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ORIGINAL ARTICLE

Comparative study of conventional colonoscopy, magnifying chromoendoscopy, and magnifying narrow-band imaging systems in the differential diagnosis of small colonic polyps between trainee and experienced endoscopist

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Abstract
Background Removal of colorectal neoplastic polyps can reduce the incidence of colorectal cancers. It is important to distinguish neoplastic from nonneoplastic polyps. We compared the ability of a trainee and an experienced endoscopist in distinguishing between neoplastic polyps and nonneoplastic polyps by conventional white-light, magnifying narrow-band imaging (NBI), and magnifying chromoendoscopy.
Materials and methods One hundred and sixty-three small colorectal polyps from 104 patients were studied. All polyps were diagnosed by trainees and experienced endoscopists using conventional white-light, magnifying NBI, and magnifying chromoendoscopy. The kappa values of interobserver agreement between trainees and experienced endoscopists were evaluated before this study. Sensitivity, specificity, and diagnostic accuracy were assessed by reference to histopathology. The first 50 polyps were diagnosed by the trainee as the first stage and the rest 113 polyps were diagnosed as the second stage.
Results Magnifying NBI and magnifying chromoendoscopy were significant better than conventional white-light by the experienced endoscopist (diagnostic accuracy: NBI 85.3%, chromoendoscopy 87.7%, conventional view 74.8%). No significant differences were found for the trainee. The kappa values (0.77~0.85) were good for each endoscopic modality for the experienced endoscopist. However, only NBI and chromoendoscopy had acceptable kappa values (0.40~0.48) for the trainee. The trainee improved diagnostic accuracy in the second stage, but not yielded the level of the experienced endoscopist.
Conclusion Magnifying NBI and magnifying chromoendoscopy had a better interobserver agreement than conventional white-light among trainees and experienced endoscopists. The trainee needs learning time to improve diagnostic ability, even using a new modality such as magnifying NBI.

Keywords Neoplastic colorectal polyps · Magnifying chromoendoscopy · Magnifying NBI · Kappa value

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Introduction

Colorectal polyps detected during colonoscopy are either neoplastic (adenoma or carcinoma) or nonneoplastic

(hyperplastic, inflammatory, and hamartomatous). Removal of colorectal neoplasia has been reported to reduce the incidence of colorectal cancers based on the concept of the adenoma–carcinoma sequence [1]. However, most small (less than 10 mm) nonneoplastic lesions are benign. It is time-consuming and uneconomical to biopsy these lesions. Therefore, it is important to distinguish neoplastic from nonneoplastic polyps before endoscopic biopsy. Magnifying chromoendoscopy can distinguish between neoplastic and nonneoplastic polyps with an accuracy rate of 80% to 95% [2–5]. Recently, a novel optical technology called narrow-band imaging (NBI) was developed by Gono et al. [6]. In a pilot study, Machida et al. concluded that NBI provided a diagnostic value equivalent to chromoendoscopy in distinguishing between neoplastic and nonneoplastic polyps [7]. However, the effectiveness of nonmagnifying conventional white-light, magnifying NBI, and magnifying chromoendoscopy in distinguishing between neoplastic and nonneoplastic polyps when used by trainees and experienced endoscopists has not yet been discussed. We prospectively conducted this study to assess the effectiveness of these three optical techniques. We also compared the ability of trainee and experienced endoscopist to distinguish between neoplastic and nonneoplastic polyps.

Materials and methods

Patients

From Oct. 2006 to Dec. 2007, consecutive individuals who received a total colonoscopy concurrently with a conventional white-light colonoscopy, magnifying NBI colonoscopy, and magnifying chromoendoscopy at the endoscopic center of Taipei Medical University Hospital (TMUH), Taiwan, were enrolled into this study. The study protocol was approved by the Institutional Review Board of Medical Ethics and the Human Clinical Trial Committee at TMUH.

Endoscopic equipment

The white-light endoscopy was performed with conventional video colonoscopes (Olympus CF-Q240ZL or CF-H260AZL Olympus Optical Ltd. Corp. Tokyo, Japan). In the NBI mode, the band-pass ranges for red, green, and blue light were narrowed to certain wavelengths with light filters (600~620 nm for red light, 530~550 nm for green light, and 400~430 nm for blue light). In addition, the intensity of the blue light was increased, allowing for optimal imaging of the mucosal morphology and vascular pattern because blue light has a minimal mucosal penetration depth [6].

Endoscopic examination

All patients prepared for the procedure by ingesting 2 L of a polyethylene glycol-electrolyte solution. Scopolamine butylbromide (20 mg) was administered intramuscularly to patients with no contraindication to this agent. A total colonoscopy was performed prospectively by two experienced endoscopists (CCC, TC), who have each performed more than 3,000 colonoscopies. When a polyp was detected, the mucus and liquid feces on the surface of the lesion were washed away. Endoscopic pictures of each lesion were taken, first for the nonmagnifying conventional white-light colonoscopy, then for magnifying (×100 magnification) NBI, and then for the magnifying (×100 magnification) chromoendoscopy.

A chromoendoscopy was performed using 5 to 10 mL of 0.2% indigo carmine which was sprayed directly onto the lesion. The gross appearance of the lesions was grouped into the superficial type (II), sessile

Table 1 Demographic characteristics of 104 patients with 163 colorectal polyps

Variable	Number
Patients	104
Gender (male/female)	64:40
Age, years (mean ± SD; range)	55.8±12.3; 27–91
Polyps	163
Morphology	
Ip	3
Is	99
IIa	61
Location	
Proximal colon	55
Distal colon	36
Rectum	72
Size, mm (mean ± SD; range)	5.15±2.26; 2–10
≤5	109
6–10	54
Pathology	
Nonneoplastic	81
Inflammatory polyp	1
Hyperplastic polyp	80
Neoplastic polyp	82
Tubular adenoma	77
Tubulovillous adenoma	4
Villous adenoma	1

SD standard deviation

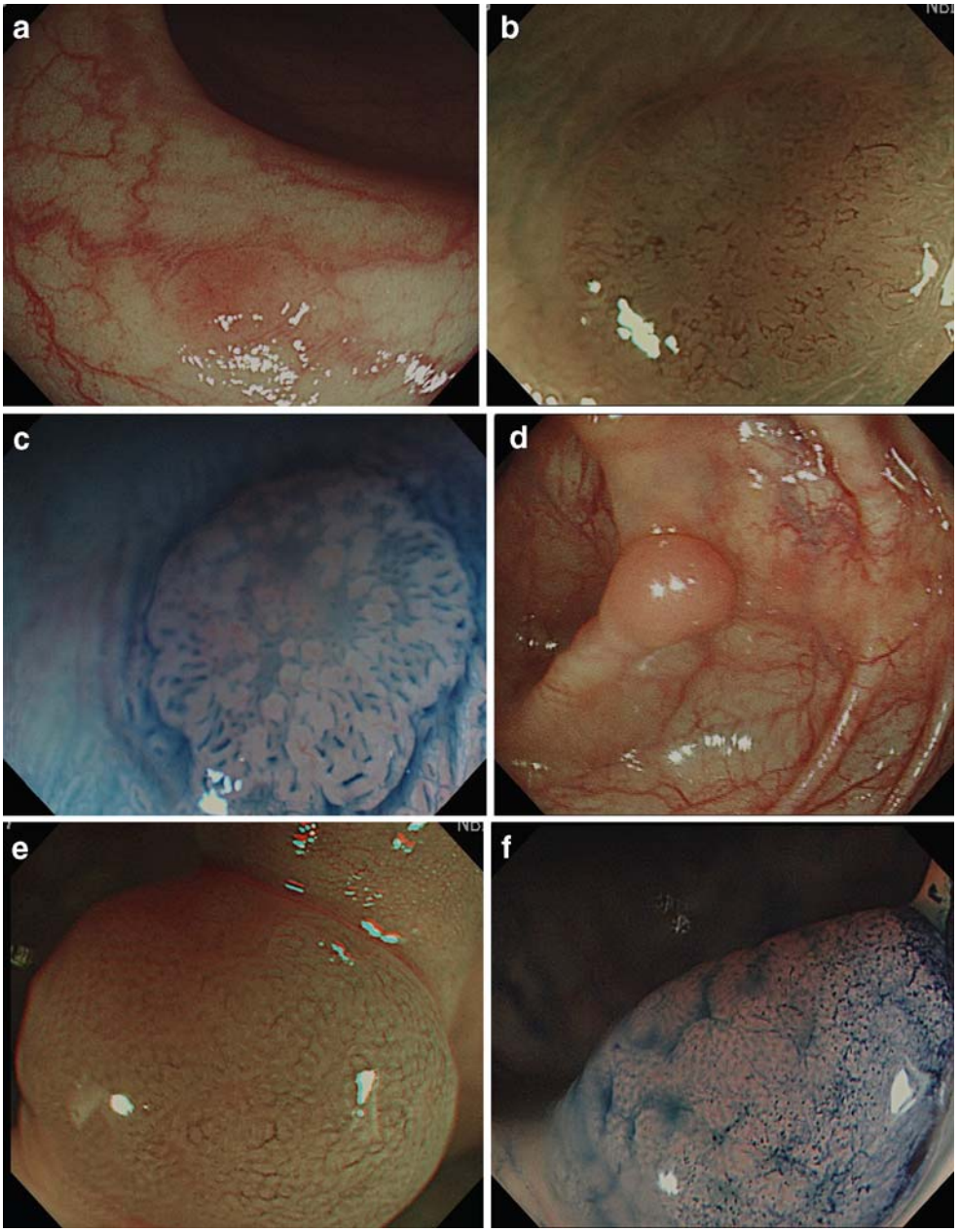

Fig. 1 **a** Conventional view of a IIa neoplastic polyp. **b** Magnifying NBI view of a IIa neoplastic polyp with a remarkable superficial mesh-capillary pattern. **c** Magnifying indigo carmine–chromoendoscopy of a IIa neoplastic polyp with type IIIs and IIIL pit patterns. **d** Conventional view of a Is nonneoplastic polyp. **e** Magnifying NBI view of a Is nonneoplastic polyp without a superficial mesh-capillary pattern. **f** Magnifying indigo carmine–chromoendoscopy of a Is nonneoplastic polyp with a type II pit pattern

type (Is), and pedunculated type (Ip) as established by the Paris endoscopic classification of superficial neoplastic lesions [8]. The size of each lesion was estimated using the open-biopsy forceps method, with a forceps with an open diameter of 7 mm (Radial Jaw 3; Boston Scientific Corp., Natick, MA, USA). The locations of the lesions were divided into three groups (rectum, proximal colon, and distal colon). Lesions larger than 10 mm in diameter were excluded because the majority of these lesions are neoplastic and should be resected [9]. Lesions

Table 2 The interobserver agreement for interpreting patterns

Characteristics of readers	C-nonmagnifying kappa value (95% CI)	NBI-magnifying kappa value (95% CI)	Indigo-magnifying kappa value (95% CI)
Experienced endoscopists	0.77 (0.67–0.87)	0.80 (0.70–0.90)	0.85 (077–0.94)
Trainees	0.29 (0.16–0.42)	0.48 (0.33–0.62)	0.40 (0.25–0.54)

Table 3 Performance (trainee and experienced endoscopist) of three endoscopic modalities in the diagnosis of 163 colorectal polyps

Endoscopic modality	Sensitivity (%)		Specificity (%)		PPV (%)		NPV (%)		Accuracy (%)		Likelihood ratio	
	Reader 1	Reader 2	Reader 1	Reader 2	Reader 1	Reader 2	Reader 1	Reader 2	Reader 1	Reader 2	Reader 1	Reader 2
A	89.0	90.2	59.3	59.3	68.9	69.2	84.2	85.7	74.2	74.8	2.19	2.22
B	91.5	95.1	56.8	75.3	68.2	79.6	86.8	93.9	74.2	85.3	2.12	3.85
C	90.1	97.6	55.6	77.8	67.0	81.6	84.9	96.9	72.4	87.7	2.03	4.39
P value (B vs. A)	0.1799	0.2304	0.7501	0.0294	0.9135	0.0883	0.7011	0.1356	0.8578	0.0184	–	–
P value (C vs. A)	0.8184	0.0579	0.6336	0.0111	0.7659	0.0391	0.9197	0.0255	0.7758	0.0028	–	–

Reader 1 trainee, *Reader 2* experienced endoscopist, *PPV* positive predictive value, *NPV* negative predictive value, *A* C-nonmagnifying, *B* NBI-magnifying, *C* Indigo-magnifying

5 mm or smaller were resected by cold biopsies and lesions 6 to 10 mm were resected by polypectomy or endoscopic mucosal resection (EMR). All specimens were evaluated by an experienced pathologist (FCL), who was blind to the endoscopic diagnosis. The histopathological diagnosis was based on WHO criteria. All endoscopic pictures were recorded in a computer and the image quality of the endoscopic pictures was evaluated by another endoscopist (LHY). Poor-quality images were excluded.

Diagnostic criteria for neoplastic and nonneoplastic polyps

White-light colonoscopy Neoplastic polyps were considered those with superficial redness; nonneoplastic polyps were those with whitish mucosa.

NBI colonoscopy Neoplastic polyps were those demonstrating as brown blobs or with brownish superficial meshwork capillaries; nonneoplastic polyps were those without brownish superficial meshwork capillaries.

Chromoendoscopy Neoplastic polyps were those with type III, IV, and V pit patterns; nonneoplastic polyps were those with type I and II pit patterns according to Kudo's classification [10].

Interpretation of endoscopic pictures

The three endoscopic pictures, nonmagnifying white-light colonoscopy, magnifying NBI, and magnifying chromoendoscopy, were assessed by an experienced endoscopist and a trainee in a randomized order. Before this study, 50 colorectal polyps were evaluated by two trainees and two experienced endoscopists to explore the interobserver agreement of these three diagnostic tools among trainees and experienced endoscopists.

Statistical analysis

The kappa statistics (k) and 95% confidence intervals were calculated to assess interobserver agreement between two readers. The strength of agreement for a kappa value was classified using the following criteria: poor agreement, 0.00 to 0.19; fair agreement, 0.20 to 0.39; moderate agreement, 0.40 to 0.59; good agreement, 0.60 to 0.79; and excellent agreement, 0.80 to 1.00. To evaluate the diagnostic accuracy of neoplastic and nonneoplastic lesions for different modalities, the sensitivity, specificity, positive predictive value, negative predictive value, accuracy, and likelihood ratio were estimated by comparing the endoscopic diagnosis with the final histopathologic diagnosis. Statistical differences in

diagnostic accuracies were estimated by the chi-square test. All statistical tests were two-tailed and a *P* value of 0.05 or less was considered statistically significant. Statistical Analysis Software (SAS; Version. 9.1; SAS Institute, Cary, NC, USA) was used for all statistical analyses.

Results

A total of 163 colorectal polyps among 104 patients were studied. Polyps larger than 10 mm were excluded because they should be resected irrespective of histopathology. Patient data and characteristics of the polyps are shown in Table 1.

Sixty-four of the 104 patients had one polyp, 28 had two polyps, six had three polyps, five had four polyps, and one had five polyps. Neoplasia was diagnosed in 41.2% (45/109) of polyps smaller than 5 mm and 68.5% (37/54) of those with 6 to 10 mm.

Figure 1a–c shows a neoplastic polyp using conventional white-light, magnifying NBI, and magnifying chromoendoscopy. Figure 1d–f shows a nonneoplastic polyp using conventional white-light, magnifying NBI, and magnifying chromoendoscopy.

The kappa values of interobserver agreement between experienced endoscopists for conventional white-light, magnifying NBI, and magnifying chromoendoscopy were 0.77, 0.80, and 0.85 (Table 2). Meanwhile, the kappa values of interobserver agreement between trainees for conventional white-light, magnifying NBI, and magnifying chromoendoscopy were 0.29, 0.48, and 0.40 (Table 2). The kappa values of interobserver agreement are better in magnifying NBI and magnifying chromoendoscopy than conventional white-light by both experienced endoscopists and trainees.

Statistical analyses for the trainee and the experienced endoscopist using the three imaging modalities are shown in Table 3. The overall accuracy of magnifying NBI was significantly superior to conventional white-light for the experienced endoscopist (85.3% vs 74.8%, *P*=0.0184). The overall accuracy of magnifying chromoendoscopy was also

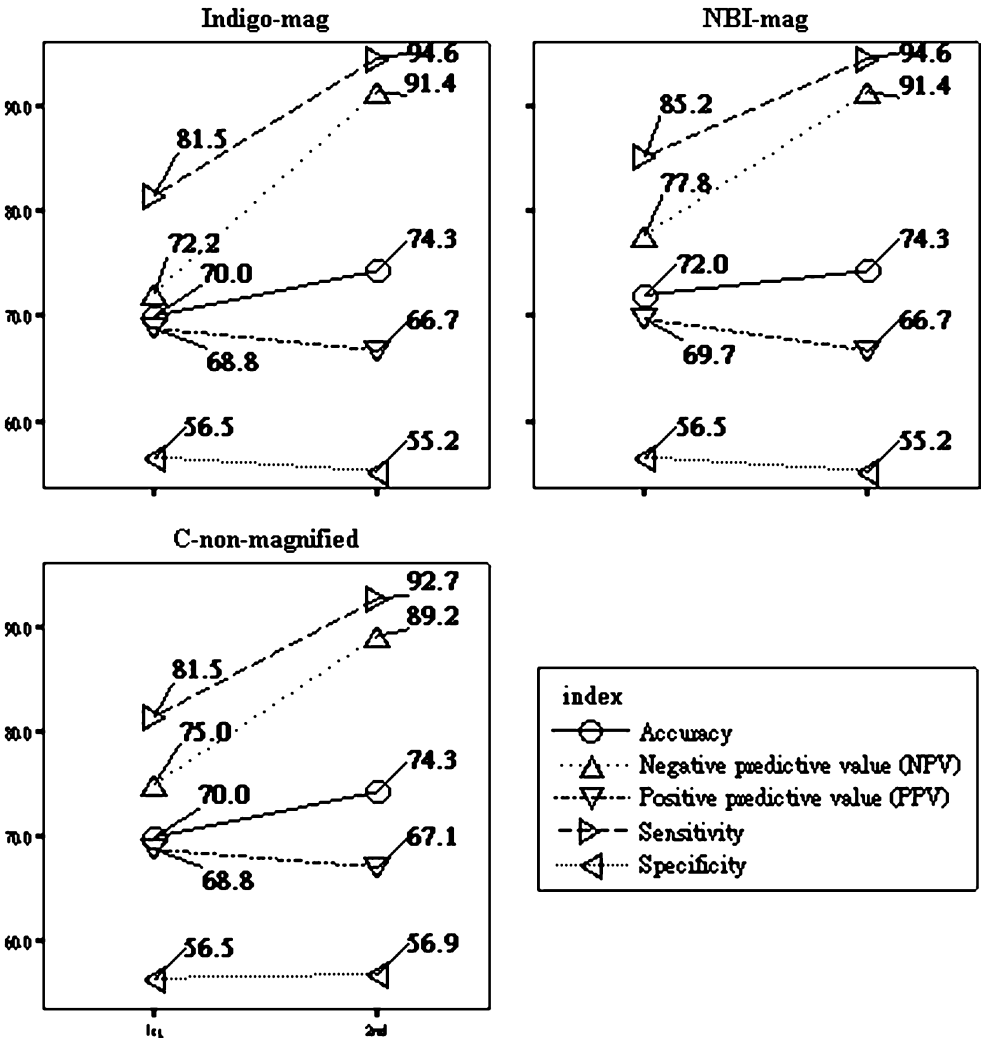

Fig. 2 Relationship between different indices and two-stage (first and second) training for three endoscopic modalities

significantly superior to conventional white-light for the experienced endoscopist (87.7% vs 74.8%, P=0.0028). However, there were no differences in diagnostic accuracy for the trainee using the three modalities.

According to the learning curve, we analyzed the first 50 (referred as the first stage) and the rest 113 colorectal polyps (referred as the second stage) diagnosed by three endoscopic modalities (Fig. 2). The diagnostic accuracy was better in the second stage than that in the first stage.

Discussion

Methods of colonoscopic treatment for colorectal polyps, which include hot biopsy, snare polypectomy, and EMR, carry risks of bleeding and perforation. The rates of complications after treatment have been reported to range from 0.4% to 1.7%, which is not negligible [11–15]. In addition, it is time-consuming and uneconomical to biopsy nonneoplastic polyps. Based on the adenoma–carcinoma sequence [1, 16], it is very important to differentiate neoplastic polyps from nonneoplastic polyps before biopsy or treatment to avoid treatment-related complications and costs.

Previous studies showed great differences in diagnostic value in the differentiation of neoplastic polyps from nonneoplastic polyps [17–23]. These differences are caused by different diagnostic modalities such as the conventional view, chromoendoscopy, high-resolution magnifying chromoendoscopy, and NBI. Moreover, the average size of the colorectal polyps and the experience of the reader also affect the diagnostic accuracy. In this study, we only included polyps smaller than 10 mm because polyps larger than 10 mm should be removed and almost all of them are neoplastic. For this reason, we can avoid inadequately increasing the diagnostic accuracy of neoplastic polyp in this study.

Our results showed that magnifying NBI and magnifying chromoendoscopy were better than conventional white-light in the differentiation of neoplastic from nonneoplastic polyps. However, no significant difference between magnifying NBI and magnifying chromoendoscopy was observed. This is similar to the pilot study of Machida et al. [7]. In NBI, the central wavelengths of dedicated trichromatic optical filters are 500, 445, and 415 nm, and each has a bandwidth of 30 nm; these spectral features correspond to penetration depths of 240, 200, and 170 μm, respectively. As the gastrointestinal mucosa has a thickness of 700 to 800 μm and a layered structure, assessment of the capillary pattern is critical to diagnosing superficial tumors. Capillary vessels are usually visualized as a dark complex by NBI when using the 415-nm wavelength, in which the blue light is most absorbed by hemoglobin [7]. Neovascularization occurs in colorectal cancers and precancerous lesions. Therefore, NBI can clearly demonstrate the superficial vessel network of colorectal neoplastic lesions. In addition, NBI utilizes two light sources and a digital image filling system. One light source is for the standard optical filter (broadband) and the other is for NBI. In practice, these light sources can be exchanged manually with the endoscope in place; this change typically takes less than 1 s. Hence, we can obtain a so-called optical chromoendoscopy image. Compared to indigo carmine–chromoendoscopy, NBI saves time and there is no need for additional dye.

The kappa values of interobserver agreement between experienced endoscopists using conventional white-light, magnifying NBI, and magnifying chromoendoscopy were 0.77, 0.80, and 0.85. These kappa values were good to excellent. Also, the study of Su et al. had extremely excellent kappa values of 1 and 0.96 for nonmagnifying NBI and nonmagnifying chromoendoscopy [23].

Previous studies have almost all been conducted by experienced endoscopists or experts. In our study, we found that the diagnostic values for the trainee were 74.2%, 74.2%, and 72.4% for conventional white-light, magnifying NBI, and magnifying chromoendoscopy, respectively. There was no significant difference between modalities. However, it showed significantly efficient for the experienced endoscopist by using magnifying NBI and magnifying chromoendoscopy than using conventional white-light in our study. It represented that magnifying NBI and magnifying chromoendoscopy are promising diagnostic modalities for the trainee becoming to an experienced endoscopist.

According to Tagashi et al., a steep learning curve for magnifying colonoscopy is required before this method will be able to attain a stable confidence, and experience with approximately 200 lesions is needed to overcome the learning curve [24]. From our study by the two stage analysis, we found that the diagnostic accuracy will increase up to 74.3% (163 lesions). Therefore, we supposed that trainees take more learning in order to achieve experienced level. Although there were no differences for the trainees with different endoscopic modalities in the initial training, the kappa values of interobserver agreement were better for magnifying NBI (0.48) and magnifying chromoendoscopy (0.40) than conventional white-light (0.29). Therefore, it means that these two novel modalities have better diagnostic criteria than conventional white-light for trainees during their learning period.

Magnifying endoscopy was not routinely used in clinical practice. In a recent study, Sikka et al. showed that NBI without optical magnification had more accuracy in prediction colon polyp histology compared with white light imaging [25]. In addition, magnifying endoscopy has been recognized as a helpful technique to the differential diagnosis between neoplastic and nonneoplastic polyps. However, it was still not be used to completely replace the histopathological examination [26].

In conclusion, magnifying NBI is as effective as magnifying chromoendoscopy in the differentiation of neoplastic from nonneoplastic colorectal polyps. Only magnifying NBI and magnifying chromoendoscopy yield acceptable kappa values of interobserver agreement between trainees. Trainees need learning time to improve their diagnostic ability even using a new modality such as magnifying NBI or magnifying chromoendoscopy.

Conflict of interest statement The authors declare no conflict of interest.

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