Diagnostic ability of linked color imaging in ultraslim endoscopy to identify neoplastic lesions in the upper gastrointestinal tract

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ABSTRACT

Background and study aims Linked color imaging (LCI) is a new image-enhancing technique that facilitates the differentiation of slight differences in mucosal color tone. We performed an exploratory analysis to evaluate the diagnostic capability of LCI in ultraslim endoscopy, using data from patients examined in the LCI-Further Improving Neoplasm Detection in upper gastrointestinal (LCI-FIND) trial, a large-scale, multicenter, randomized controlled trial that demonstrated the capability of LCI for detecting neoplastic lesions in the upper gastrointestinal tract.

Patients and methods Data from the LCI-FIND prospective trial were used. In the LCI-FIND trial, 1502 patients with a history of gastrointestinal cancer were randomly assigned to two groups based on examination methods: white light imaging (WLI) followed by LCI (WLI group) and LCI followed by WLI (LCI group). The present exploratory analysis investigated the outcomes of patients who underwent ultraslim and standard endoscopies.

Results Ultraslim endoscopes were used in 223 patients and standard endoscopes in 1279 patients. The primary endpoint of the LCI-FIND trial was the percentage of patients diagnosed with a neoplastic lesion using WLI or LCI. The corresponding percentage tended to be higher with LCI than with WLI among patients who underwent ultraslim endoscopy and among those who underwent standard endoscopy; the crude risk ratio was 2.21 [95% confidence interval (CI): 1.06–4.67], and the adjusted odds ratio was 2.46 (95% CI: 1.07–5.63).

Conclusions Our exploratory analysis of data from the LCI-FIND trial showed that LCI is useful in identifying neoplastic lesions, when used in ultraslim endoscopy.

Introduction

Upper gastrointestinal endoscopy mainly detects neoplastic lesions in the pharynx, esophagus, and stomach. However, conventional white light imaging (WLI) is disadvantageous because it is likely to overlook early-stage lesions [1–3]. A new image processing technique, linked color imaging (LCI), was developed for the LASEREO system using laser beams (Fujifilm Corporation, Tokyo, Japan). LCI is an image-enhanced endoscopic observation method in which conventional white light and short-wavelength narrowband light are applied simultaneously in an appropriately balanced manner to emphasize slight color differences of the membrane by making reddish colors appear redder and whitish colors whiter through simultaneous enhancement and weakening of colors. Although the usefulness of LCI in the qualitative diagnosis of upper gastrointestinal lesions has been reported [4–14]. There has been no large-scale clinical trial focused on detection and diagnosis of upper gastrointestinal lesions. We previously conducted a large-scale randomized controlled clinical trial–the LCI-Further Improving Neoplasm Detection in upper gastrointestinal (LCI-FIND) trial–and demonstrated the capability of LCI for detecting neoplastic lesions in the upper gastrointestinal tract [15].

Endoscopes used for observation of the upper gastrointestinal tract are divided into two types: ultraslim and standard with a relatively larger caliber. Whereas standard endoscopes can only be inserted transorally, ultraslim endoscopes can be inserted transorally and transnasally, causing less burden on the patient undergoing endoscopic examination. However, because of the small caliber, ultraslim endoscopy has a risk of producing lower-quality images and decreased operability compared with standard endoscopy. There is, however, a recent report documenting that ultraslim endoscopy is equivalent to standard endoscopy in terms of diagnostic capability.[16] The LCI-FIND trial used both ultraslim and standard endoscopic instruments. Hence, we performed a sub-analysis using data from the LCI-FIND trial to examine whether the ability of ultraslim endoscopy to detect neoplastic lesions is no-inferior to that of standard endoscopy.

Patients and methods

Since the methods used in the LCI-FIND trial have been described in detail in a previous report on the results of the primary endpoint [15], only an outline of the methods is shown here.

Patients

The subjects were patients aged 20 to 89 years who were scheduled for upper gastrointestinal endoscopy in 19 major hospitals in Japan. All of them were known to have a history or current diagnosis of gastrointestinal cancer (pharyngeal, esophageal, gastric, or colorectal).

This study was performed after obtaining approval from the institutional review boards of all participating institutions. This study is registered under the UMIN Clinical Trial Registry (UMIN000023863). Written informed consent was obtained from all subjects. This study received the provision of medical equipment and financial support from Fujifilm Corporation, but an agreement was made that the company would not influence the content and results of the study.

Methods

This study was conducted after patient recruitment as a post-hoc analysis of the LCI study. The minimization method was used for the random assignment of the patients. The following four stratification factors were used: facility, age (≥70 or <70 years), presence/absence of current cancer, and presence/absence of surgical history of gastric or esophageal resection.

The endoscopic devices used included LASEREO, LASEREO 7000 system, and upper gastrointestinal endoscopes (EG-L580NW, EG-L590WR, EG-L590ZW, EG-L600ZW, EG-L580NW7, EG-L600WR7, and EG-L600ZW7) (Fujifilm Corporation, Tokyo, Japan). The choice of endoscopic equipment was

left to the free will of the endoscopists. In this study, patients in whom EG-L580NW or EG-L580NW7 were used were in the group subjected to ultraslim endoscopy, and those in whom other endoscopes with greater calibers were used were in the group subjected to standard endoscopy.

The image resolution of endoscopy was evaluated by the United States Air Force (USAF) resolution test chart (▶Fig. 1) on a monitor of the endoscopy system at distances of 50 mm and 70 mm between the distal end of the endoscopy and the chart. Evaluated endoscopes were EG-L580NW7 categorized as ultraslim-scope, EG-L590WR and EG-L600WR7 as standard-scope. EG-L580NW used in this study has the same optical specification as L580NW7. Also, EG-L590ZW was the same as EG-L590WR and EG-L600ZW7 were the same as EG-600WR7 in optical specification, respectively. Image resolution was defined by the maximal resolvable lines per mm of the USAF test chart. The results are shown in ▶Table 1. The EG-L580NW7 and EG-L590WR had almost the same resolution and the EG-L600WR7 had higher resolution than two scopes.

During the endoscopic procedure, each location was observed with WLI followed by LCI (WLI group) or with LCI followed by WLI (LCI group). The number of detected lesions, neoplastic/nonneoplastic, and the degree of endoscopist's confidence (high/low) about the malignant potential were recorded for each observation of each location. The degree of endoscopist confidence was rated as high when the endoscopist judged the lesion as being definitely cancer, whereas it was rated as low when the endoscopist judged that the possibility of cancer was not deniable for the lesion. The time required for observation of the esophagus and stomach was calculated from the recorded time data on photographs taken at the beginning and end of the observation of each location.

Biopsy specimens were obtained from all diagnosed lesions. Neoplastic lesions were defined as high-grade dysplasia and carcinoma of the pharynx, intraepithelial neoplasia (IN), carcinomas of the esophagus, and adenoma and carcinoma of the stomach. Duodenal lesions were not included in this study because of their low frequency.

Endpoints included the percentage of patients diagnosed with pharyngeal, esophageal, or gastric neoplastic lesions observed by WLI and LCI in the primary mode; the percentages of patients diagnosed with a neoplastic lesion observed by WLI and LCI in the primary mode by location, size, morphology type, and degree of endoscopist confidence; and neoplastic lesions detected by WLI and LCI in the secondary mode.

The presence of *Helicobacter pylori* infection was not assessed in this study.

Statistical analysis

Patients who underwent standard endoscopy and those who underwent ultraslim endoscopy were analyzed separately. Since this was an exploratory study that used data after the confirmatory analysis of the primary endpoint, the percentage and 95 % confidence interval (CI) were calculated and presented for each item. The 95 % CI was calculated by exact binomial distribution. As for relative risk, the crude risk ratio without adjustment, odds ratio adjusted for age, presence/absence of cur-
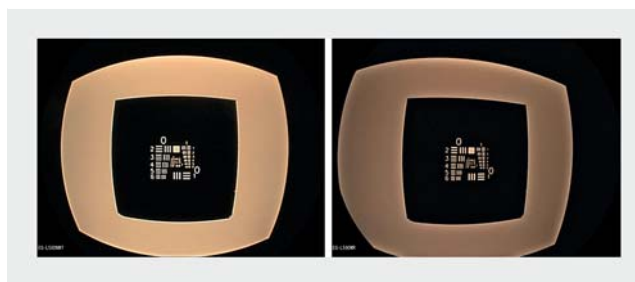
▶Fig. 1 The images shown are a comparison of resolution chart at a 50-mm distance between the scope and the resolution chart. The distinguishable lines are 1 to 2 for the ultraslim endoscopy (left) and 1 to 3 for the normal-diameter endoscopy (right), which when converted to resolution are 2.24 LP/mm and 2.52 LP/mm, respectively.

▶Table 1 Results of image resolution evaluation on the ultraslim-scope and the standard scopes using the USAF test chart.

| Endoscope	Resolution (lines/mm)	
	50 mm	70 mm
EG-L580NW7	2.24	1.41
EG-L590WR	2.52	1.59
EG-L600WR7	3.56	2.52

USAF, United States Air Force.

rent cancer, and presence/absence of surgical history using a logistic model, and 95 % CI were calculated.

Results

A total of 1,508 patients were recruited between November 2016 and July 2018, and 1,504 patients who gave consent to the study were registered and randomized to the WLI (753 patients) and the LCI groups (752 patients). The final population for evaluation comprised 751 patients in the WLI group and 750 patients in the LCI group, excluding two patients: one patient in the WLI group who underwent standard endoscopy because of a large amount of residue and another patient in the LCI group who underwent standard endoscopy because of stenosis caused by pharyngeal neoplasm (▶Fig. 2).

Ultraslim endoscopes were used in 223 patients, and standard endoscopes were used in 1,279 patients. Standard endoscopes were inserted transorally in all the 1,279 patients, whereas ultraslim endoscopes were inserted transorally in 44 (19.7 %) patients and transnasally in the remaining patients. The number of examinations for each type of endoscopy by medical facility are shown in ▶Table 2.

Baseline characteristics of the study subjects are shown in ▶Table 3. Among the patients who underwent ultraslim endoscopy, the presence of current cancer was slightly more frequent in the LCI group, and the history of radiation therapy was slightly more frequent in the WLI group. Sedation was performed in 28 of 223 patients (12.6 %) in the ultraslim group and 502 of

▶ Fig. 2 Consort diagram.
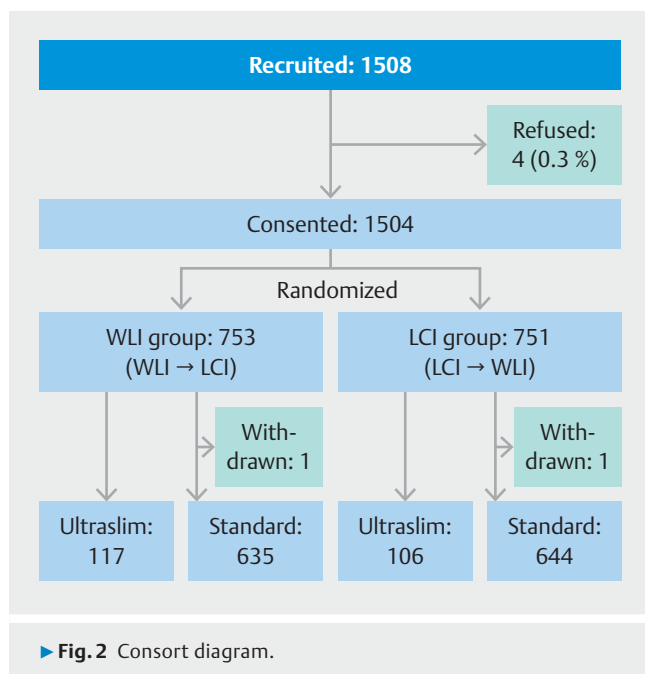
1279 patients (39.2 %) in the standard group, with a significantly higher rate in the standard group ($P < 0.001$).

Neoplastic lesions were detected in 48 of 530 patients (9.06 %) in the sedation group and 77 of 972 patients (7.92 %) in the non-sedation group, with a slight but not significant difference in the sedation group ($P = 0.447$).

▶ Fig. 3 shows the LCI and WLI endoscopic images of representative cancer lesions in the esophagus obtained by ultraslim endoscopy.

▶ Table 4 shows the numbers of neoplastic lesions and patients with neoplastic lesions detected by ultraslim endoscopy or standard endoscopy with WLI and LCI in the primary and secondary modes. The primary endpoint of the LCI-FIND trial was the percentage of patients diagnosed with a neoplastic lesion using WLI or LCI in the primary mode. Among patients who underwent ultraslim endoscopy, the corresponding percentage in primary mode was significantly higher in LCI than in WLI group; the crude risk ratio was 2.21 (95 % CI: 1.06–4.67), and the adjusted odds ratio was 2.46 (95 % CI: 1.07–5.63). In secondary mode, the percentage of patients diagnosed with a neoplastic lesion tended to be lower in LCI; the crude risk ratio was 0.28

▶ Table 2 Number of examinations for each type of endoscope by medical facility.

Facility	Ultraslim endoscope	Standard endoscope	Total
A	21	471	492
B	0	344	344
C	145	1	146
D	1	90	91
E	1	71	72
F	3	68	71
G	0	57	57
H	43	11	54
I	0	44	44
J	2	29	31
K	1	20	21
L	0	21	21
M	0	16	16
N	0	13	13
O	0	10	10
P	0	8	8
Q	6	0	6
R	0	4	4
S	0	1	1
Total	223	1279	1502

▶ Table 3 Baseline characteristics of the study subjects.

	Ultraslim endoscopy (N = 223)		Standard endoscopy (N = 1279)	
	WLI group (N = 117)	LCI group (N = 106)	WLI group (N = 635)	LCI group (N = 644)
Age	73 (66–77)	71 (67–76)	71 (66–77)	72 (66–77)
Age < 70 years	44 (37.6; 28.8–47.0)	40 (37.7; 28.5 –47.7)	255 (40.2; 36.3–44.1)	259 (40.2; 36.4–44.1)
Male	95 (81.2; 72.9–87.8)	86 (81.1; 72.4–88.1)	483 (76.1; 72.6–79.3)	496 (77.0; 73.6–80.2)
Surgical history	16 (13.7; 8.0–21.3)	13 (12.3; 6.7–20.1)	62 (9.8; 7.6–12.3)	72 (11.2; 8.9–13.9)
Current cancer	16 (13.7; 8.0–21.3)	19 (17.9; 11.2–26.6)	103 (16.2; 13.4–19.3)	102 (15.8; 13.1–18.9)
History of radiation therapy	32 (27.4; 19.5–36.4)	24 (22.6; 15.1–31.8)	56 (8.8; 6.7–11.3)	63 (9.8; 7.6–12.3)

Data are shown as medians (25 %–75 %) or numbers (percentage; 95 % confidence interval).
WLI, white-light imaging; LCI, linked color imaging.
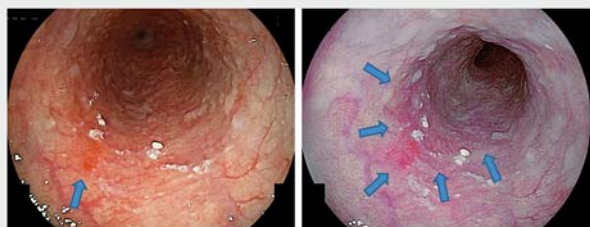
▶ **Fig. 3** Typical case of early esophageal cancer detected by ultraslim endoscopy with linked color imaging. The white light imaging image on the left shows only a slight reddening of the arrowhead area, whereas the linked color imaging on the right shows a well-defined, reddish depression, which is recognizable as a depressed early-stage esophageal cancer

(95 % CI: 0.04–2.45), and the adjusted odds ratio was 0.27 (95 % CI: 0.04–1.83). In contrast, among patients who underwent standard endoscopy, the percentage of patients diagnosed with a neoplastic lesion in primary mode was higher in LCI than in WLI; the crude risk ratio was 1.53 (95 % CI: 0.96–2.45), and the adjusted odds ratio was 1.57 (95 % CI: 0.96–2.57), while the corresponding percentage in secondary mode was significantly lower in the LCI group; the crude risk ratio was 0.18 (95 % CI: 0.07–0.49), and the adjusted odds ratio was 0.17 (95 % CI: 0.06–0.49).

▶ **Table 5** shows the number of neoplastic lesions detected in the primary mode according to location, size, and morphological type of the lesion. Among patients who underwent ultraslim endoscopy, the number of neoplastic lesions detected by LCI was greater than that detected by WLI in all cases, except for pharyngeal lesions and lesions measuring 11–20 mm, in which the number of lesions detected by WLI and LCI were comparable and diffuse lesions in which the number of detected lesions by LCI was one-third of that detected by WLI. In particular, the ability of LCI to detect esophageal lesions and depressed lesions was suggested to be higher in ultraslim endoscopy than in standard endoscopy.

▶ **Table 6** shows the number of lesions biopsied for suspicion of tumor and the number of detected tumors by location. Among patients examined by ultraslim endoscopy, the proportion of detected tumors to all biopsied lesions was higher for LCI than for WLI. The superiority of LCI was more prominent in these patients than in those examined by standard endoscopy.

Discussion

The previously reported LCI-FIND trial [15] demonstrated that LCI detected neoplastic lesions significantly better, by 1.67 times, than WLI. In this regard, the superiority of LCI to WLI in the diagnostic ability when used in ultraslim endoscopy was examined in this study. The results showed that the potential of ultraslim endoscopy with LCI was comparable to that of standard endoscopy with LCI. In particular, the results suggested that

▶ **Table 4** Patient-based results (primary results): neoplastic lesions detected using WLI and LCI in primary and secondary modes.

		Ultraslim endoscopy (N = 223)				Standard endoscopy (N = 1279)			
		WLI group (N = 117)	LCI group (N = 106)	Risk ratio	Adjusted odds ratio	WLI group (N = 635)	LCI group (N = 644)	Risk ratio	Adjusted odds ratio
Total	Patient	12 (10.3; 5.4–17.2)	19 (17.9; 11.2–26.6)	1.75 (0.90–3.42)	1.91 (0.89–4.10)	48 (7.6; 5.6–9.9)	46 (7.1; 5.3–9.4)	0.95 (0.64–1.39)	0.94 (0.62–1.43)
	Lesion	14	21	–	–	49	50	–	–
Detected by primary mode		Detected by WLI	Detected by LCI			Detected by WLI	Detected by LCI		
	Patient	9 (7.7; 3.6–14.1)	18 (17.0; 10.4–25.5)	2.21 (1.06–4.67)	2.46 (1.07–5.63)	27 (4.3; 2.8–6.1)	42 (6.5; 4.7–8.7)	1.53 (0.96–2.45)	1.57 (0.96–2.57)
	Lesion	10	20	–	–	27	46	–	–
Detected by secondary mode		Detected by LCI	Detected by WLI			Detected by LCI	Detected by WLI		
	Patient	4 (3.4; 0.9–8.5)	1 (0.9; 0.0–5.1)	0.28 (0.04–1.81)	0.27 (0.04–1.83)	22 (3.5; 2.2–5.2)	4 (0.6; 0.2–1.6)	0.18 (0.07–0.49)	0.17 (0.06–0.49)
	Lesion	4	1	–	–	22	4	–	–

Data are shown as numbers (percentages; 95 % confidence interval), ratios (95 % confidence interval), or numbers.
WLI, white-light imaging; LCI, linked color imaging
Odds ratios for the neoplastic lesions detected, obtained from a logistic regression analysis, were adjusted according to age, presence or absence of current cancer, and surgical history.

► **Table 5** Lesion-based results (descriptive results): clinicopathological features of lesions, including their number, detected in the WLI and LCI groups and endoscopic confidence prediction using WLI and LCI (only the first endoscopic procedure in each group).

		Ultraslim endoscopy		Standard endoscopy	
		Detected by WLI in the WLI group (9 patients/10 lesions)	Detected by LCI in the LCI group (18 patients/ 20 lesions)	Detected by WLI in the WLI group (27 patients/ 27 lesions)	Detected by LCI in the LCI group (42 patients/ 46 lesions)
Lesion location					
Pharynx		2 (20.0)	2 (10.0)	0 (0)	5 (10.9)
	SCC	2	2	0	5
Esophagus		6 (60.0)	13 (65.0)	4 (14.8)	5 (10.9)
	SCC	6	11	4	5
	IN	0	2	0	0
Stomach		2 (20.0)	5 (25.0)	23 (85.2)	36 (78.3)
	Adenocarcinoma	2	4	20	34
	Intestinal type	1	4	20	31
	Diffuse type	1	0	0	3
	Adenoma	0	1	3	2
Lesion size					
≤10 mm		6 (60.0)	14 (70.0)	18 (66.7)	25 (54.3)
10 to ≤20 mm		4 (40.0)	4 (20.0)	7 (25.9)	17 (37.0)
>20 mm		0 (0)	2 (10.0)	2 (7.4)	3 (6.5)
Median size (mm)		13 (7–16)	13 (9–25)	11 (7–17)	11 (8–19)
Lesion morphology					
Unidentified or untreated		0 (0)	0 (0)	0 (0)	1 (2.2)
Mass		1 (10.0)	2 (10.0)	11 (40.7)	13 (28.3)
Diffuse infiltrative		6 (60.0)	2 (10.0)	3 (11.1)	9 (20.0)
Depressed	Total	3 (30.0)	16 (80.0)	13 (48.1)	24 (52.2)

Data are shown as numbers (percentages), numbers, or medians (25%–75%).
WLI, white-light imaging; LCI, linked color imaging; SCC, squamous cell carcinoma; IN, intraepithelial neoplasia

ultraslim endoscopy would be superior to standard endoscopy in detecting esophageal and depressed lesions. Based on these findings, it seems that the results of the LCI-FIND trial can be extrapolated to examination by ultraslim endoscopy. The use of ultraslim endoscopes should be further promoted in screening and surveillance tests, considering the lower burden of this modality on patients. As the results of this study show, the sedation rate was significantly lower in the ultraslim endoscopy group than in the standard endoscopy group, and one advantage of ultraslim endoscopy is that it avoids the need for sedation.

When observing the esophagus, the procedure time tended to be longer for ultraslim endoscopy than for standard endoscopy. This may be because ultraslim endoscopy allows closer observation of the esophagus owing to the small caliber of the endoscope, which is unlikely to cause a vomiting reflex in patients. The reason for the higher detection rate of neoplastic lesions with the Ultraslim endoscopy is not clear, but it may be possible that there was a difference in detection rates between endoscopists who used it primarily on a daily basis and those who had less experience using it.

The limitations of this study are as follows. This was not a confirmatory study, but an exploratory study that was performed after completion of the main analysis. In addition, the frequency of use of ultraslim endoscopes and standard endoscopes varied greatly among medical facilities, and it is not deniable that the results of this analysis were influenced by facilities or endoscopists associated with the heavy use of ultraslim endoscopy. In this regard, an endoscopist in one facility used ultraslim endoscopy most frequently, and there was the possi-

▶ **Table 6** Proportion of detected tumors versus all lesions biopsied for the number of lesions detected and tumors in the pharynx, esophagus, and stomach with WLI and LCI.

	Ultraslim endoscopy		Standard endoscopy	
	WLI	**LCI**	**WLI**	**LCI**
Pharynx	2/5 (40.0; 5.3–85.3)	2/6 (33.3; 4.3–77.7)	0/1 (0)	5/11 (45.5; 16.8–76.6)
Esophagus	6/13 (46.2; 19.2–74.9)	13/22 (59.1; 36.4–79.3)	4/8 (50.0; 15.7–84.3)	5/17 (29.4; 10.3–56.0)
Stomach	2/13 (15.4; 1.9–45.5)	5/19 (26.3; 9.2–51.2)	23/81 (28.4; 18.9–39.5)	36/110 (32.7; 24.1–42.3)
Total	10/31 (32.3; 16.7–51.4)	20/47 (42.6; 28.3–57.8)	27/90 (30.0; 20.8–40.6)	46/138 (33.3; 25.5–41.9)

Data are shown as number of tumor lesions detected/number of lesions detected (percentage; 95% confidence interval).
WLI, white-light imaging; LCI, linked color imaging.

bility that the data obtained from this endoscopist had high influence on the overall results. However, the analysis of data excluding those from this endoscopist showed the same tendency as that observed in the present study (data not shown). Therefore, the results of this study were unlikely to be affected by the characteristics of the practice of this endoscopist. Also, the proportion of patients with previous surgical and radiotherapy was slightly higher in the group with ultraslim endoscopy.

Thus, it was apparent that the detection rate of neoplastic lesions was about two-fold higher with LCI than with WLI in ultraslim endoscopy of the upper gastrointestinal tract. Based on this finding, use of ultraslim endoscopy with LCI should be encouraged for screening tests and surveillance tests. The BLI mode is also useful in the diagnosis of neoplastic lesions. It is recommended that screening observations are made in LCI, and when a lesion is visible, close and detailed observations are made in BLI [17, 18].

Conclusions

In conclusion, an exploratory analysis of data from the LCI-FIND trial showed that LCI was very useful for identifying neoplastic lesions in the pharynx, esophagus, and stomach, even when used in ultraslim endoscopy. Therefore, it is recommended that ultraslim endoscopy with LCI be used for screening tests and surveillance tests of the upper gastrointestinal tract.

Competing interests

References

[1] Hosokawa O, Tsuda S, Kidani E et al. Diagnosis of gastric cancer up to three years after negative upper gastrointestinal endoscopy. Endoscopy 1998; 30: 669–674

[2] Hosokawa O, Hattori M, Douden K et al. Difference in accuracy between gastroscopy and colonoscopy for detection of cancer. Hepatogastroenterology 2007; 54: 442–444

[3] Suvakovic Z, Bramble MG, Jones R et al. Improving the detection rate of early gastric cancer requires more than open access gastroscopy: a five-year study. Gut 1997; 41: 308–313

[4] Fukuda H, Miura Y, Hayashi Y et al. Linked color imaging technology facilitates early detection of flat gastric cancers. Clin J Gastroenterol 2015; 8: 385–389

[5] Sun X, Dong T, Bi Y et al. Linked color imaging application for improving the endoscopic diagnosis accuracy: a pilot study. Sci Rep 2016; 6: 33473

[6] Dohi O, Yagi N, Onozawa Y et al. Linked color imaging improves endoscopic diagnosis of active Helicobacter pylori infection. Endosc Int Open 2016; 4: E800–E805

[7] Mizukami K, Ogawa R, Okamoto K et al. Objective endoscopic analysis with linked color imaging regarding gastric mucosal atrophy: a pilot study. Gastroent Res Pract 2017; 2017: 5054237

[8] Ono S, Abiko S, Kato M. Linked color imaging enhances gastric cancer in gastric intestinal metaplasia. Dig Endosc 2017; 29: 230–231

[9] Yoshifuku Y, Sanomura Y, Oka S et al. Evaluation of the visibility of early gastric cancer using linked color imaging and blue laser imaging. BMC Gastroenterol 2017; 17: 150

[10] Kanzaki H, Takenaka R, Kawahara Y et al. Linked color imaging (LCI-, a novel image-enhanced endoscopy technology, emphasizes the color of early gastric cancer. Endosc Int Open 2017; 5: E1005–E1013

[11] Sun X, Bi Y, Dong T et al. Linked color imaging benefits the endoscopic diagnosis of distal gastric diseases. Sci Rep 2017; 7: 5638

[12] Kitagawa Y, Hara T, Ikebe D et al. Magnified endoscopic observation of small depressed gastric lesions using linked color imaging with indigo carmine dye. Endoscopy 2018; 50: 142–147

[13] Ono S, Kato M, Tsuda M et al. Lavender color in linked color imaging enables noninvasive detection of gastric intestinal metaplasia. Digestion 2018; 98: 222–230

[14] Fukuda H, Miura Y, Osawa H et al. Linked color imaging can enhance recognition of early gastric cancer by high color contrast to surrounding gastric intestinal metaplasia. J Gastroenterol 2019; 54: 396–406

[15] Ono S, Kawada K, Dohi O et al. Linked color imaging focused on neoplasm detection in the upper gastrointestinal tract: a randomized trial. Ann Intern Med 2021; 174: 18–24

[16] Nakata H, Enomoto S, Maekita T et al. Transnasal and standard trans-oral endoscopies in the screening of gastric mucosal neoplasias. World J Gastrointest Endosc 2011; 3: 162–170

[17] Osawa H, Miura Y, Takezawa T et al. Linked color imaging and blue laser imaging for gastrointestinal screening. Clin Endosc 2018; 51: 513–526

[18] Shinozaki S, Osawa H, Hayashi Y et al. Linked color imaging for the detection of early gastrointestinal neoplasms. Ther Adv Gastroenterol 2019; 12: 1–10