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ORIGINAL ARTICLE

Clinical Trials Study

Diagnostic value of high-resolution micro-endoscopy for the classification of colon polyps

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Author contributions: Tan T and Qu YW made equal contributions to this work; Liu HF designed the study; Tan T and Qu YW performed the research; Shu J, Liu ML and Zhang L selected the images and analyzed the data; Tan T wrote the paper.

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Abstract

AIM: To study a new imaging equipment, high-resolution micro-endoscopy (HRME), in the diagnosis and pathological classification of colon polyps.

METHODS: We selected 114 specimens of colon polyps, 30 of which were colon polyps with known pathological types and 84 that were prospective polyp specimens; 10 normal colon mucosa specimens served as controls. We obtained images of 30 colon polyp specimens with known pathological types using HRME and analyzed the characteristics of these images to develop HRME diagnostic criteria for different pathological types of colon polyps. Based on these criteria, we performed a prospective study of 84 colon polyp specimens using HRME and compared the results with those of the pathological examination to evaluate the diagnostic value of HRME in the pathological classification of different types of colon polyps.

RESULTS: In the 30 cases of known pathological type of colon polyp samples, there were 21 cases of adenomatous polyps, which comprised nine cases of tubular adenoma, seven cases of villous adenoma and five cases of mixed adenomas. The nine cases of non-adenomatous polyps included four cases of inflammatory polyps and five cases of hyperplastic polyps five. Ten cases of normal colonic mucosa were confirmed pathologically. In a prospective study of 84 cases using HRME, 23 cases were diagnosed as

inflammatory polyps, 11 cases as hyperplastic polyps, 18 cases as tubular adenoma, eight cases as villous adenoma and 24 cases as mixed adenomas. After pathological examination, 24 cases were diagnosed as inflammatory polyps, 11 cases as hyperplastic polyps, 19 cases as tubular adenoma, eight cases as villous adenoma and 22 cases as mixed adenomas. Compared with the pathological examinations, the sensitivities, specificities, accuracies, and positive and negative predictive values of HRME in diagnosing inflammatory polyps (87.5%, 96.7%, 94.0%, 91.3% and 95.1%), hyperplastic polyps (72.7%, 95.9%, 92.9%, 72.7% and 95.9%), tubular adenomas (73.7%, 93.8%, 89.3%, 77.8% and 92.4%), villous adenomas (75.0%, 97.4%, 95.2%, 75.0% and 97.4%), and mixed adenomas (75.0%, 93.3%, 88.1%, 81.8% and 90.3%) were relatively high.

CONCLUSION: HRME has a relatively high diagnostic value in the pathological classification of colon polyps. Thus, it may be an alternative to confocal microendoscopy in lower-resource or community-based settings.

Key words: High-resolution micro-endoscopy; Colon polyps; Pathology; Diagnostic criteria

Core tip: High-resolution micro-endoscopy (HRME) is a new imaging method for cytology imaging that can obtain real time pathological diagnosis. In this study, we determined the HRME diagnostic criteria for pathological types of colon polyps. According to the criteria, we performed a prospective study of the diagnostic value of colon polyps using HRME. The results showed that HRME has a relatively high diagnostic value in the pathological classification of colon polyps. This low cost microendoscopic technique might be an alternative to confocal microendoscopy in lower-resource or community-based settings.

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INTRODUCTION

Colon polyps are common diseases of the gastrointestinal system[1-3]. Generally, colon polyps can be divided into adenomatous polyps and nonadenomatous polyps. Adenomatous polyps have a tendency to develop in to tumors, but nonadenomatous polyps do not. At present, the diagnosis of colon polyps depends mainly on conventional white light endoscopy (WLE); however, WLE cannot identify the pathological types of colon polyps directly [1-3]. When polyps are observed, endoscopic resection (endoscopic mucosal resection or endoscopic submucosal dissection) is used to remove the polyp tissues for pathology examination to determine its pathological type. This method increases the risk of bleeding and perforation, and is unnecessary for nonadenomatous polyps. At the same time, it also increases the cost and time for patients.

Therefore, we need a new endoscopic technique that can judge the pathological types of colon polyps timely, accurately and quickly, to reduce unnecessary biopsies and costs. Ideally, this technique should involve optical biopsy under endoscopy.

High-resolution micro-endoscopy (HRME) is a new imaging technique that allows real-time pathological diagnoses using nuclear imaging[4,5]. Recently, HRME has been applied in clinical trials and achieved satisfactory outcomes[6,7]. Based on these experiences, we designed an HRME imaging system. To verify the effectiveness of this imaging system in clinical practice, we selected *ex vivo* colon polyp specimens as our subjects and performed HRME imaging of these specimens. We analyzed different types of colon polyps to develop preliminary diagnostic criteria for HRME. In addition, we compared the results of HRME with those of the pathological examination to evaluate the value of this imaging system in the diagnosis of different types of colon polyps.

MATERIALS AND METHODS

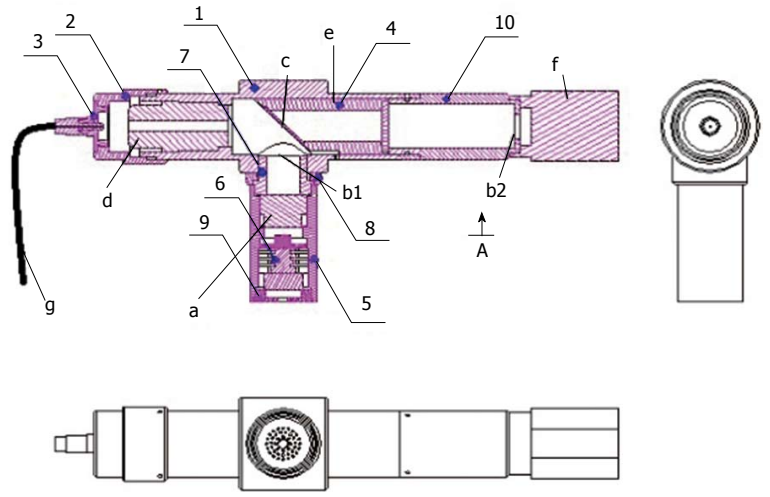
Objects

The present study included 114 patients diagnosed with colon polyps who underwent electronic colonoscopy between August 2014 and November 2014 in the Gastrointestinal Endoscopy Center of the General Hospital of Chinese People's Armed Police Forces. We obtained 114 polyp specimens via electrocoagulation, endoscopic mucosal resection (EMR), or endoscopic submucosal dissection (ESD), and observed the specimens *ex vivo* using HRME. In addition, we obtained 10 normal colon mucosa specimens by biopsy. The study was approved by the hospital ethics committee.

General methods

HRME system: We used our self-developed HRME imaging system in the present study. This system included a 30000-pixel optical fiber of 1.8 m in length, a 10 × microscope lens, a 500-nm dichroscope, an optical filter, a three-dimensional combined translation stage, a scientific-grade cooled CCD camera, and image-processing software. During the imaging process, images were transferred to the computer at a rate of 17 frames/s.

The probe used in the current study provides a 720 μm diameter field-of-view with 4.4 μm spatial



No.	Drawing No.	Name	Quantity
1	01-1	Body sleeve	1
2	01-2	Front cover	1
3	01-3	SMA905 connector	1
4	01-4	Inner sleeve	1
5	01-5	LED sleeve	1
6	01-6	LED heatsink	1
7	01-7	LED connection seat	1
8	01-8	LED connecting ring	1
9	01-9	LED cooling bottom	1
10	01-10	CCD fittings	1

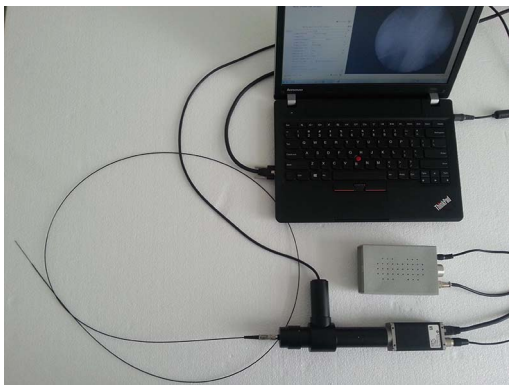


Figure 1 Structural diagram and image of the high-resolution micro-endoscopy equipment.

resolution (Figure 1).

Reagents: Reagents used included the following: 0.01% proflavine hydrochloride (Sigma Company, San Francisco, United States), normal saline (Chen Xin Pharmaceutical Company, Beijing, China), pronase particles (Beijing Tide Pharmaceutical Company, Beijing, China), and sodium bicarbonate (Beijing Tide Pharmaceutical Company, Beijing, China).

Imaging methods: Routine bowel preparation was carried out for all patients before inspection, because during the inspection, the bowel should be clean. Endoscopic resection was performed on colon polyps found during WLE, and imaging of the specimens was then carried out using HRME.

For HRME sample pretreatment, we washed the removed polyp and biopsy specimens with normal saline slowly to remove fecal residue on the surface, and then washed the polyp and biopsy specimens repeatedly with a solution containing pronase and sodium bicarbonate (1 g of sodium bicarbonate and 20000 units of pronase were dissolved in 50 mL water) to remove the mucus on the surface. The specimens were washed with normal saline again and wiped with dry cotton balls.

As noted, we established an imaging system and activated the imaging software. We adjusted the focus so that each pixel could be identified clearly in the field of view, which was defined as the optimal imaging state.

For image processing, we placed a specimen on the imaging plate and sprayed the specimen with 2-3 mL of 0.01% proflavine hydrochloride topically. After 30 s, the specimen was washed with phosphate-buffered saline to remove the stain, and the liquid on the surface was gently wiped off using dry cotton balls. The surface of the specimen was observed from different angles using the cephalic end of the optical fiber. Each imaging site was marked and recorded during the imaging process to ensure that the same site observed by HRME and pathology. Clear images were retained for subsequent analysis.

Pathological examination: After imaging, each site of the imaged tissues was removed for pathological examination. In pathological examination, we used transverse section slices instead of longitudinal sections. Pathological diagnosis divided the colon polyps into adenomatous polyps (tubular adenomas, villous adenomas and mixed adenomas) and nonadenomatous polyps (inflammatory polyps and hyperplastic polyps). Two pathologists completed the pathological diagnosis.

HRME diagnosis: HRME diagnosis proceeded as follows: First, we established the diagnostic criteria. Retrospective analysis was carried out for HRME imaging of 30 colon polyp specimens, and HRME diagnostic criteria were established according to the characteristics of various images for different pathological types of colon polyps.

According to the established diagnostic criteria, we carried out a prospective study of HRME imaging for 84 colon polyp specimens and compared the results with those of the pathological examination to evaluate the sensitivities, specificities, accuracies, positive predictive values and negative predictive values of HRME in diagnosing various types of colon polyps.

The entire process of HRME imaging was completed within 15 min. The specimens were examined by two systemically trained doctors together. The result of image analysis was compared with that of the pathological examination. The image analysis was carried out in a double-blind mode.

Statistical analysis

We used SPSS 17.0 (IBM, Armonk, NY, United States) for data analysis. Data in the present study were analyzed using the fourfold table test. We calculated the sensitivities, specificities, accuracies and positive and negative predictive values of HRME in diagnosing inflammatory polyps, hyperplastic polyps, tubular adenomas, villous adenomas and mixed adenomas.

RESULTS

General conditions

Among 114 patients, 77 were males and 37 were females (male:female ratio = 2.1:1). The mean age was 48.4 ± 5.3 year (range, 19-81 year). Polyp diameters ranged from 0.6 to 4.2 cm. Among 30 colon polyp specimens with known pathological types, 21 were adenomatous polyps (including nine cases of tubular adenomas, seven cases of villous adenomas, and five cases of mixed adenomas) and nine cases were nonadenomatous polyps (including four cases of inflammatory polyps and five cases of hyperplastic polyps). Ten normal colon mucosa specimens were proved by pathological examination to be non-polypous colons.

HRME diagnostic criteria for colon polyps

HRME identifies the target tissue by observing the size, morphology, arrangement and glandular structures of the nucleus, and calculating the nuclear-cytoplasmic ratio of the region of interest. The image characteristics of colon polyps with different pathological types were analyzed and summarized to develop initial HRME diagnostic criteria. For inflammatory polyps, the nuclei had the same size and regular round, oval, and daisy-like glandular structures (Figure 2A). For hyperplastic polyps, the size, morphology and cavity diameter of the glands were slightly curved and dilated, or, occasionally, expanded epithelia were observed (Figure 2B). For tubular adenomas, there were many linear crypts: The glands were enlarged, parallel arrangement of the nuclei with dilated openings was observed occasionally, and the glands were tube-like in shape (Figure 2C). For villous adenomas, there were extra wide or even open crypts as in tubular adenoma; the lengths of the glands were different, and villous-like structures were observed (Figure 2D). For mixed adenomas, the characteristics of the mixed adenoma fell between those of villous adenomas and those of tubular adenomas (Figure 2E).

Results of the prospective study using HRME

Among 84 cases enrolled in the prospective study, HRME showed that 50 specimens were adenomatous polyps, including 18 cases of tubular adenomas, 8 cases of villous adenomas, and 24 cases of mixed adenomas, and that 34 specimens were nonadenomatous polyps, including 23 cases of inflammatory polyps and 11 cases of hyperplastic polyps. The pathological examination showed that 49 specimens were adenomatous polyps, including 19 cases of tubular adenomas, 8 cases of villous adenomas, and 22 cases of mixed adenomas, and that 35 specimens were nonadenomatous polyps, including 24 cases of inflammatory polyps and 11 cases of hyperplastic polyps. Statistical analysis showed that the sensitivities, specificities, accuracies, positive predictive values (PPV), and negative predictive values (NPV) of HRME were relatively high in diagnosing inflammatory polyps, hyperplastic polyps, tubular adenomas, villous adenomas and mixed adenomas (Table 1).

DISCUSSION

Colon polyps are abnormal growths that arise from the mucosa of the colon and protrude into the lumen and are the most common benign tumors in the colon[1-3]. Substantial clinical, pathological and epidemiological data have suggested that the incidence of adenomas developing into colon cancer is 1.5%-9.4%, and that the process of oncogenesis requires 8-10 years[8,9]. Clinical studies have shown that about 80% of colon cancers develop from colon adenomas and that the incidence of colon cancer in patients with colon adenomas is four times that in the normal population[10]. Therefore, physicians must learn the clinical and pathological characteristics of colon polyps to prevent colon cancer and reduce its incidence and mortality.

Based on histopathological features, colon polyps are divided into nonadenomatous polyps and adenomas[10,11]. Nonadenomatous polyps include inflammatory polyps, hyperplastic polyps and hamartomatous polyps. Adenomas polyps include

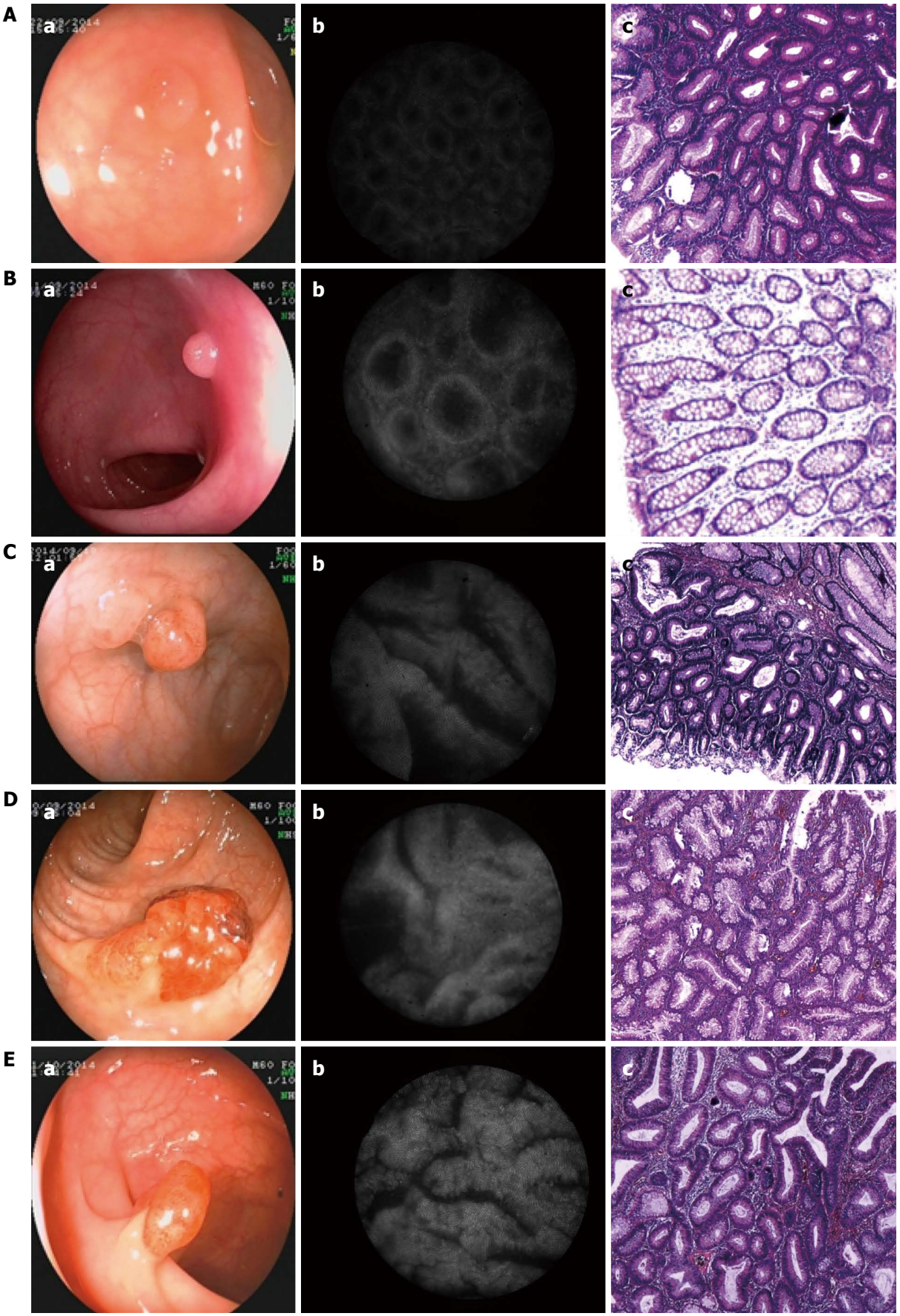


Figure 2 High-resolution micro-endoscopy diagnostic criteria for colon polyps. A: Inflammatory polyps (a: WLE images; b: HRME images; c: Pathological images); B: Hyperplastic polyps (a: WLE images; b: HRME images; c: Pathological images); C: Tubular adenoma (a: WLE images; b: HRME images; c: Pathological images); D: Villous adenomas (a: WLE images; b: HRME images; c: Pathological images); E: Mixed adenomas (a: WLE images; b: HRME images; c: Pathological images). WLE: White light endoscopy; HRME: High-resolution micro-endoscopy.

Table 1 Efficacy of diagnosis using high-resolution micro-endoscopy for colon polyp classification

HRME	Sensitivity	Specificity	Accuracy	PPV	NPV
Inflammatory	87.5%	96.7%	94.0%	91.3%	95.1%
Hyperplastic	72.7%	95.9%	92.9%	72.7%	95.9%
Tubular	73.7%	93.8%	89.3%	77.8%	92.4%
Villous	75.0%	97.4%	95.2%	75.0%	97.4%
Mixed	75.0%	93.3%	88.1%	81.8%	90.3%

HRME: High-resolution micro-endoscopy; PPV: Positive predictive values; NPV: Negative predictive values.

tubular adenomas, villous adenomas and tubular-villous adenomas (mixed type). The process of adenoma-carcinoma transition has been investigated by molecular studies, which showed that the oncogenesis of adenomatous polyps is closely related to their size, morphology and pathological type[12]. Therefore, clinicians need early identification of the pathological types of adenomatous polyps[10-12]. The results of the present study showed that HRME was highly effective in diagnosing tubular adenomas, villous adenomas and mixed adenomas. Compared with histopathological examination, HRME has advantages such as simple operation, short process time, low cost and real-time pathological imaging. Therefore, we believe that HRME has an important value in identifying the pathological types of colon polyps[6,13,14]. The sample size in the present study was limited and the training of personnel participating in the study was not homogeneous; therefore, large-sample studies should be carried out, and personnel training should be improved to increase the reliability of the results.

HRME is a new imaging method based on high-resolution fiber optics and molecular imaging techniques. It can perform real-time imaging of the target tissue and thereby achieve tissue imaging at the cellular level[4]. HRME uses a light-emitting diode as an excitation source to emit light. The excitation light is filtered by an optical filter to form a narrow-band excitation light that is focused by the objective lens and is conducted through the high-resolution optic fiber to reach the targeted tissue, producing a fluorescent signal. The fluorescent signal returns via the optical fiber and is magnified by the objective lens. The excitation light and the fluorescent signal are separated by a dichroscope, and only the fluorescent signal is conducted to the charge-coupled device (CCD) chip for imaging. Cytological images of the target tissue are thus obtained. At present, when we find lesions under white light endoscopy, we cannot judge the character of lesions. As an alternative, we could use HRME for lesions imaging, because of the instant histopathological characteristics of HRME, allowing us to make an accurate judgment of lesion properties at first pass, which will help doctors to make the best the choice of treatment.

Recently, scholars have used the HRME technique for *in vivo* histopathological imaging, and the results suggested a favorable future for its application[15-19]. Their results suggested that high-resolution fiber optics could be combined with endoscopy in clinical practice to develop images of the target lesions. In 2014, Vila *et al*[15] combined HRME with WLE to observe Barrett mucosa-associated tumors and achieved satisfactory results. In 2012, Pierce[7] combined HRME with colonoscopy for real-time imaging of the cervical epithelia, and found that the efficacy of diagnosis was improved. In addition, researchers combined HRME with cystoscopy and bronchoscopy to observe cellular changes in target lesions directly. They found that HRME was quite useful in guiding biopsy and in identifying the surgical margin[7,16,19].

At present, the study of HRME is still at the preclinical stage. Although many studies have suggested its promising future, this technique still has some shortcomings[4,15-19]. Firstly, HRME is a small field-of-view imaging technique (720 μm); therefore, it cannot realize macroscopic imaging for lesions. Thus, HRME can only be used for further detailed checks of a suspicious lesion after wide field endoscopic examination. Secondly, HRME is a microscopic imaging method, subtle movement in the process of imaging, such as breathing and heartbeat, could produce motion artifacts; therefore, it is more difficult to perform HRME than white light endoscopy. Thirdly, the lack of contrast agents is a major problem for HRME. Recently, more and more studies have examined specific contrast agents developed for certain molecules. These specific contrast agents could be used in HRME imaging to obtain quantitative and qualitative data to improve the diagnostic rate for certain diseases. To date, there is no unified standard description of lesions observed during HRME, which limits the clinical application of this imaging technique. In the present study, we used HRME to image colon polyps, developed diagnostic criteria for the different types of colon polyps, and laid the foundation for future research.

How to connect HRME diagnosis with pathological diagnosis is the focus of HRME imaging research. HRME only observes the tissue surface; therefore, in the pathological process, we must ensure that it is a transverse section instead of longitudinal section. In this study, all of the specimens for pathological examinations were made with transverse sections. This is the true sense of point-to-point biopsy.

The limitations of this study were as follows. First, we used HRME to image *ex vivo* specimens of colon polyps, but we did not make an *in vivo* study. Second, the fluorescence imaging agent used was proflavine hydrochloride, which combines with the DNA and RNA in the nucleus. However, proflavine hydrochloride is a nonspecific fluorescence imaging agent that cannot be used in targeted imaging of lesions. Finally, some of the specimens used came from biopsy, and because of the small size of the biopsy specimens, it was difficult

to rinse them completely, which might have affected the imaging and thus influenced the outcome of the preliminary diagnosis.

So far, evaluation of the diagnostic utility of HRME is still at the preclinical stage, although it shows good prospects for clinical application. HRME imaging equipment has not bee perfected and it is not widely used in clinical settings. The practicability and diagnostic accuracy of HRME need to be validated in further randomized controlled trials to validate before HRME could be applied clinically.

In conclusion, HRME is a newly developed imaging tool that shows promise for imaging at the cellular and subcellular levels, and has the potential to carry out real-time pathological imaging in target tissues[4,5,7,15-19]. Preclinical studies have verified that this technique has relatively high sensitivity, specificity and accuracy, which suggest a promising future in clinical practice[6,7,13-19]. Future research should improve this imaging system, particularly in terms of new contrast agents that promote the combination of this technique with endoscopy.

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COMMENTS

Background

Polyps are the most common benign tumors in the colon. Substantial clinical, pathological and epidemiological data have suggested that the incidence of adenomas developing into colon cancer is 1.5%-9.4%. Clinical studies have proved that about 80% of colon cancers develop from colon adenomas, and the incidence of colon cancer in patients with colon adenomas is four times that in the normal population. White light endoscopy is the most common method used to diagnose colon polyps; however, it cannot identify the pathological types of colon polyps directly. Pathological examination requires more time and money.

Research frontiers

This study developed new, low-cost imaging equipment (HRME) to image colon polyps. The characterization of colon polyps by HRME has not been studied before. This study summarized the HRME characteristics of different pathological types of colon polyps and evaluated the diagnostic value of HRME in the pathological classification of different types of colon polyps.

Innovations and breakthroughs

The authors determined the HRME diagnostic criteria for colon polyps, which will allow us to judge the pathological types of colon polyps timely, accurately and quickly in the future.

Applications

HRME can be used in many fields. It can distinguish benign and malignant lesions quickly and accurately, thereby reducing the waiting time for pathology.

Terminology

HRME: A new imaging method based on high-resolution fiber optics and molecular imaging techniques. It can perform real-time imaging of the target tissue and thereby achieve tissue imaging at the cellular level. It identifies the target tissue by observing the size, morphology, arrangement and glandular structures of the nucleus and calculates the nuclear-cytoplasmic ratio of the region of interest.

Peer-review

Overall, this is an interesting study that shows clearly that HRME has a relatively high diagnostic value in the pathological classification of colon polyps.

REFERENCES

1 **Solakoğlu T**, Atalay R, Köseoğlu H, Özer Sarı S, Demirezer Bolat A, Akın E, Yürekli ÖT, Selvi E, Büyükaşık Ş, Ersoy O. Analysis of 2222 colorectal polyps in 896 patients: a tertiary referreal hospital study. *Turk J Gastroenterol* 2014; **25**: 175-179 [PMID: 25003678 DOI: 10.5152/tjg.2014.5059]

2 **Bertolini J**, Wittekind C. [Large adenomas of the colon and rectum--specific features of the diagnostics]. *Zentralbl Chir* 2013; **138** Suppl 2: e70-e74 [PMID: 22174119 DOI: 10.1055/s-0031-1283740]

3 **Guarinos C**, Sánchez-Fortún C, Rodríguez-Soler M, Pérez-Carbonell L, Egoavil C, Juárez M, Serradesanferm A, Bujanda L, Fernández-Bañares F, Cubiella J, de-Castro L, Guerra A, Aguirre E, Herreros-de-Tejada A, Bessa X, Herráiz M, Marín-Gabriel JC, Balmaña J, Cuatrecasas M, Balaguer F, Castells A, Soto JL, Alenda C, Payá A, Jover R. Clinical subtypes and molecular characteristics of serrated polyposis syndrome. *Clin Gastroenterol Hepatol* 2013; **11**: 705-711; quiz e46 [PMID: 23376323 DOI: 10.1016/j.cgh.2012.12.045]

4 **Pierce M**, Yu D, Richards-K. High-resolution fiber-optical microendoscopy for in situ imaging. *J Visual Exper* 2011; **11**: 2306 [DOI: 10.1016/j.cgh.2014.08.004]

5 **Parikh ND**, Perl D, Lee MH, Chang SS, Polydorides AD, Moshier E, Godbold J, Zhou E, Mitcham J, Richards-Kortum R, Anandasabapathy S. In vivo classification of colorectal neoplasia using high-resolution microendoscopy: Improvement with experience. *J Gastroenterol Hepatol* 2015; **30**: 1155-1160 [PMID: 25753782 DOI: 10.1111/jgh.12937]

6 **Parikh ND**, Perl D, Lee MH, Shah B, Young Y, Chang SS, Shukla R, Polydorides AD, Moshier E, Godbold J, Zhou E, Mitcham J, Richards-Kortum R, Anandasabapathy S. In vivo diagnostic accuracy of high-resolution microendoscopy in differentiating neoplastic from non-neoplastic colorectal polyps: a prospective study. *Am J Gastroenterol* 2014; **109**: 68-75 [PMID: 24296752 DOI: 10.1038/ajg.2013.387]

7 **Pierce MC**, Guan Y, Quinn MK, Zhang X, Zhang WH, Qiao YL, Castle P, Richards-Kortum R. A pilot study of low-cost, high-resolution microendoscopy as a tool for identifying women with cervical precancer. *Cancer Prev Res (Phila)* 2012; **5**: 1273-1279 [PMID: 22926339 DOI: 10.1158/1940-6207.CAPR-12-0221]

8 **Grahn SW**, Varma MG. Factors that increase risk of colon polyps. *Clin Colon Rectal Surg* 2008; **21**: 247-255 [PMID: 20011435 DOI: 10.1055/s-0028-1089939]

9 **Steele SR**, Johnson EK, Champagne B, Davis B, Lee S, Rivadeneira D, Ross H, Hayden DA, Maykel JA. Endoscopy and polyps-diagnostic and therapeutic advances in management. *World J Gastroenterol* 2013; **19**: 4277-4288 [PMID: 23885138 DOI: 10.3748/wjg.v19.i27.4277]

10 **Levene Y**, Hutchinson JM, Tinkler-Hundal E, Quirke P, West NP. The correlation between endoscopic and histopathological measurements in colorectal polyps. *Histopathology* 2015; **66**: 485-490 [PMID: 24898056 DOI: 10.1111/his.12472]

11 **Rickert A**, Aliyev R, Belle S, Post S, Kienle P, Kähler G. Oncologic colorectal resection after endoscopic treatment of malignant polyps: does endoscopy have an adverse effect on oncologic and surgical outcomes? *Gastrointest Endosc* 2014; **79**: 951-960 [PMID: 24412574 DOI: 10.1016/j.gie.2013.11.014]

12 **Paggi S**, Radaelli F, Repici A, Hassan C. Advances in the removal of diminutive colorectal polyps. *Expert Rev Gastroenterol Hepatol* 2015; **9**: 237-244 [PMID: 25155348 DOI: 10.1586/17474124.2014.950955]

13 **Chang SS**, Shukla R, Polydorides AD, Vila PM, Lee M, Han H, Kedia P, Lewis J, Gonzalez S, Kim MK, Harpaz N, Godbold

J, Richards-Kortum R, Anandasabapathy S. High resolution microendoscopy for classification of colorectal polyps. *Endoscopy* 2013; **45**: 553-559 [PMID: 23780842 DOI: 10.1055/s-0032-1326502]

14 **Hur C**, Choi SE, Kong CY, Wang GQ, Xu H, Polydorides AD, Xue LY, Perzan KE, Tramontano AC, Richards-Kortum RR, Anandasabapathy S. High-resolution microendoscopy for esophageal cancer screening in China: A cost-effectiveness analysis. *World J Gastroenterol* 2015; **21**: 5513-5523 [PMID: 25987774 DOI: 10.3748/wjg.v21.i18.5513]

15 **Vila PM**, Kingsley MJ, Polydorides AD, Protano MA, Pierce MC, Sauk J, Kim MK, Patel K, Godbold JH, Waye JD, Richards-Kortum R, Anandasabapathy S. Accuracy and interrater reliability for the diagnosis of Barrett's neoplasia among users of a novel, portable high-resolution microendoscope. *Dis Esophagus* 2014; **27**: 55-62 [PMID: 23442220 DOI: 10.1111/dote.12040]

16 **Regunathan R**, Woo J, Pierce MC, Polydorides AD, Raoufi M, Roayaie S, Schwartz M, Labow D, Shin D, Suzuki R, Bhutani MS, Coghlan LG, Richards-Kortum R, Anandasabapathy S, Kim MK. Feasibility and preliminary accuracy of high-resolution imaging of the liver and pancreas using FNA compatible microendoscopy (with video). *Gastrointest Endosc* 2012; **76**: 293-300 [PMID: 22817784 DOI: 10.1016/j.gie.2012.04.445]

17 **Muldoon TJ**, Roblyer D, Williams MD, Stepanek VM, Richards-Kortum R, Gillenwater AM. Noninvasive imaging of oral neoplasia with a high-resolution fiber-optic microendoscope. *Head Neck* 2012; **34**: 305-312 [PMID: 21413101 DOI: 10.1002/hed.21735]

18 **Vila PM**, Park CW, Pierce MC, Goldstein GH, Levy L, Gurudutt VV, Polydorides AD, Godbold JH, Teng MS, Genden EM, Miles BA, Anandasabapathy S, Gillenwater AM, Richards-Kortum R, Sikora AG. Discrimination of benign and neoplastic mucosa with a high-resolution microendoscope (HRME) in head and neck cancer. *Ann Surg Oncol* 2012; **19**: 3534-3539 [PMID: 22492225 DOI: 10.1245/s10434-012-2351-1]

19 **Quinn MK**, Bubi TC, Pierce MC, Kayembe MK, Ramogola-Masire D, Richards-Kortum R. High-resolution microendoscopy for the detection of cervical neoplasia in low-resource settings. *PLoS One* 2012; **7**: e44924 [PMID: 23028683 DOI: 10.1371/journal.pone.0044924]

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