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MINIREVIEWS

Image-enhanced endoscopy for diagnosis of colorectal tumors in view of endoscopic treatment

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Abstract

Recently, image-enhanced endoscopy (IEE) has been used to diagnose gastrointestinal tumors. This method is a change from conventional white-light (WL) endoscopy without dyeing solution, requiring only the push of a button. In IEE, there are many advantages in diagnosis of neoplastic tumors, evaluation of invasion depth for cancerous lesions, and detection of neoplastic lesions. In narrow band imaging (NBI) systems (Olympus Medical Co., Tokyo, Japan), optical filters that allow narrow-band light to pass at wavelengths of 415 and 540 nm are used. Mucosal surface blood vessels are seen most clearly at 415 nm, which is the wavelength that corresponds to the hemoglobin absorption band, while vessels in the deep layer of the mucosa can be detected at 540 nm. Thus, NBI also can detect pit-like structures named surface pattern. The flexible spectral imaging color enhancement (FICE) system (Fujifilm Medical Co., Tokyo, Japan) is also an IEE but different to NBI. FICE depends on the use of spectral-estimation technology to reconstruct images at different wavelengths based on WL images. FICE can enhance vascular and surface patterns. The autofluorescence imaging (AFI) video endoscope system (Olympus Medical Co., Tokyo, Japan) is a new illumination method that uses the difference in intensity of autofluorescence between the normal area and neoplastic lesions. AFI light comprises a blue light for emitting and a green light for hemoglobin absorption. The aim of this review is to highlight the efficacy of IEE for diagnosis of colorectal tumors for endoscopic treatment.

Key words: Flexible spectral imaging color enhancement; Narrow band imaging; Autofluorescence imaging; Colorectal polyps; Image-enhanced endoscopy

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INTRODUCTION

Colorectal cancer is a common gastrointestinal malignancy in United States, Europe and Japan. Most colorectal cancers are thought to arise from preexisting adenomas based on the concept of the adenoma-carcinoma sequence[1]. Therefore, adenomatous polyps should be resected using endoscopic techniques such as endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD)[2-4]. Colonoscopy is considered an effective examination for the detection of colorectal neoplastic lesions. However, the diagnostic capability of white-light (WL) endoscopy for the differentiation of neoplastic and

non-neoplastic polyps has demonstrated low sensitivity (38%-76%) and variable specificity (66%-97%)[5-7]. On the other hand, chromoendoscopy, using Kudo and Tsuruta's pit pattern classification, is a powerful tool for differential diagnosis of colorectal polyps[7-9]. The diagnostic capability of chromoendoscopy for the differentiation of neoplastic and non-neoplastic polyps has demonstrated high sensitivity (96.3%-97.0%) and high specificity (93.5%-100%)[10,11]. However, the operation of chromoendoscopy is relatively cumbersome, time-consuming and costly, not conducive to observe the vascular structure. Recently, image-enhanced endoscopy (IEE) has been carried out to diagnose gastrointestinal tumors. This method is a change from conventional WL without the need for a dyeing solution, requiring only the push of a button. In IEE, including narrow-band imaging (NBI), flexible spectral imaging color enhancement (FICE) and autofluorescence imaging (AFI), there are many advantages in diagnosis of neoplastic tumors, evaluation of invasion depth for cancerous lesions, and detection of neoplastic lesions. The aim of this review is to support the efficacy of IEE for diagnosis of colorectal tumors with a view to endoscopic treatment.

PRINCIPLE OF IEE: NBI, FICE AND AFI

In the NBI systems (Olympus Medical Co., Tokyo, Japan), optical filters that allow narrow-band light to pass at wavelengths of 415 and 540 nm are mechanically inserted between a xenon arc lamp and a red/green/blue rotatable filter[12-16]. Narrow mucosal surface blood vessels are seen most clearly at 415 nm, which is the wavelength that corresponds to the hemoglobin absorption band, while thick vessels in the deep layer of the mucosa can be detected at 540 nm. Thus, NBI with or without magnification, can enhance vascular patterns. Moreover, NBI also can detect the pit-like structures, which were named surface patterns in the Japanese consensus symposium[17]. On the other hand, the FICE system (Fujifilm Medical Co., Tokyo, Japan) is also an IEE but is unlike NBI. Previously, FICE was defined as "Fuji Intelligent Color Endoscopy", but this definition has been changed recently. FICE depends on the use of spectral-estimation technology to reconstruct images at different wavelengths based on WL images[18]. The suitable RGB wavelength settings and each wavelength contrast level for FICE to evaluate colorectal polyp were 540 (1), 460 (4), and 460 (4) nm, respectively[19]. FICE with or without magnification can enhance vascular and surface patterns[6,7,19-22]. The AFI system (Olympus Medical Co., Tokyo, Japan) is a new illumination method that uses the difference in intensity of autofluorescence between normal areas and neoplastic lesions[23-25]. AFI light comprises a blue light for emitting and a green light for hemoglobin absorption. Neoplastic areas involve a thickening of the mucosal layer and increased hemoglobin so such areas emit weaker autofluorescence compared to non-neoplastic areas. Recently, the AFI system has been used to enhance detection of early lesions in the esophagus, stomach, and colon.

IEE WITHOUT MAGNIFICATION

Magnifying endoscopy is less common in United States, and Europe. Therefore, accurate diagnosis of colorectal polyps using endoscopy without magnification is required. In NBI, high-definition colonoscopy, without magnification, is reported to be able to predict whether a colorectal polyp is neoplastic or non-neoplastic[26,27]. Various studies about NBI without magnification demonstrated accuracy of 89.0%-92.7%, sensitivity of 87.9%-95.7% and specificity of 87.0%-90.5% (Table 1)[26-29]. On the other hand, FICE without magnification is also reported to be useful for differentiation between a neoplastic polyp and non-neoplastic polyp. Various studies about FICE without magnification, demonstrated accuracy of 84.4%-89.4%, sensitivity of 89.4%-93.2% and specificity of 81.2%-88.0% almost similar to the data of the NBI studies (Table 1)[7,19,30].

A meshed capillary network is one of the important endoscopic features of neoplastic polyps in NBI without magnification, as defined by Sano *et al*[14](Figure 1). Other reports using NBI without magnification also point to meshed capillary vessels as being characteristic of neoplastic polyps[27]. Rex[28] adopted surface patterns including pit and vascular patterns for neoplastic endoscopic features in NBI. Rastogi *et al*[5] used 5 different surface patterns (including mucosal, pit and vascular patterns) to differentiate neoplastic polyps from non-neoplastic polyps. In FICE, the detection of surface patterns is a reliable method to determine whether a polyp is neoplastic or non-neoplastic though one study demonstrated evaluation of vascular patterns (Figure 2). The reason was that FICE without magnification could not detect detail vascular patterns clearly compared to NBI[19].

In a report about NBI without magnification, when polyp size was considered, the accuracy in polyps 6-9 mm in diameter (accuracy: 96.0%) were better than those for polyps 5 mm or less in diameter (accuracy: 90.0%)[27]. In FICE without magnification, the accuracy, sensitivity, and specificity in polyps 6 mm or greater in diameter (97.1%, 95.2%, 90.0%) were better than for polyps 5 mm or less in diameter (82.7%, 78.0%, 87.5%)[19,31]. Diagnosis of small polyps is important for the prevention of colorectal cancer. A procedural decision to avoid resection of non-neoplastic polyps would spare patients the cost and risk of a polypectomy. The DISCARD trial reported by Ignjatovic *et al*[32] demonstrates that for polyps less than 10 mm in size, *in-vivo* optical diagnosis including NBI without magnification seems to be an acceptable strategy to differentiate adenomatous polyp from hyperplastic polyp (sensitivity: 94%, specificity 89%).

Recently, an international cooperative group was formed and consists of members from Japan, United States and Europe, named the Colon Tumor NBI Interest Group. This group has developed NBI international

Table 1 Reports about image-enhanced endoscopy without magnification for differentiation between neoplastic polyps and non-neoplastic polyps (%)

Ref.	System	No. of cases	Accuracy	Sensitivity	Specificity	PPV	NPV
Henry *et al*[27]	NBI	126	90.0	93.0	88.0	93.0	91.0
Su *et al*[29]	NBI	110	92.7	95.7	87.5	93.0	92.1
Tischendorf *et al*[26]	NBI	100	89.0	87.9	90.5	92.7	84.4
Rex[28]	NBI	451	89.0	92.0	87.0	88.0	91.0
Lonqcroft-Wheaton GR	FICE	232	88.0	-	-	-	-
Pohl *et al*[61]	FICE	321	84.4	93.2	61.2	88.0	76.4
Yoshida *et al*[22]	FICE	151	89.4	89.4	88.0	93.4	83.3
Sato *et al*[34]	AFI	358	91.9	92.7	92.9	-	-

NBI: Narrow-band imaging; FICE: Flexible spectral imaging color enhancement; PPV: Positive predictive value; NPV: Negative predictive value; AFI: Autofluorescence imaging.

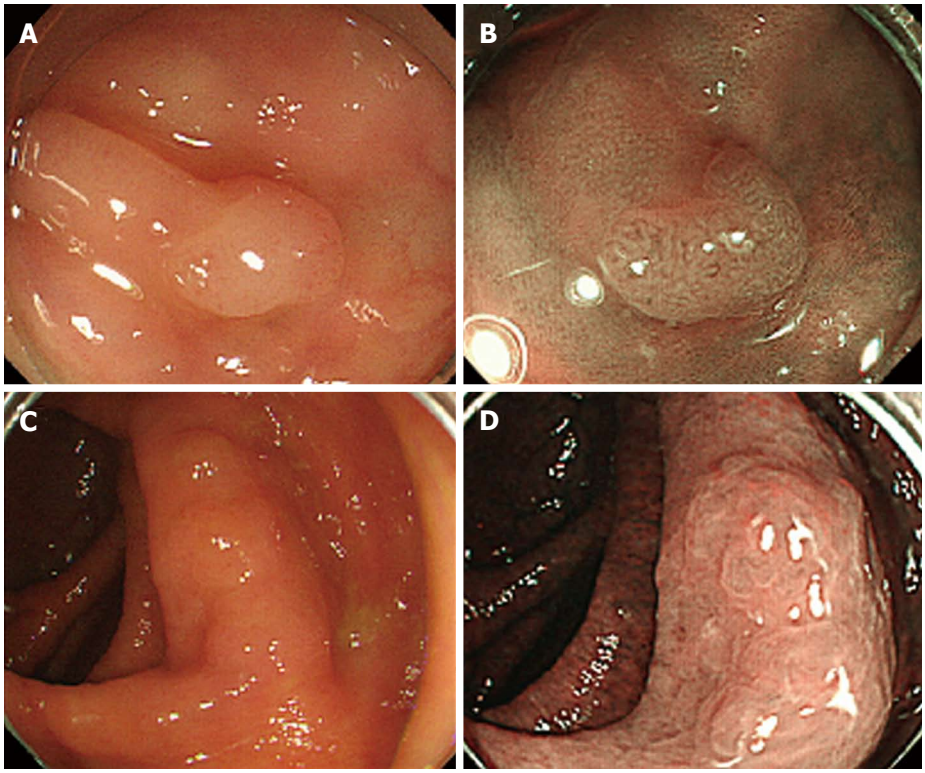

Figure 1 Narrow band imaging without magnification. A: Ⅰa polyp 3 mm in diameter. White-light (WI) endoscopy figure; B: Meshed capillary pattern and oval surface pattern were detected with narrow band imaging (NBI) without magnification. The polyp was diagnosed as a neoplastic polyp; C: Ⅱa polyp 16 mm in diameter. WI endoscopy figure; D: Meshed capillary pattern was not detected with NBI without magnification, but a round surface pattern was detected. The polyp was diagnosed as a non-neoplastic polyp.

colorectal endoscopic (NICE) classification, which classifies colorectal tumors into types 1-3 by closely observing colorectal tumors without magnification[17]. Now, NICE classification of the capability of differential diagnosis between non-neoplastic polyp, adenoma, and cancer in United States, Europe and Japan has been validated.

AFI has been reported to have an advantage in providing better visualization of polyps than WL and, therefore, may be able to improve the capability of differential diagnosis between neoplastic and non-neoplastic polyps and the detection of adenomas[33]. Some reports demonstrated that AFI may be more effective for the characterization of colorectal adenomas because of better visualization of such lesions compared to NBI (Table1, Figure 3)[33,34].

NBI AND FICE WITH MAGNIFICATION FOR THE DIFFERENTIATION OF NEOPLASTIC OR NON-NEOPLASTIC AND DIAGNOSIS OF CANCER DEPTH

There have been many studies on NBI and FICE with magnification[12-14,35-37]. In the differentiation of neoplastic or non-neoplastic polyps, these studies reported an accuracy of 93.4%-98.9%, sensitivity of 90.9%-100.0%, specificity of 75.0%-98.9%, positive predictive value

Table 2 Reports about image-enhanced endoscopy with magnification for differentiation between neoplastic polyps and non-neoplastic polyps (%)

Ref.	System	No. of cases	Accuracy	Sensitivity	Specificity	PPV	NPV
Machida *et al*[12]	NBI	43	93.4	100.0	75.0	91.2	100.0
Sano *et al*[14]	NBI	150	95.3	96.4	92.3	97.3	90.0
Wada *et al*[35]	NBI	617	96.7	90.9	97.1	-	-
Tanaka *et al*[17]	NBI	289	98.9	100.0	98.9	-	-
Togashi *et al*[6]	FICE	107	87.0	93.0	70.0	90.0	76.0
dos Santos *et al*[20]	FICE	111	92.8	97.8	79.3	93.0	92.0

NBI: Narrow-band imaging; FICE: Flexible spectral imaging color enhancement; PPV: Positive predictive value; NPV: Negative predictive value.

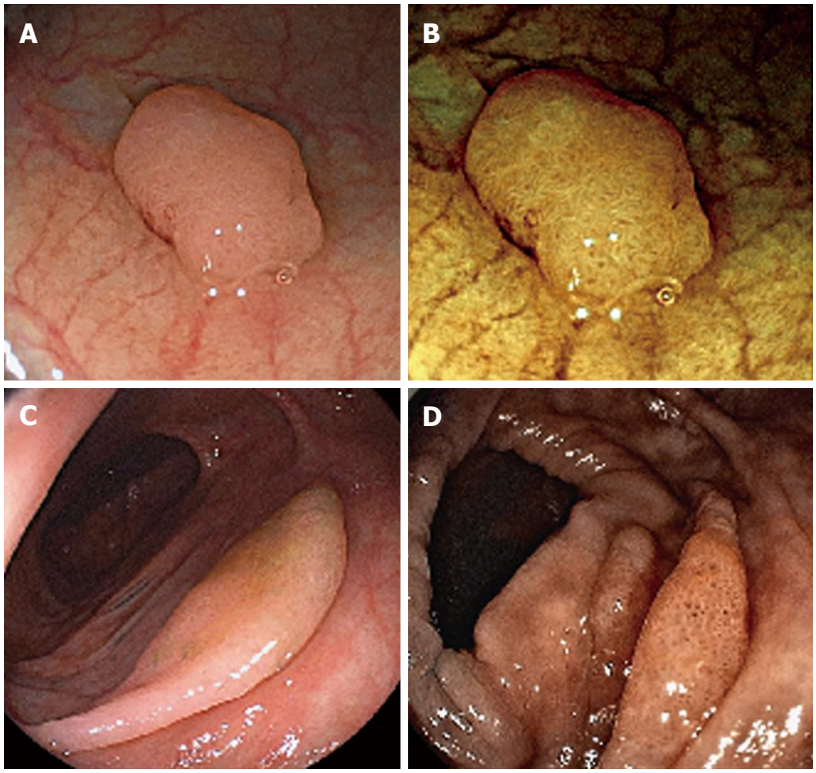

Figure 2 Flexible spectral imaging color enhancement without magnification. A: Ⅰa polyp 5 mm in diameter. White-light (WI) endoscopy figure; B: Flexible spectral imaging color enhancement (FICE) without magnification. FICE settings were RGB wavelengths 550, 500 and 470 nm. Round pits were identified as non-neoplastic surface patterns; C: Ⅱa polyp 16 mm in diameter. WI endoscopy figure; D: Meshed capillary pattern was not detected with FICE without magnification, but round surface pattern was detected. The polyp was diagnosed as a non-neoplastic polyp.

(PPV) of 91.2%-97.3%, and negative predictive value (NPV) of 90.0%-100.0% (Table 2). There are four published classifications of NBI with magnification such as the Sano classification, Hiroshima classification, Showa classification, Jikei classification and one published FICE classification[14,16,21,35,38]. In brief, the Sano classification, Showa classification and Jikei classification classify using only vascular pattern. On the other hand, the Hiroshima classification and FICE classification use surface and vascular patterns. The efficacy of surface pattern detection in NBI and FICE magnification has been reported previously[16,21]. We have reported on the detectability of NBI and FICE with magnification and the difference between them[21]. In that, in magnifying endoscopy NBI could detect thinner vessels than FICE could (Figure 4). The avascular area detected in deeply submucosal invasive cancer by NBI is observed frequently in FICE. So, massively submucosal invasive cancer cannot be diagnosed only by the avascular area in FICE[21]. Thus, observation with FICE requires both vascular pattern and surface pattern and thus FICE classification was defined, modifying the Hiroshima classification of NBI[21].

The accuracy, sensitivity, and specificity of each NBI and FICE classification for massively submucosal invasive cancer are described in Table 3[14,16,21,35,39]. These studies reported accuracy of 87.7%-98.3%, sensitivity of 77.7%-100.0%, specificity of 88.7%-100.0%, PPV of 71.8%-100.0%, and NPV of 90.0%-96.2%. Therefore, NBI and FICE magnification were thought to be useful for determining therapeutic strategies, including

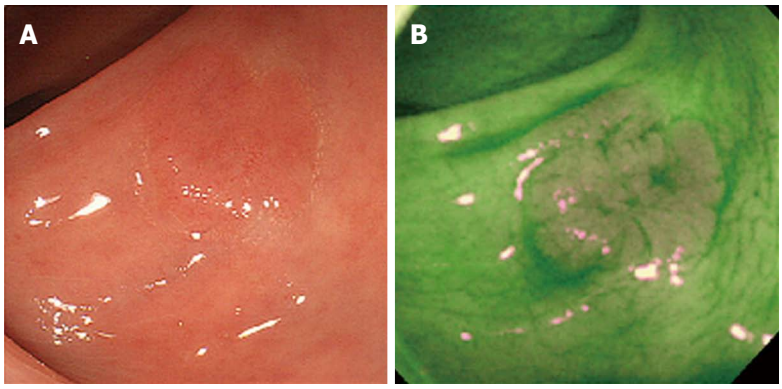

Figure 3 Autofluorescence imaging. A: Ⅱa polyp 14 mm in diameter (White-light endoscopy figure); B: In autofluorescence imaging, the normal mucosa was detected by green color and the neoplastic polyp was detected by magenta color.

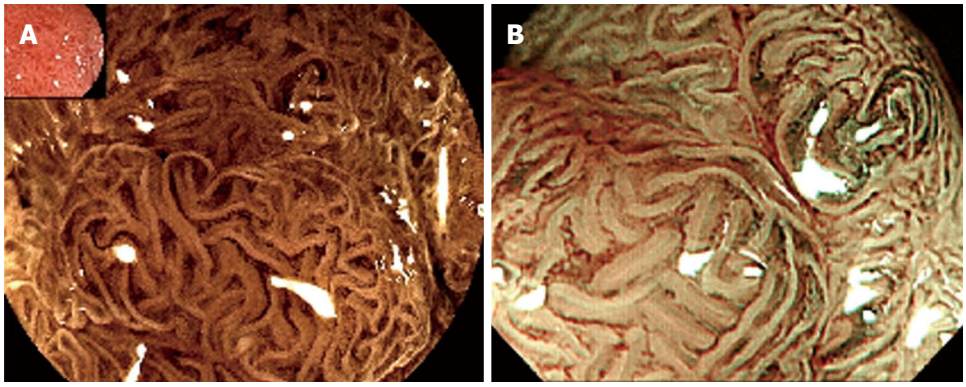

Figure 4 The surface and vascular patterns as seen by flexible spectral imaging color enhancement magnification and narrow band imaging magnification are shown. A: Flexible spectral imaging color enhancement; B: Narrow band imaging.

endoscopic resection by EMR, ESD, or surgical operation of colorectal tumors. However, the sensitivity (77.7%-100.0%) and the specificity (88.7%-100.0%) were not sufficient. Chromoendoscopy using pit pattern classification should be performed in a case which is suspected as cancerous with NBI and FICE or which is diagnosed by NBI and FICE with low confidence.

Recent studies have reported outcomes of training in NBI with magnification for the differentiation of neoplastic or non-neoplastic polyps. These studies revealed that a 20-60 min training lecture could increase the differential diagnostic skills of operators inexperienced in NBI with magnification to expert levels[40,41].

Sano classification

Based on the surface characteristics of the meshed capillaries (Figure 5)[14], capillary pattern (CP) type I is defined as invisible meshed capillary pattern, detected in hyperplastic polyps (Figure 5A). CP type Ⅱ is the regular small-caliber capillaries observed in adenomatous polyps (Figure 5B). CP type Ⅲ is defined as demonstrating irregular and unarranged patterns in a mesh-like microvascular architecture, exhibiting at least one of the following: irregular size, complicated branching, disrupted irregular winding. Moreover, CP type Ⅲ lesions are further classified into two groups: types ⅢA or ⅢB according to microvascular architecture and high microvessel density with lack of uniformity, blind ending, branching and curtailed irregularly (Figure 5 C-E). CP type ⅢA is observed mainly in adenoma, intramucosal cancer and slightly invaded submucosal cancer. CP type ⅢB is observed 28% in intramucosal cancer and 72% in massively invaded submucosal cancer (Figure 6).

Hiroshima classification

Hiroshima classification classifies according to vascular pattern and surface pattern such as type A, type B, or type C[16]. NBI magnification findings are considered: type A when microvessels are not observed or are extremely opaque; type B when fine microvessels are observed around the surface patterns and clear surface patterns can be observed *via* the nest of microvessels; and type C when the microvessels are irregular and the vessel diameter or distribution is heterogeneous (Figure 5). Type A is observed in hyperplastic polyps and type B is observed mainly in adenoma and intramucosal cancer. Type C is divided into 3 subtypes (C1, C2 and C3) according to: surface patterns visibility, vessel diameter, irregularity, and distribution. In type C1, microvessels comprise an irregular network, surface patterns observed *via* the microvessels are slightly non distinct and vessel diameter or distribution is homogeneous (Figure 5C). In the previous

Table 3 Reports about image-enhanced endoscopy with magnification for differentiation of massively submocosal invasive cancer (%)

Ref.	System	No. of cases	Accuracy	Sensitivity	Specificity	PPV	NPV
Fukuzawa *et al*[39]	NBI	112	92.9	81.4	100.0	100.0	90.0
Wada *et al*[35]	NBI	584	96.1	100.0	95.8	-	-
Tanaka *et al*[17]	NBI	97	94.1	63.8	100.0	-	-
Ikematsu *et al*[58]	NBI	130	87.7	84.8	88.7	71.8	94.5
Yoshida *et al*[22]	FICE	124	98.3	77.7	100.0	100.0	98.2

NBI: Narrow-band imaging; FICE: Flexible spectral imaging color enhancement; PPV: Positive predictive value; NPV: Negative predictive value.

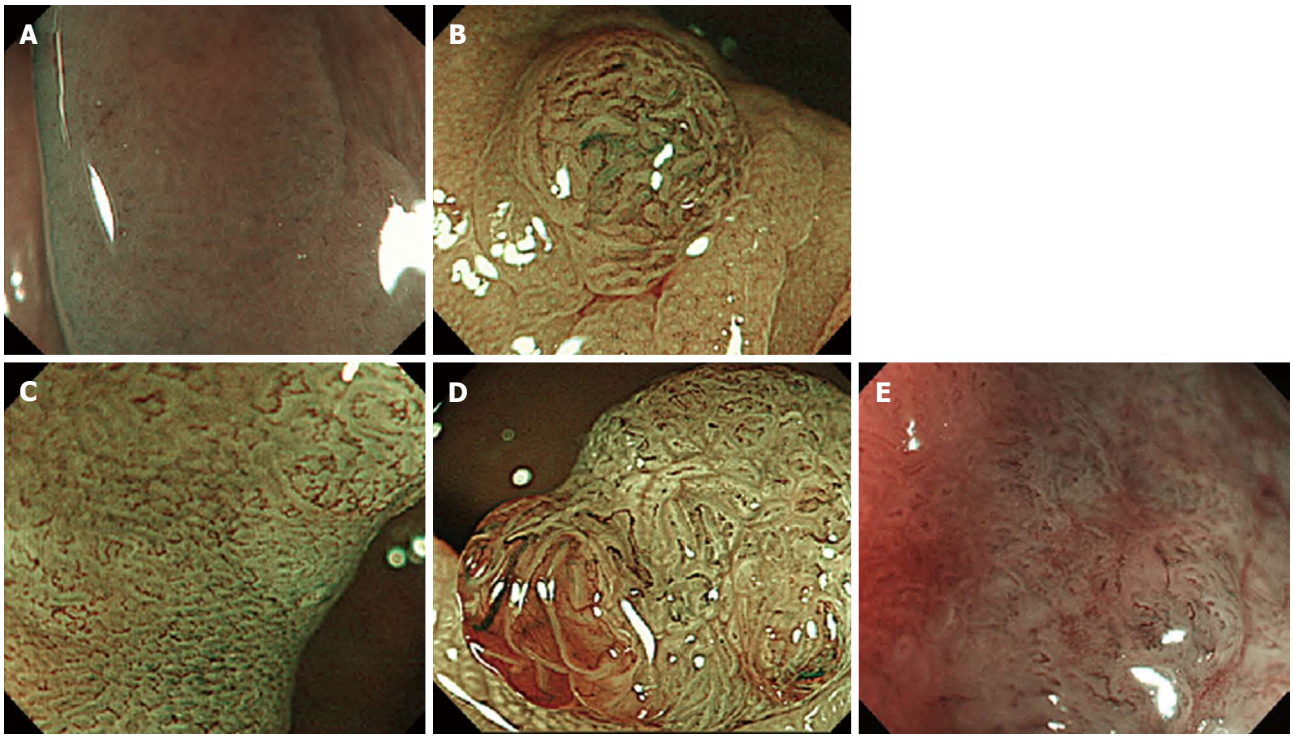

Figure 5 Narrow band imaging classification. A: Capillary pattern (CP) type Ⅰ in Sano classification. Type A in Hiroshima classification; B: CP type Ⅱ in Sano classification. Type B in Hiroshima classification; C: CP type ⅢA in Sano classification. Type C1 in Hiroshima classification; D: CP type ⅢB in Sano classification. Type C2 in Hiroshima classification; E: CP type ⅢB in Sano classification. Type C3 in Hiroshima classification.

report, type C1 is observed 46.7% in adenoma, 42.2% in intramucosal cancer, and 11.1% in massively invaded submucosal cancer[16]. In type C2, microvessels form an irregular network, surface patterns observed *via* the microvessels are irregular, and vessel diameter or distribution is heterogeneous (Figure 5D). Type C2 is observed 45.5% in intramucosal cancer and 54.5% in massively invaded submucosal cancer (Figure 6). In type C3, surface patterns *via* the microvessels are invisible, irregular vessel diameter is thick, or the vessel distribution is heterogeneous, and avascular areas are observed (Figure 5E). Type C3 is mainly observed in massively invaded submucosal cancer (Figure 6).

Showa classification

Showa classification has been divided into six groups according to endoscopical vascular features: normal, faint, network, dense, irregular and sparse. Most hyperplastic polyps show a faint pattern. The vascular patterns of adenomas are mainly network or dense ones. The predominant vascular patterns of cancer are irregular and sparse. Indeed, irregular pattern has found to be characteristic for protruded or flat-elevated cancer, whereas sparse pattern is unique to depressed cancer. Irregular or sparse pattern is observed in intramucosal cancer and adenoma (37%), and massively invaded submucosal cancer (63%) (Figure 6)[35].

Papillary and tubular patterns with in the vascular pattern

Variations are seen within the vascular pattern in neoplastic lesions. The two most important two vascular patterns, the papillary and the tubular pattern are shown. The papillary pattern shows thicker and more widening than the tubular pattern (Figure 7A). The tubular pattern shows a honeycomb-like network (Figure 7B). The

Histopathological diagnosis	Hyperplastic polyp	Adenoma Intramucosal cancer Slightly submucosal invasive cancer	Massively invaded submucosal cancer
Therapy	No therapy	Endoscopic resection	Surgical operation
Sano classification	Type Ⅰ	Type Ⅱ Type ⅢA	Type ⅢB
Hiroshima classification	Type A	Type B Type C1	Type C3 Type C2
Showa classification	Faint pattern	Dense pattern Network pattern	Sparse pattern Irregular pattern

Figure 6 The various narrow band imaging classifications and histopathological diagnoses. Classification of suspect histopathological diagnoses and therapy according to the pattern diagnosed.

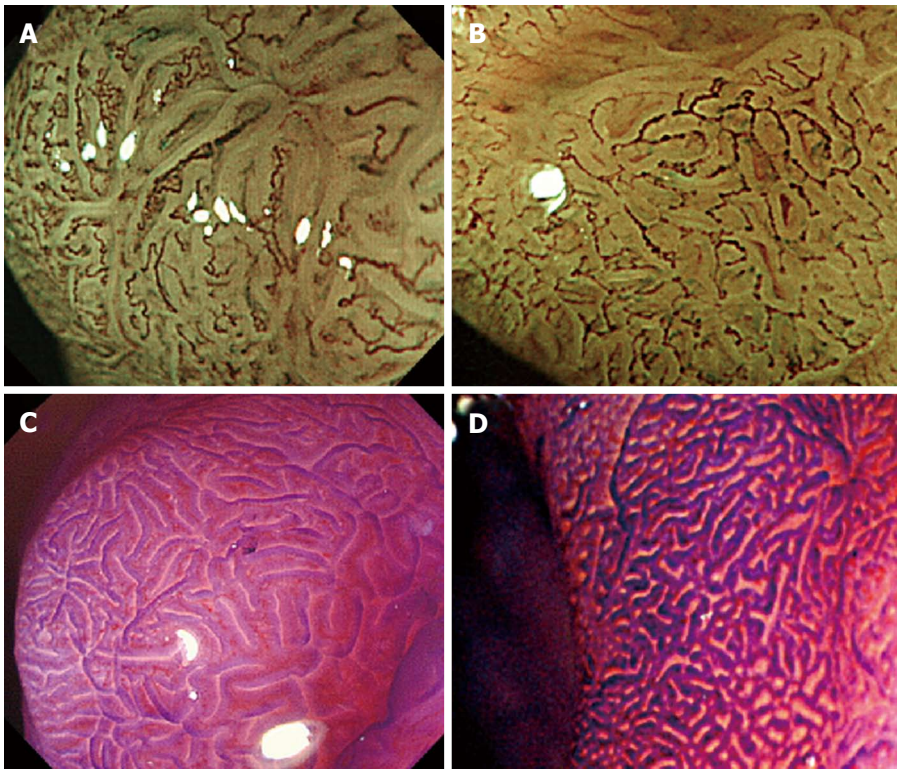

Figure 7 Papillary pattern and tubular pattern in vascular pattern. A: Papillary type. Papillary pattern is thicker and more winding than the tubular pattern. The surface pattern shows a regular pattern like the Ⅳ pit structure according to Hiroshima classification. The pattern was diagnosed type B in Sano classification, type B in Hiroshima classification, Network in Showa classification; B: Tubular type. Tubular pattern shows a regular honeycomb-like network. The surface pattern shows a regular pattern according to Hiroshima classification. The pattern was diagnosed type B in Sano classification, type B in Hiroshima classification, Network in Showa classification; C: The pit pattern classification using crystal violet showed Ⅳ pit. The histopathological diagnosis of these two patterns shows tubular adenoma; D: The pit pattern classification using crystal violet showed ⅢL pit mainly and Ⅳ pit partially. The histopathological diagnosis of these two patterns indicated tubular adenoma.

irregularity of the papillary pattern seems to be greater than that of tubular pattern. However, the surface patterns of these lesions shows a regular pattern according to the Hiroshima classification. The pits of the lesions with these patterns showed adenoma characteristics (Figure 7C, D). In addition, the histopathological diagnosis of these two patterns indicates tubular adenoma. Lesions with the papillary pattern have to be diagnosed carefully taking into account their surface pattern.

Adenoma detection rate

Colonoscopy is considered to be the standard examination against which the sensitivity of other colorectal cancer screening tests is compared[42,43]. However, polyp miss rates during colonoscopy have been evaluated in several studies[44-46]. A meta-analysis of six studies revealed that the miss rate for polyps of any size was 22%[44]. This study also demonstrated that the adenoma miss rate was 2%, 13%, and 26% for polyp sizes of 10 mm and higher, 5-10 mm and 1-5 mm respectively[44]. Another study showed that sessile or flat polyps were significantly associated with a higher miss rate[45]. The reasons for missing polyps were considered to be the quality of bowel preparation, lesion characteristics (location, number, morphology and size), the endoscopist's experience, the endoscopist's insertion and the withdrawal technique[45-48]. Many clinical studies including randomized controlled studies into the effect of NBI on improvement of miss rate in

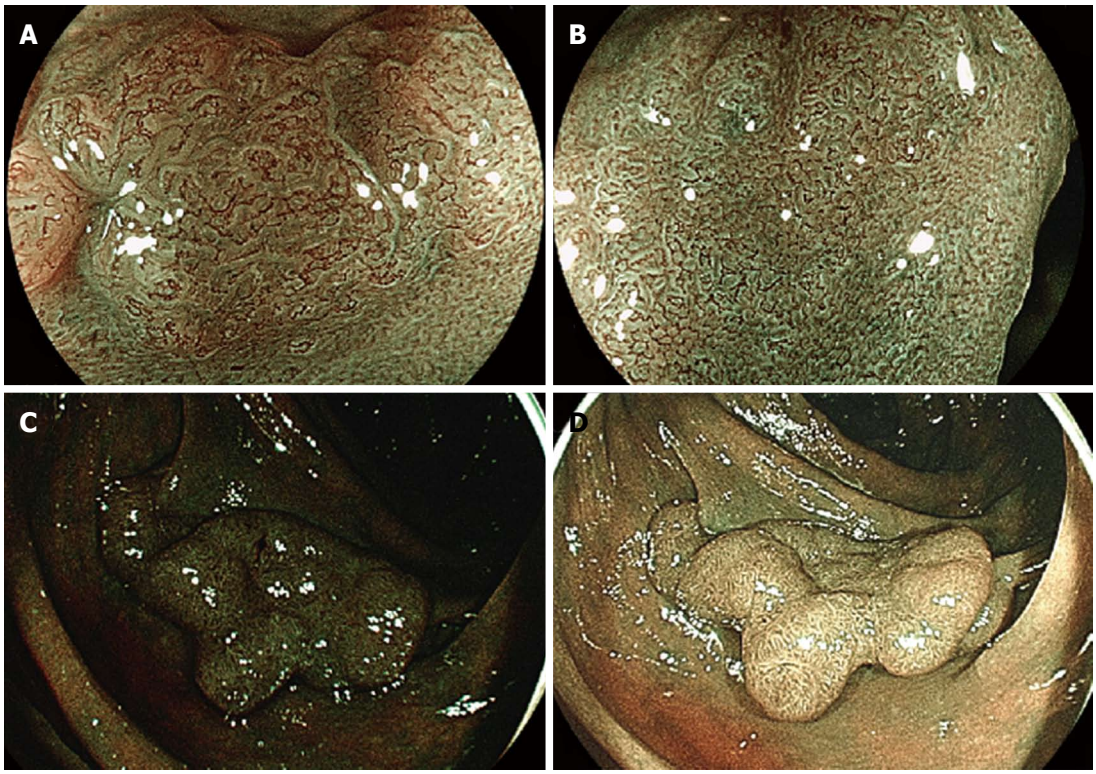

Figure 8 Blue laser imaging. A: Blue laser imaging (BLI) mode. Clear vascular patterns and the surface pattern can be seen; B: BLI mode. Clear vascular patterns and the surface pattern can be seen; C: BLI mode is slightly dark; D: BLI-bright mode is brighter than BLI mode.

colonoscopy have been reported[48-57]. In conclusion, the efficacy of NBI has been mainly unsatisfactory. One positive study by Inoue *et al*[56] demonstrated that there was a significantly higher number of adenomas detected with pancolonic NBI (22%) *vs* WL (14%), including higher number of diminutive (< 5 mm) adenomas. Moreover, the one controlled randomized study, performed in selected patients undergoing colonoscopy for colorectal screening, suggested that NBI seems to improve the detection of flat adenoma[57].

On the other hand, one negative study for NBI by Rex *et al*[51] showed that there were no differences between the NBI and WL groups in either the prevalence of adenomas or the total number of adenomas detected. Ikematsu *et al*[58] reported a Japanese multicenter prospective trial about adenoma detection rates of NBI (42.3%) and WL (42.5%) in right colon endoscopy screening. They concluded that NBI did not improve the adenoma detection rate. However, they also showed that the adenoma miss rate was significantly less with NBI (31.3%) than WL (27.8%) ($P < 0.05$). Analysis of flat and depressed lesions was performed in this study and detection rates of these lesions were not significantly different between NBI and WL.

A recent meta-analysis revealed that there was no statistically significant difference in the rates of adenoma detection rate between NBI and WL[59]. Moreover, one systemic review including 8 randomized controlled studies showed that NBI did not improve detection of colorectal polyps when compared to WL[60]. However, withdrawal time is associated with these studies. Some studies showed longer withdrawal time in NBI observation because the NBI image was dark at some distance from the polyps. If the withdrawal time is similar, the WL group might have a better adenoma detection rate during the withdrawal phase compared to that of the NBI group[60]. This may have led to the finding of significantly greater number of polyps in the WL group. In addition, poor bowel preparation made performance of the NBI visualization poorer[60]. Moreover, the use of a variety of endoscopic systems, such as the LUCERA series and EXERA-Ⅱ, may have had some impact on NBI findings. Uraoka *et al*[55] demonstrated that there are significant differences in the detection of adenomas between the sequential LUCERA series used in Japan and the simultaneous EXERA-Ⅱ series produced in Europe and America.

Three studies on FICE in the detection of neoplastic polyps have been reported[61-63]. One study showed that the detection of polyps was not significantly different between FICE and chromoendoscopy 7[61]. Two RCTs also showed that any objective improvement of FICE was not correlated with the adenoma detection rate[62,63]. On the other hand, FICE systems have been improved recently and the combination of recent systems with endoscopy allow high resolution, providing better contrast for vascular and surface patterns in magnifying endoscopy than previous FICE systems offered. Further multicenter RCT should be expected to evaluate the capability of adenoma detection in FICE.

NOVEL IEE

A new endoscope system, "EXERA Ⅲ" has been developed by Olympus. The NBI in this system delivers significantly increased brightness and contrast. This improved brightness may open new possibilities for polyp detection. Moreover, it allows "dual focus", a unique system based upon an innovative two-stage optical system enabling the user to switch between two focus settings. "Near mode" features ground breaking resolution power for close mucosal observation and "Normal mode" allows normal observation. On the other hand, a new endoscope system, "LASEREO", developed by Fujifilm, uses a semiconductor laser as a light source. The LASEREO system has two lasers, with wavelengths of 415 nm and 450 nm. The "blue laser image (BLI)", which functions as a narrow-band light and is consisted of the combination of two lasers and fluorescent light, is useful for acquiring mucosal surface information including surface blood vessel and structure patterns (Figure 8A, B). By controlling the power of the two lasers, a BLI-bright mode is set by an appropriate combination of WL and BLI light. This mode is brighter than the BLI mode alone, and it can be useful for tumor detection and observation of whole tumors (Figure 8C, D).

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