



The efficacy of polyp detection and tumor characterization of blue laser imaging, blue light imaging, and linked color imaging with light-emitted diode (LED) and LASER endoscope

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Colonoscopic resection of adenoma is reported to reduce the colorectal cancer incidence and death (1). However, standard observation of the colorectum using white-light imaging (WLI) causes polyp miss and its rate was reported to be 22% in a systematic review (2). Additionally, lots of patients receive surveillance colonoscopy due to the recent improvement of endoscopic resection and metachronous polyps should be detected and removed (3). Various researches have been performed to decrease polyp miss rate and increase adenoma detection rate (ADR) (4). However, image-enhanced endoscopy such as narrow band imaging (NBI) and flexible intelligence color enhancement (FICE) are not enough to improve these rates.

Novel endoscopes with a light-emitted diode (LED) light source (ELUXEO: 7000 systems in the West or 6000 series in Japan; Fujifilm, Tokyo, Japan) has been marketed since 2017–2018 in the world including the U.S., Europe, and Japan (5). LED endoscopes have 410 nm-LED light and 450 nm-LED light and multi-light technology provides high-quality images with blue laser imaging (BLI) as well as linked color imaging (LCI) for narrow-band light observation (*Figure 1*) (6). BLI with or without magnification enables to detect surface pattern and vessel pattern of colorectal lesions clearly and is useful for tumor characterization. Additionally, BLI is made to improve tumor detection, making neoplastic lesions brownish. On the other hand, LCI has a bright view and makes neoplastic

lesions appear reddish and this can be useful for tumor detection.

A LASER endoscopic system (LASEREO: Fujifilm Co., Tokyo, Japan) was marketed in 2012. Two laser lights, whose wavelength are 410 and 450 nm laser lights, and fluorescent light were used in this system and LASER endoscope enable us to perform BLI and LCI (*Figure 1*) (7–10). BLI makes lesions brownish and is useful for improving tumor detection, similar to BLI with LED endoscope. We previously reported that it improved polyp visibility more than WLI using endoscopists subjective polyp visibility score using videos (10). LCI is made using with the laser lights balance of same power value to BLI. LCI makes adenomatous polyps and inflammation appear more reddish and oppositely, it makes the surrounding mucosa around the lesions more whitish. So, the contrast between lesions and surrounding mucosa becomes high and lesions can be detected easily. Additionally, LCI is brighter than NBI and BLI and the residual liquid in the colorectum becomes reddish (11). Previously, we published a report that LCI could improve the diagnostic accuracy of atrophic gastritis due to the infection of *Helicobacter pylori* (12). A study showed that LCI improved the visibility of sessile serrated adenoma and polyps (SSA/P) and adenoma using videos and pictures compared to WLI and BLI (13). Additionally, our study showed that LCI was useful for improving detectability of SSA/P and flat neoplastic lesions

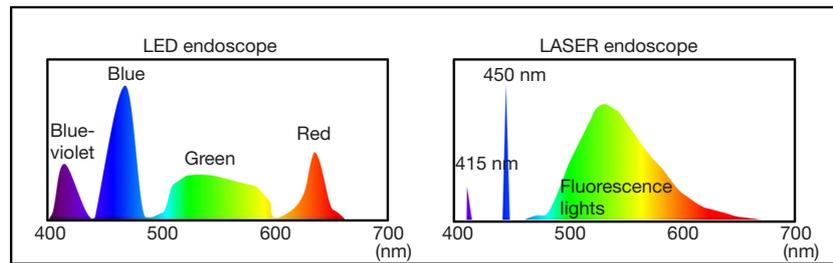


Figure 1 The comparison between LASER endoscope and LED endoscope. LED, light-emitted diode.

	Type 1	Type 2A (regular)	Type 2B (irregular)	Type 3 (destroyed)
Vessel pattern	· Invisible	· Regular caliber · Regular distribution (meshed · spiral)	· Variable caliber · Irregular distribution	· Loose vascular area · Interruption of thick vessel
Surface pattern	· Uniform dark or white spots · Similar to surrounding normal mucosa	· Regular (tubular · branched · papillary)	· Irregular or unclear	· Amorphous
Typical predicted pathology	Hyperplastic polyp	Adenoma with low grade dysplasia	High grade dysplasia	Deeply invasive T1 cancer

Figure 2 JNET classification for BLI magnification of LED endoscope (setting: EP-6000, EC-6600ZP). JNET, Japan NBI Expert Team; BLI, blue laser imaging; LED, light-emitted diode.

using endoscopic pictures (11). Moreover, our recent multicenter study proved the color difference (CD) value as an objective indicator of adenoma for LCI was significantly higher than BLI (14). Oppositely, the CD value of SSA/P was significantly higher in BLI than LCI. LCI also kept polyp visibility better than BLI and WLI, even with a 1.5-time faster withdrawal speed for observation than usual. We suggest this probably leads to faster observation and better polyp detection.

Regarding tumor characterization, NBI is used regularly in the world. Narrow-band imaging international colorectal endoscopic (NICE) classification is used for NBI without magnification and Japan NBI Expert Team (JNET) classification is used for NBI with magnification (15,16). We previously reported NBI classification can be used for

BLI of LASER endoscope with magnification comparing the difference between NBI magnification and BLI magnification (8). Thus, NICE and JNET classification can be used for BLI magnification both of LASER and LED endoscope (Figure 2). We introduce the details described as follows. In the JNET classification, both vessel pattern and surface pattern have to be diagnosed. Type 1 indicates hyperplastic polyp (HP) and SSA/P; type 2A adenoma; type 2B high grade dysplasia, and type 3 T1b (Figure 3). Regarding SSA/P, dilated crypts and vessels are useful for BLI magnification of LASER and LED endoscopes to differentiate SSA/P from HP according to a previous paper though it was reported for NBI magnification (Figure 4) (17).

Recently, lots of reports have shown the efficacy of BLI and LCI in polyp detection (Table 1) (18-24). We

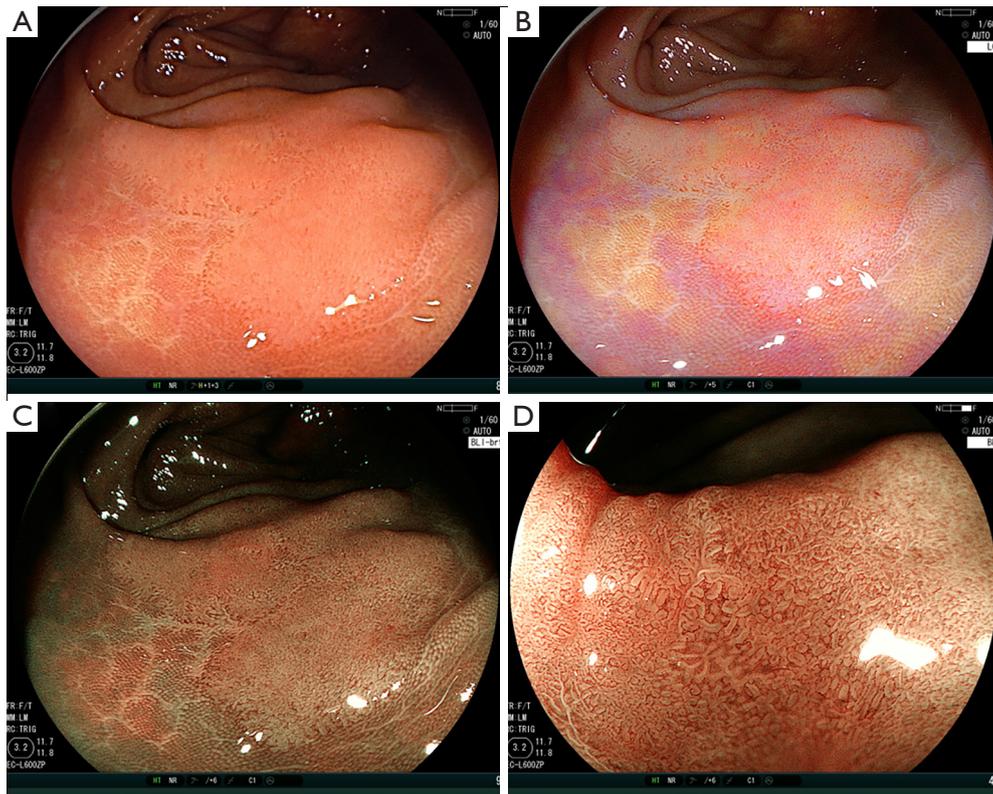


Figure 3 A case presentation of LASER endoscope with linked color imaging (LCI) and blue laser imaging (BLI). (A) White light imaging. Non-polypoid lesion, 20 mm, Transvers colon. High-grade dysplasia; (B) LCI improves tumor detectability; (C) BLI improves tumor detectability; (D) BLI with magnification showed irregular pattern as JNET type 2B. JNET, Japan NBI Expert Team.

previously reported the efficacy of BLI for polyp detection in a multicenter study. It showed polyp number in BLI was significantly more than WLI and another study showed BLI improved polyp miss rate for right-sided colon (18,19). However, residual liquid is reddish in BLI and it makes endoscopic views darker. A randomized control trial (RCT) with LASER endoscope from China in tandem endoscopy proved that LCI increased sensitivity of polyp detection for the whole colorectum more than WLI (LCI *vs.* WLI: 73% *vs.* 91%, $P < 0.001$) (20). A single-center RCT with LASER endoscope from Japan using a tandem endoscopy setting showed the SSA/P miss rate in WLI was significantly higher than that in LCI (21.6% *vs.* 3.2%, $P = 0.02$) (21). Additionally, a single-center RCT from Italy with LED endoscope showed LCI improved polyp miss rate significantly more than WLI in the right-sided colon (cecum and ascending colon) (11.8% *vs.* 30.8%, $P < 0.001$) (22). Furthermore, we previously reported that an additional 30-second observation for the cecum and

ascending colon with LCI after initial WLI observation in LASER endoscope improved adenoma and SSA/P detection rate more than additional WLI observation after initial WLI observation (18.5% *vs.* 6.2%, $P = 0.03$) (23). A recent tandem RCT of LASER endoscope from Brazil about WLI, BLI, and LCI showed ADR of them were 43.2% *vs.* 54.0% *vs.* 56.9%, (LCI *vs.* WLI, $P = 0.03$) (24). From the above points, we suggest LCI can be an appropriate tool for routine colonoscopic examination though there have been only limited reports from the limited area. However, we suggest LCI has a demerit about halation in an endoscopic observation because of its strong brightness, although this has not been analyzed before. Another possible demerit of LCI is about detectability of SSA/P. Because our previous multicenter study using an objective indicator using CD values showed the value for SSA/P about LCI was inferior than that about BLI in LASER endoscope (17.2 ± 7.5 *vs.* 20.2 ± 9.2 , $P = 0.04$) (14). Further studies should be performed to prove and improve these points.

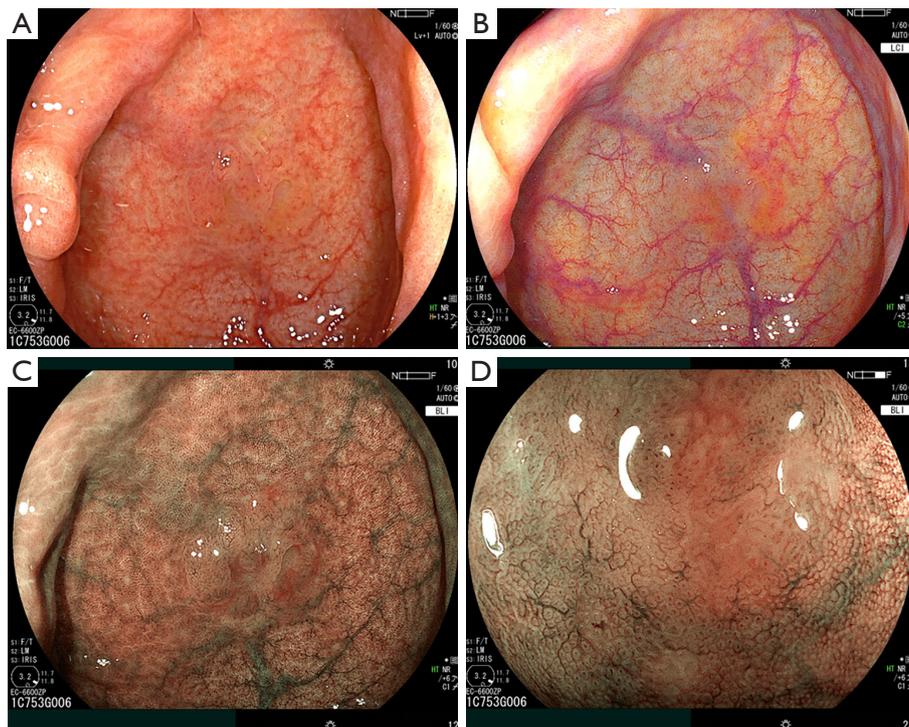


Figure 4 A case presentation of LED endoscope linked color imaging (LCI) and blue laser imaging (BLI). (A) White light imaging. Non-polypoid lesion, 10 mm, Cecum. High-grade adenoma; (B) LCI improves tumor detectability; (C) BLI improves tumor detectability; (D) BLI with magnification showed dilated crypts and dilated vessels. LED, light-emitted diode.

Table 1 Reports about tumor detection for BLI and LCI in LED and LASER endoscope

Author	System	Setting	No. of cases	Indicator	Main results
Ikematsu H, <i>et al.</i>	LASER	RCT, WLI vs. BLI	963	Polyp number per patient from the cecum to hepatic flexure	WLI vs. BLI: 1.43 ± 1.64 vs. 1.84 ± 2.09 ($P=0.01$)
Shimoda R, <i>et al.</i>	LASEER	RCT, WLI vs. BLI	127	Adenoma miss rate in tandem endoscope for the right sided colon	WLI vs. BLI: 10.0 vs. 1.6 ($P=0.001$)
Min M, <i>et al.</i>	LASER	RCT, WLI vs. LCI	141	Sensitivity of polyp detection in tandem endoscope for the whole colorectum	Sensitivity of WLI vs. LCI: 73% vs. 91% ($P<0.001$)
Fujimoto D, <i>et al.</i>	LASER	RCT, WLI vs. LCI	44	SSA/P miss rate in tandem endoscope from the cecum to splenic flexure	WLI vs. LCI: 21.6% vs. 3.2% ($P=0.02$)
Paggi S, <i>et al.</i>	LED	RCT, WLI vs. LCI	600	Polyp miss rate in tandem endoscope for the right-sided colon	WLI vs. LCI: 30.8% vs. 11.8% ($P<0.001$)
Yoshida N, <i>et al.</i>	LASER	Parallel, WLI vs. LCI	130	Adenoma and SSA/P detection rate with additional 30 secs observation to the right sided colon	WLI vs. LCI: 6.2% vs. 18.5% ($P=0.03$)
Oliveira Dos Santos CE, <i>et al.</i>	LASER	Tandem RCT, WLI vs. LCI vs. BLI	379	ADR for the whole colorectum	WLI vs. BLI vs. LCI: 43.2% vs. 54.0% vs. 56.9% (LCI vs. WLI, $P=0.03$)

BLI, blue laser imaging; LCI, linked color imaging; RCT, randomized control trial; WLI, white-light imaging; SSA/P, sessile serrated adenoma and polyps; ADR, adenoma detection rate.

In this editorial, we introduced the update of BLI and LCI for tumor characteristics and tumor detection in LASER endoscope and LED endoscope.

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Footnote

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