of bladder stones and external genitalia. The colposcopist utilized the Olympus Endocytoscopy System, which is equipped with a soft silicone cap at its distal end, and gently dilated the vagina using a speculum to expose the cervix. The cervical mucus was then carefully removed using physiological saline. The endoscope, fitted with the soft silicone cap, was inserted into the vagina for cervical observation under white light, ensuring that at least one image was captured. After the removal of the endoscope, acetic acid was applied to the cervix and vaginal surface. The colposcopist then reinserted the endoscope for repeated observation and image capture after 40 s, ensuring the acquisition of at least four images. Following this, the endoscope was removed, and the trial continued with additional examinations and biopsies according to standard colposcopy protocols. The statistical analysis was performed using SPSS version 22.0, with a significance level set at $P < 0.05$ to indicate statistical significance.

3. Results

During the trial, 59 patients underwent colposcopic examinations. The mean age was 39.32 ± 11.68 years. The distribution of cytology results, HPV status, and biopsy pathology diagnoses is presented in Table 1.

Colposcopic and endoscopic images: Fig. 1 presents a comparison of colposcopic and endoscopic images from patients with various pathological types. The endoscopic images exhibited superior resolution and more defined vascular features compared to the colposcopic images. In scenarios where there was an increased risk of missed diagnoses or atypical presentations during colposcopy, endoscopy emerged as a valuable supplementary tool.

Diagnostic Performance: Fig. 2 presents the confusion matrix for the diagnosis using two testing methods. It is evident that both colposcopy and endoscopy exhibit higher detection rates and greater consistency in diagnosing cervical HSIL and cervical cancer. In

Table 1
Distribution of cytology, HPV status, and biopsy pathology diagnosis.

Cytology	n	HPV	n	Pathology	n
NILM**	19	Type 16+	18	Normal	26
ASCUS	13	Type 18+	7	LSIL	10
LSIL	10	Other high risk HPV types+	35	HSIL	10
ASH-H	6	Moderate and low risk HPV+	5	SCC	13
HSIL	7	Multiple HPV types +	9		
LSIL, ASC-H	1	HPV negative	5		
AGC	1				
SCC	2				

**Negative for Intraepithelial Lesion or Malignancy.

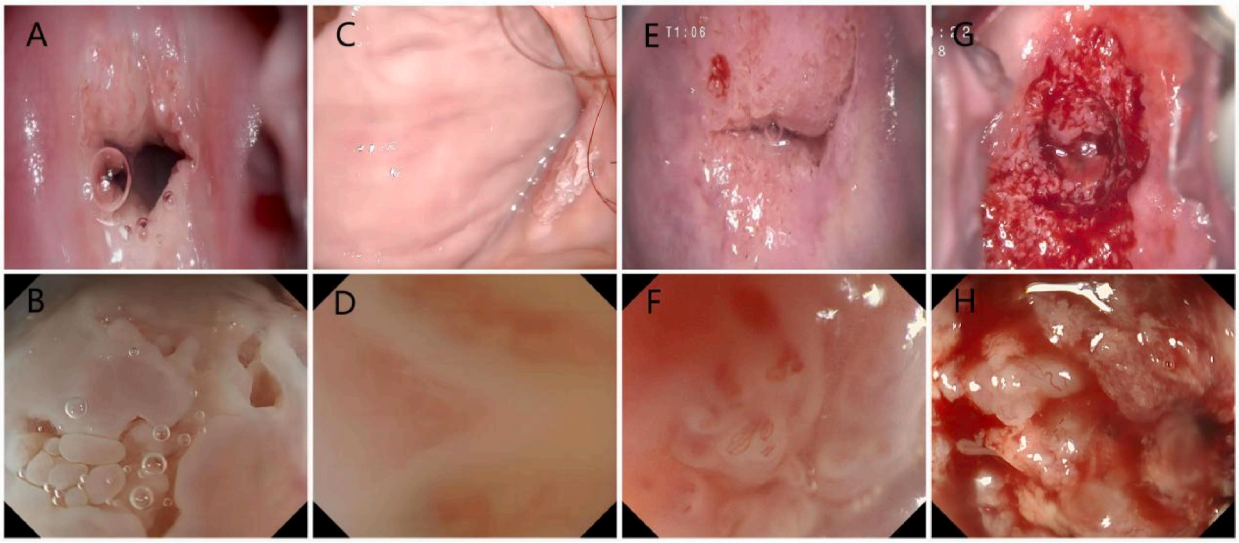

Fig. 1. Comparison of colposcopic and endoscopic images of patients with different pathological types.
A, B: LCT: ASCUS, HPV66+. Pathology: Inflammation. A is a colposcopic image indicating inflammation; B presents an endoscopic image, revealing clear columnar epithelium with granular appearance, suggesting inflammation.
C, D: LCT: LSIL, HPV 11+. Pathology: External genital warts. C displays a colposcopic image illustrating cluster-like warts, with an impression of genital warts; D is an endoscopic image showing clear vascular loops, also suggestive of genital warts.
E, F: LCT: LSIL, HPV 16+. Pathology: Cervical HSIL. E presents a colposcopic image, showing thin acetowhite epithelium with an impression of LSIL. F depicts an endoscopic image illustrating dot-like blood vessels, a peripheral ring-like appearance, acetowhite epithelium, and slight local elevation, suggestive of HSIL.
G, H: LCT: HSIL, HPV 31+. Pathology: Invasive cervical squamous cell carcinoma. G is a colposcopic image with an impression of cancer. H displays an endoscopic image demonstrating a cervical mass, atypical blood vessels, and necrotic tissue, supporting the impression of cancer.

contrast, both examination tools show lower detection rates and limited consistency in diagnosing cervical inflammation and LSIL. The detailed diagnostic results for each lesion corresponding to colposcopy and endoscopy are provided in Tables 2–5. The sensitivity of colposcopy for diagnosing inflammation, LSIL, HSIL, and cervical cancer (Ca) is 23.08 %, 10 %, 90 %, and 84.62 %, respectively, with specificities of 93.94 %, 67.35 %, 71.43 %, and 100 %, respectively. Conversely, the sensitivity of endoscopy for diagnosing inflammation, LSIL, HSIL, and cervical cancer is 42.31 %, 40 %, 90 %, and 92.31 %, respectively, with specificities of 87.88 %, 77.55 %, 83.67 %, and 100 %, respectively. Overall, endoscopy demonstrates superior performance compared to colposcopy in detecting cervical lesions.

4. Discussion

The endoscopic system has been proven effective in diagnosing cervical glandular cancer. Studies conducted by Kunihisa Uchita [5] and Noriko Nishiyama [6] revealed that compared to traditional colposcopy, ME-NBI offered higher sensitivity, specificity, and accuracy in identifying cervical lesions. Additionally, Uchita et al.'s study found that the use of endoscopic forceps biopsy can mitigate the trauma caused by the biopsy procedure [7]. However, the previous studies had a limited number of cases (four studies with 2 [8], 10 [6], 24 [5], 32 [7] and 88 [9] cases, respectively). Moreover, endoscopic procedures were complicated and often required referral to specialized endoscopists and endoscopy rooms, which added to patient inconvenience and clinical challenges. In our study, 59 patients indicated for colposcopy underwent sequential examinations with both endoscopy and colposcopy by colposcopists with endoscopy training. This approach eliminated the need to change the operation site and made the clinical procedures easier to perform. This study represents the first in China to explore the use of endoscopy for diagnosing cervical lesions, offering new avenues for further research and the application of endoscopic techniques in gynecology.

The aim of this study was to assess the sensitivity and specificity of magnifying endoscopy in diagnosing cervical precancerous lesions compared to conventional colposcopy. The results indicated that magnifying endoscopy demonstrated superior sensitivity and specificity for detecting cervical lesions relative to colposcopy. These findings suggest that magnifying endoscopy is more effective in accurately identifying cervical lesions and exhibits a lower rate of false positives, thereby facilitating a more precise diagnosis. Compared with conventional magnifying endoscopes, the EC's enhanced magnification capability allows for cellular-level observation of lesions, contributing to a better assessment of histopathological features. The improved performance of magnifying endoscopy can be attributed to its ability to magnify lesions up to 520 times, enabling detailed visualization of cellular structures, anatomical features, and vascular signals. This enhanced visualization aids in the identification of subtle lesions that may be overlooked by conventional colposcopy.

However, it is important to note that this study had a relatively small sample size of 59 patients. Further studies with larger sample

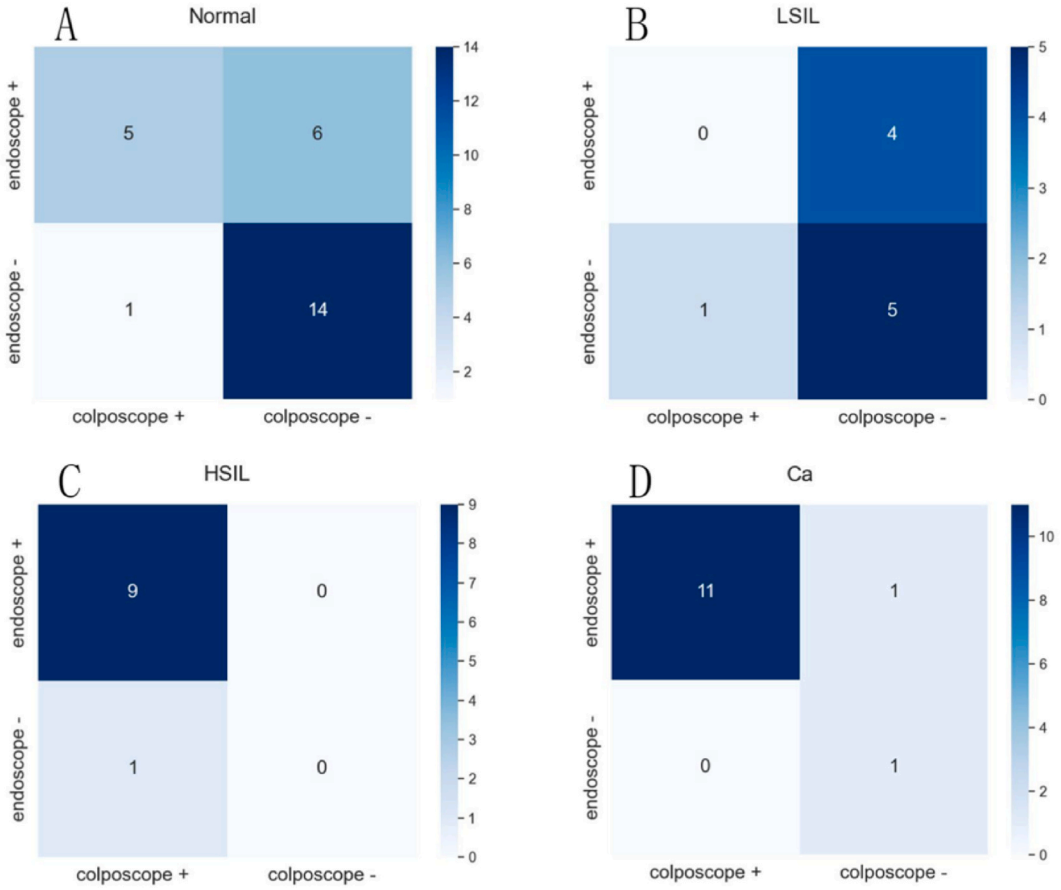

Fig. 2. Confusion matrix diagrams for endoscopic and colposcopic diagnoses.
A: Confusion matrix diagram for endoscopic and colposcopic diagnoses of cervical inflammation. Fisher's exact test, P: 0.054.
B: Confusion matrix diagram for endoscopic and colposcopic diagnoses of cervical LSIL.
Fisher's exact test, P: 1.000.
C: Confusion matrix diagram for endoscopic and colposcopic diagnoses of cervical HSIL.
D: Confusion matrix diagram for endoscopic and colposcopic diagnoses of cervical cancer. Fisher's exact test, P: 0.154.

Table 2
Sensitivity and specificity of the two diagnostic methods for normal/inflammation compared to pathological results.

normal/inflammation				
	Pathological results+	Pathological results-	sensitivity	specificity
Colposcopic results:+	6	2	23.08 %	93.94 %
Colposcopic results:-	20	31		
Endoscopic results:+	11	4	42.31 %	87.88 %
Endoscopic results:-	15	29		

Table 3
Sensitivity and specificity of the two diagnostic methods for LSIL compared to pathological results.

LSIL				
	Pathological results+	Pathological results-	sensitivity	specificity
Colposcopic results:+	1	16	10 %	67.35 %
Colposcopic results:-	9	33		
Endoscopic results:+	4	11	40 %	77.55 %
Endoscopic results:-	6	38		

Table 4
Sensitivity and specificity of the two diagnostic methods for HSIL compared to pathological results.

HSIL				
	Pathological results+	Pathological results-	sensitivity	specificity
Colposcopic results:+	9	14	90 %	71.43 %
Colposcopic results:-	1	35		
Endoscopic results:+	9	8	90 %	83.67 %
Endoscopic results:-	1	41		

Table 5
Sensitivity and specificity of the two diagnostic methods for cancer compared to pathological results.

Cancer				
	Pathological results+	Pathological results-	sensitivity	specificity
Colposcopic results:+	11	0	84.62 %	100 %
Colposcopic results:-	2	46		
Endoscopic results:+	12	0	92.31 %	100 %
Endoscopic results:-	1	46		

sizes are necessary to validate these findings and provide more robust evidence for the clinical application of magnifying endoscopy in diagnosing cervical lesions.

In conclusion, this study demonstrates that magnifying endoscopy exhibits superior sensitivity and specificity compared to colposcopy in diagnosing cervical precancerous lesions. The improved accuracy of magnifying endoscopy highlights its potential as a valuable tool in clinical practice for early detection and precise diagnosis of cervical lesions. Further research is warranted to validate these findings and investigate the long-term clinical outcomes associated with the use of magnifying endoscopy in the diagnosis of cervical lesion.

CRediT authorship contribution statement

Qing Li: Writing – review & editing, Writing – original draft, Data curation. **Jue Wang:** Methodology, Formal analysis. **Tao Sun:** Methodology. **Hongwei Zhang:** Data curation. **Limei Chen:** Conceptualization. **Qing Wang:** Supervision. **Long Sui:** Supervision. **Keqin Hua:** Writing – review & editing, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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