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Optical diagnosis of colorectal polyps with Blue Light Imaging using a new international classification

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Abstract

Background: Blue Light Imaging (BLI) is a new imaging technology that enhances mucosal surface and vessel patterns. A specific BLI classification was recently developed to enable better characterisation of colorectal polyps (BLI Adenoma Serrated International Classification (BASIC)). The aim of this study was to validate the diagnostic performance of BASIC in predicting polyp histology in experienced and trainee endoscopists.

Methods: Five experienced and five trainee endoscopists evaluated high-definition white light (HDWL) and BLI images from 45 small polyps to assess baseline accuracy, sensitivity, specificity, and positive and negative predictive values (NPVs) of polyp histology. Each endoscopist was trained with the BLI classification before repeating the exercise. Results were compared pre- and post-training.

Results: The overall pre-training accuracy improved from 87% to 94%. The sensitivity and NPV of adenoma diagnosis also improved significantly from 79% to 96% and 81% to 95% with BASIC training. This improvement was noted in both groups. The interobserver level of agreement was very good ($K = 0.90$) in the experienced cohort and good ($K = 0.66$) in the trainee group post-training.

Conclusions: BLI is a useful tool for optical diagnosis, and the use of BASIC with adequate training can significantly improve the accuracy, sensitivity and NPV of adenoma diagnosis.

Keywords

Adenoma, Blue Light Imaging, classification, colorectal polyps, optical diagnosis

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Key summary

1. Summarise the established knowledge on this subject:
   - Accurate optical diagnosis of polyps may allow endoscopists to 'resect and discard' polyps with no malignant potential.
   - Advanced endoscopic imaging technologies can facilitate polyp characterisation by enhancing mucosal pit and vessel patterns.
   - Blue Light Imaging (BLI) is a new technology with a unique classification that has not yet been validated.
2. What are the significant and/or new findings of this study?
   - BLI improved the optical diagnostic performance in a range of endoscopists when compared to high-definition white light.
   - Experienced and inexperienced endoscopists alike could be trained to achieve high levels of accuracy, sensitivity and negative predictive value >90% using a bespoke classification.

Introduction

The pathway to development of cancer from adenomas is well recognised.[1] Therefore, detection and removal of adenomas can reduce the risk of colorectal cancer.[2–4] Various enhanced-imaging technologies have been developed to improve recognition of neoplastic lesions such as Narrow Band Imaging (NBI; Olympus, Tokyo, Japan), i-SCAN (Pentax, Tokyo, Japan) and Flexible Spectral Imaging Colour Enhancement (FICE; Fujifilm, Tokyo, Japan). The American Society for Gastrointestinal Endoscopy (ASGE) Preservation and Incorporation of Valuable Endoscopic Innovations (PIVI) initiative recommends that a technology achieve a threshold of 90% or greater negative predictive value (NPV) for adenomatous histology to guide the decision to leave suspected diminutive rectosigmoid hyperplastic polyps (HPs) in place.[5] A recent meta-analysis calculating the pooled NPV of NBI, i-SCAN and FICE optical biopsy for predicting adenomatous histology showed that the NPV for NBI exceeded 90% (91%; 95% confidence interval (CI): 88% to 94%). This effect was pronounced in academic centres with experts.[6]

Blue Light Imaging (BLI; Fujifilm, Tokyo, Japan) is a new technology based on the direct emission of blue light with a short (410 nm) wavelength that is selectively absorbed by haemoglobin. Four individual light-emitting diodes are used to create bright, high-contrast imaging. This may improve optical diagnosis and adenoma detection.[7,8–10] A suitable system of education and training in real-time diagnostics will need to be developed to enable endoscopists to characterise polyps accurately enough to implement a resect and discard strategy. Previous studies on training using NBI have shown diagnostic accuracy rates ranging from 81% to 90% among endoscopists of different experience levels following computer-based training.[11–13]

In vivo characterisation of polyps has been based on vascular and mucosal surface pit patterns. The NBI International Colorectal Endoscopic (NICE) classification was developed to differentiate between neoplastic and non-neoplastic polyps on NBI.[14] However, a recent study demonstrated that NICE did not work optimally when used for optical diagnosis using a different technology (FICE).[15]

Therefore, a new bespoke classification system for differentiating among HPs, sessile-serrated and adenomatous polyps using BLI was recently developed.[16] This classification (BLI Adenoma Serrated International Classification (BASIC)) incorporates the polyp morphology (surface) as well as pit and vessel characteristics. This has not been validated for clinical use.

The aim of our study was to develop a simple training module and validate this novel BLI classification in a group of experienced and trainee endoscopists.

Methods

Image library

The images for this study were obtained from elective outpatient colonoscopies performed between December 2016 to February 2017 with Fujifilm colonoscope series ELUXEO TM 7000 (ELUXEO, VP-7000, BL-7000; Fujifilm, Tokyo, Japan) in three institutions (Portsmouth, Milan and Rome). All patients consented for the polyp images from their procedure to be used anonymously for educational purposes. For each polyp, a paired non-magnification, high-definition white light (HDWL) and BLI image was stored. The size, location and morphology (Paris classification)[17] of the polyps were recorded. All polyps were resected and sent for histopathological examination. The histopathologist was not aware of the endoscopic optical diagnostic characteristics for each polyp and classified the polyp histology according to the revised Vienna

classification.[18] The histopathological diagnosis was used as the gold-standard true diagnosis.

Only high-quality and clear images of small (6–9 mm) and diminutive (1–5 mm) colorectal polyps were selected by one research fellow (S.S.) experienced in optical diagnosis. An equal number of adenomas and HPs were selected. Sessile-serrated polyps and poor-quality images were excluded.

Training module

Fifteen polyps (equally split by subtype) were used in the development of the training module. These images were not used in the testing. Microsoft PowerPoint (Microsoft Corporation, Redmond, WA, USA) was used as the training platform. The training module was delivered by an expert endoscopist (P.B.) and experienced research fellow in a face-to-face session. The module was structured as follows:

- Overview of the importance of endoscopic polyp characterisation to facilitate the recognition of HPs with high confidence that may be suitable for the resect and discard strategy.
- Review of ASGE PIVI thresholds.
- Evolution of advanced-imaging technology and BLI mode of action.
- Explanation of the individual descriptors used for BASIC including distinguishing between pseudodepression and truly depressed (i.e. Paris IIC)[17] morphology.
- Algorithm for differentiation between polyp histological types using BASIC (Figure 1).
- Presentation of BLI images with illustration on the surface, pit and vessel pattern descriptors to formulate a diagnosis (Figure 2).

Direct feedback was given to the endoscopists during the session with emphasis on the interpretation of mucosal surface and vessel patterns using the training set. This was run as an in-training quiz with explanations provided on the correct use of BASIC descriptors.

Study participants

Two groups of five participants were involved. The first group consisted of five endoscopists who were experienced in using NBI for polyp characterisation during colonoscopy but had limited (<6 months) experience in BLI with no formal training in optical diagnosis. They had all performed >1000 colonoscopies.

The second group was made up of five gastroenterology trainees with minimal colonoscopy experience (<400 procedures) and no experience or training in any advanced endoscopic imaging.

Study phases

The study incorporated a pre- and post-training phase. In both phases, the diagnostic performance was assessed for each modality and each participant group by calculating the sensitivity, specificity, positive

BASIC Algorithm					
		HYPERPLASTIC	ADENOMA	SESSILE SERRATED	CANCER
SURFACE	Mucus present	No	No	Yes	No
	Regular (smooth) or irregular	Regular	Regular/ irregular	Regular/ irregular	Irregular
	Pseudodepression	No	Yes	No	No
	Depression	No	No	No	Yes
PITS	Featureless?	Yes	No	No	No
	Type (round/not round)	Round pits	Not round (e.g tubular)	Round pits with/without dark spots	Round or non round
	Distribution (regular = homogenous/ irregular = heterogenous - >1 pit pattern)	Homogenous	Homogenous or heterogenous without focal loss	Homogenous/ heterogenous	Heterogenous with focal loss
VESSELS	Present?	Yes or no	Yes	Yes or no	Yes
	Type	Lacy	Pericryptal	Pericryptal	Irregular

Figure 1. Proposed algorithm to utilise Blue Light Imaging Adenoma Serrated International Classification (BASIC).

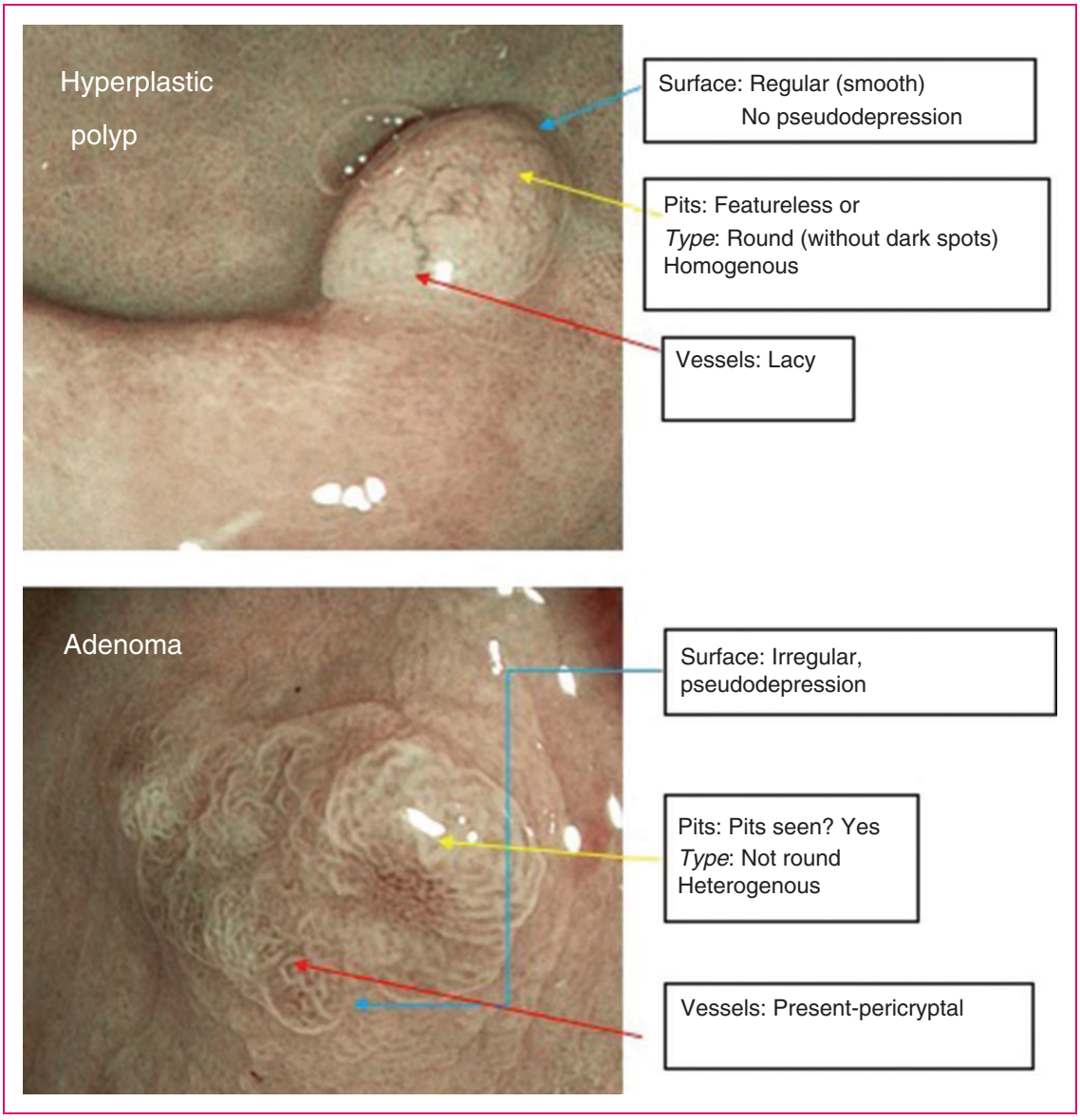

Figure 2. Illustrative polyp images included in training module to identify Blue Light Imaging Adenoma Serrated International Classification (BASIC) descriptors.

predictive value (PPV), NPV and accuracy with corresponding CIs.

Phase 1. The aim of this phase was to assess the baseline performance of both groups. Each group was shown separately a set of 45 non-magnified HDWL and BLI images (consisting of 23 adenomas and 22 HPs). The polyps were arranged randomly and participants were blinded to the proportion of histological subtypes, location, morphology and size of polyps in the set. The participants recorded the endoscopic diagnosis and level of confidence (high/low). Participants selected the high confidence option if they were at least 90% certain. No feedback on diagnostic accuracy was given following this phase.

Phase 2. This phase of the study was conducted three months following Phase 1 to minimise recall bias. All participants underwent face-to-face training session in the use of BASIC as previously described. The participants were then tested on the same 45-polyp image library presented in a different random order to the pre-training set. All participants were still blinded to the polyp characteristics as before. They rated each image using the BASIC descriptors and scored their

level of confidence. Feedback on diagnostic accuracy was supplied following this phase.

In Phases 1 and 2, participants viewed the images on site using a high-definition screen and test conditions (discussion between the participants to reach a diagnosis was not permitted).

Ethical approval

This was an image-based, non-interventional endoscopic evaluation study with no patient identifiable data collected. Institutional review board approval was obtained (ICH 477/16, 1 December 2016) and the study was carried out in accordance with the 1975 Declaration of Helsinki.

Statistical analysis

The study was powered on the assumption that there would be a difference of 10% in diagnostic accuracy between the pre- and post-training tests. Using a power of 80% with 5% significance level, 200 observations were required in each phase. By recruiting five participants for each group, we generated 225 observations per group (450 in total), which satisfied the power calculations. All data were collected in Microsoft Excel (Microsoft Corporation, Redmond, Washington USA). Stata version 15.1 (StataCorp, College Station, TX, USA) was used for statistical analysis. To allow for the non-independence of the data, a bootstrapping approach was used to calculate CI for the differences between modalities. Multilevel logistic regression was used for the analysis.

The interobserver agreement between users pre- and post-training was made using the kappa statistic. A bootstrapping approach was used to calculate CI around the calculated value at each time point and also to compare between time points.

Results

The results are presented in a per-protocol fashion. There were no missing data and all ratings were included in the analysis. Table 1 shows the baseline characteristics of the 45 polyps included in the test phases. The proportions of adenomas and HPs were roughly equal (51.1% and 48.9%) with a majority (75%) deemed diminutive.

Table 1. Characteristics of polyps included in the study.

Polyp characteristics		*N* (%)
Size	1–5 mm	34 (75.6%)
	6–9 mm	11 (24.4%)
Location	Rectum	13 (28.9%)
	Sigmoid	15 (33.3%)
	Descending colon	7 (15.5%)
	Transverse colon	4 (8.9%)
	Ascending colon	3 (6.7%)
	Caecum	3 (6.7%)
Morphology (Paris classification)	0-IIa	23 (51.1%)
	0-IIb	10 (22.2%)
	0-Is	12 (26.7%)
Histology	Adenoma	23 (51.1%)
	Hyperplastic polyp	22 (48.9%)

Phase 1 results

Table 2 shows the performance of both groups on HDWL compared to BLI. The greatest improvement in sensitivity using BLI was observed in the experienced group (69% on HDWL, 95% CI: 60% to 77% vs 79% on BLI, 95% CI: 69% to 85%, $p = 0.02$). The proportion of high confidence predictions increased significantly in both groups when BLI was used (from 52% to 71% in the experienced cohort and 40% to 67% in the inexperienced group). When the results for both groups were combined, similar patterns were observed with increased sensitivity and high confidence with BLI, but no difference noted in the other parameters.

When a subgroup analysis was performed stratifying results according to confidence level, the performance of BLI improved further (albeit not reaching statistical significance) as sensitivity and NPV reached 85% with corresponding accuracy rates of 90% (Table 3).

Phase 2 results (pre- vs post-training)

HDWL. Table 4 shows the results of the pre- and post-training analysis using 45 HDWL images. When only experienced endoscopists are considered in the analysis, there was a highly significant improvement in the diagnostic sensitivity (from 69%, 95% CI: 60% to 77%, to 83%, 95% CI: 76% to 89%) and accuracy (from 83%, 95% CI: 78% to 87%, to 90%, 95% CI: 87% to 94%) following training. In the trainee group, smaller, non-statistically significant improvements were noted in sensitivity (75% to 84%), NPV (79% to 84%) and accuracy (86% to 87%). Notably, the specificity dropped in this group (97% to 89%), reflective of an increase in the false-positive rate of adenoma predictions.

BLI. The same analysis was carried out on the 45 BLI images assessed pre- and post-training (Table 5). The results for experienced raters suggested a much higher

Table 2. Polyp diagnosis using HDWL and BLI in experienced and trainee groups.

Variable	HDWL % (95% CI)	BLI % (95% CI)	Odds ratio[a] (95% CI)	*p* value
Experienced group				
Sensitivity	69 (60, 77)	79 (69, 85)	2.52 (1.14, 5.59)	**0.02**
Specificity	97 (92, 99)	95 (90, 99)	0.43 (0.10, 1.99)	0.28
PPV	96 (93, 100)	94 (90, 98)	0.58 (0.14, 2.38)	0.45
NPV	75 (69, 83)	81 (73, 88)	1.46 (0.81, 2.61)	0.21
Accuracy	83 (78, 87)	87 (82, 91)	1.70 (0.86, 3.38)	0.13
High confidence	52 (45, 58)	71 (65, 77)	2.80 (1.77, 4.43)	<**0.001**
Trainee group				
Sensitivity	75 (67, 82)	79 (70, 85)	1.43 (0.68, 3.02)	0.35
Specificity	97 (93, 98)	96 (93, 99)	0.72 (0.15, 3.56)	0.69
PPV	97 (91, 99)	96 (89, 98)	0.79 (0.17, 3.65)	0.77
NPV	79 (72, 87)	82 (74, 88)	1.20 (0.65, 2.19)	0.56
Accuracy	86 (81, 91)	88 (83, 92)	1.26 (0.65, 2.48)	0.49
High confidence	40 (35, 48)	67 (60, 72)	2.95 (2.01, 4.33)	<**0.001**
All				
Sensitivity	72 (64, 77)	79 (72, 84)	1.87 (1.09, 3.20)	**0.02**
Specificity	97 (94, 99)	95 (92, 98)	0.55 (0.19, 1.64)	0.29
PPV	96 (92, 98)	95 (91, 97)	0.66 (0.24, 1.86)	0.43
NPV	77 (71, 81)	81 (77, 86)	1.33 (0.87, 2.02)	0.18
Accuracy	84 (81, 88)	87 (84, 90)	1.46 (0.91, 2.35)	0.12
High confidence	46 (42, 50)	69 (64, 73)	2.70 (2.03, 3.58)	<**0.001**

BLI: Blue Light Imaging; CI: confidence interval; HDWL: high-definition white light; NPV: negative predictive value; PPV: positive predictive value.

Table 3. Polyp diagnosis on HDWL and BLI according to level of confidence in prediction.

Variable	HDWL % (95% CI)	BLI % (95% CI)	Odds Ratio[a] (95% CI)	*p* value
High confidence				
Sensitivity	81 (73, 89)	85 (78, 90)	2.32 (0.9, 5.83)	0.07
Specificity	97 (93, 98)	97 (94, 99)	0.95 (0.19, 4.70)	0.95
PPV	96 (92, 100)	97 (92, 98)	1.00 (0.23, 4.32)	0.99
NPV	85 (76, 89)	85 (79, 90)	1.02 (0.54, 1.96)	0.95
Accuracy	89 (86, 94)	90 (87, 94)	1.84 (0.84, 4.05)	0.13
Low confidence				
Sensitivity	64 (56, 73)	65 (55, 79)	1.15 (0.57, 2.34)	0.70
Specificity	97 (95, 100)	93 (84, 97)	0.40 (0.08, 1.98)	0.26
PPV	96 (88, 99)	90 (81, 98)	0.31 (0.07, 1.38)	0.13
NPV	71 (63, 78)	75 (66, 83)	1.27 (0.71, 2.23)	0.42
Accuracy	80 (74, 84)	80 (76, 87)	1.11 (0.56, 5.72)	0.61

BLI: Blue Light Imaging; CI: confidence interval; HDWL: high-definition white light; NPV: negative predictive value; PPV: positive predictive value.

sensitivity post-training compared to pre-training, with an increase from 79% to 97% ($p < 0.001$). There was also an increase in NPV, accuracy and results made with high confidence post-training. There was no change in either specificity or PPV, but these were already high pre-training.

Sensitivity (79% to 94%, $p = 0.002$) and high confidence results (67% to 80%, $p < 0.001$) also increased

Table 4. Pre- and post-training results in experienced and trainee groups using HDWL.

Variable	Pre-training % (95% CI)	Post-training % (95% CI)	Odds ratio[a] (95% CI)	*p* value
Experienced group				
Sensitivity	69 (60, 77)	83 (76, 89)	3.35 (1.37, 8.16)	**0.008**
Specificity	97 (92, 99)	98 (94, 99)	1.48 (0.23, 9.57)	0.68
PPV	96 (93, 100)	98 (95, 100)	1.80 (0.29, 11.1)	0.52
NPV	75 (69, 83)	84 (7 9, 90)	1.82 (0.99, 3.33)	0.05
Accuracy	83 (78, 87)	90 (87, 94)	2.40 (1.25, 4.59)	**0.008**
High confidence	52 (45, 58)	75 (69, 80)	3.26 (2.08, 5.11)	<**0.001**
Trainee group				
Sensitivity	75 (67, 82)	84 (70, 85)	2.03 (0.94, 4.38)	0.07
Specificity	97 (93, 98)	89 (83, 95)	0.22 (0.06, 0.84)	**0.03**
PPV	97 (91, 99)	89 (83, 94)	0.28 (0.08, 1.03)	0.06
NPV	79 (72, 87)	84 (78, 90)	1.48 (0.77, 2.82)	0.24
Accuracy	86 (81, 91)	87 (82, 90)	1.09 (0.61, 1.94)	0.77
High confidence	40 (35, 48)	31 (24, 37)	0.57 (0.36, 0.90)	**0.02**
All				
Sensitivity	72 (64, 77)	83 (78, 87)	2.53 (1.40, 4.61)	**0.002**
Specificity	97 (94, 99)	94 (90, 97)	0.41 (0.16, 1.09)	0.08
PPV	96 (92, 98)	93 (89, 96)	0.50 (0.19, 1.33)	0.16
NPV	77 (71, 81)	84 (80, 89)	1.64 (1.06, 2.57)	**0.03**
Accuracy	84 (81, 88)	88 (85, 92)	1.55 (1.01, 2.37)	**0.04**
High confidence	46 (42, 50)	53 (48, 58)	1.43 (1.05, 1.94)	**0.02**

CI: confidence interval; HDWL: high-definition white light; NPV: negative predictive value; PPV: positive predictive value.

Table 5. Pre- and post-training results in experienced and trainee groups using BLI.

Variable	Pre-training % (95% CI)	Post-training % (95% CI)	Odds ratio[a] (95% CI)	*p* value
Experienced group				
Sensitivity	79 (69, 85)	97 (94, 100)	17.1 (3.65, 79.8)	<**0.001**
Specificity	95 (90, 99)	96 (94, 99)	2.47 (0.43, 14.2)	0.31
PPV	94 (90, 98)	97 (92, 100)	1.85 (0.51, 6.74)	0.35
NPV	81 (73, 88)	97 (93, 99)	8.15 (2.38, 27.9)	**0.001**
Accuracy	87 (82, 91)	97 (95, 100)	7.26 (2.72, 19.4)	<**0.001**
High confidence	71 (65, 77)	88 (83, 91)	3.46 (2.04, 5.89)	<**0.001**
Trainee group				
Sensitivity	79 (70, 85)	94 (90, 98)	5.49 (1.89, 15.9)	**0.002**
Specificity	96 (93, 99)	87 (79, 92)	0.29 (0.08, 0.81)	**0.02**
PPV	96 (89, 98)	89 (80, 93)	0.34 (0.11, 1.07)	0.06
NPV	82 (74, 88)	93 (86, 97)	3.10 (1.28, 7.53)	**0.01**
Accuracy	88 (83, 92)	91 (85, 93)	1.44 (0.76, 2.71)	0.26
High confidence	67 (60, 72)	80 (76, 86)	4.00 (2.10, 7.62)	<**0.001**
All				
Sensitivity	79 (72, 84)	96 (92, 97)	8.44 (3.48, 20.4)	<**0.001**
Specificity	95 (92, 98)	92 (86, 95)	0.54 (0.23, 1.26)	0.15
PPV	95 (91, 97)	92 (89, 95)	0.67 (0.30, 1.49)	0.33
NPV	81 (77, 86)	95 (92, 98)	4.62 (2.27, 9.38)	<**0.001**
Accuracy	87 (84, 90)	94 (92, 96)	2.61 (1.55, 4.38)	<**0.001**
High confidence	69 (64, 73)	84 (81, 88)	3.73 (2.48, 5.62)	<**0.001**

BLI: Blue Light Imaging; CI: confidence interval; NPV: negative predictive value; PPV: positive predictive value.

post-training in the trainee group. However, increases in sensitivity were offset by a significant decrease in specificity (96% pre-training to 87% post-training, $p = 0.02$). There was no change in overall accuracy between time periods.

When all raters were combined, there was a significant increase in sensitivity, NPV, accuracy and high confidence results ($p < 0.001$).

A subgroup analysis of high confidence predictions for all endoscopists on BLI images pre- and post-training showed an increase from 69% to 84% ($p < 0.001$). There was a significant improvement in sensitivity (85% to 97%, $p < 0.001$), NPV (85% to 96%, $p = 0.002$) and accuracy (90% to 96%, $p = 0.006$).

Interobserver agreement. The diagnostic agreement using BASIC on BLI images among experienced endoscopists showed an increase in the level of agreement from 0.67 (95% CI: 0.55 to 0.80) pre-training to 0.90 (95% CI 0.82 to 0.98) post-training ($p = 0.003$). There was no significant change between time points for the trainee endoscopists ($K = 0.66$ pre- and post-training). See Table 6.

Discussion

This study has shown that endoscopists with different levels of experience can be trained using a bespoke classification (BASIC) to achieve high levels of optical diagnostic accuracy (94%), sensitivity (96%) and NPV (95%) to differentiate between neoplastic and non-neoplastic polyps using a novel BLI technology.

In Phase 1 (baseline comparison between HDWL and BLI), there was a small improvement in sensitivity and NPV using BLI. The high degree of brightness and contrast on the HDWL image alone may account for its relatively good performance and therefore less incremental gain using BLI. Because BLI was a new tool for the endoscopists, we did not anticipate that there would be a significant difference between HDWL and BLI results without any training. The baseline performance of the experienced group was not significantly better than the trainees and, in fact, displayed a lower pre-training sensitivity on HDWL (69%) with high specificity. This may allude to inherent preconceived decisions on polyp diagnosis in experienced endoscopists who were also exposed to other technologies (NBI). The low sensitivity could also be a result of less risk-averse behaviour with fewer adenoma predictions resulting in a higher false-negative rate. It was evident that although BLI showed potential in improving optical diagnosis, both groups were unable to utilise it optimally to implement the resect and discard strategy.

However, upon implementation of face-to-face training using BASIC, the optical diagnostic parameters using BLI in both groups of endoscopists improved significantly, surpassing 90% in sensitivity, NPV and accuracy. These improvements were greater in the experienced cohort with no decrease in specificity. BASIC training allowed this group to adapt prior optical diagnostic knowledge and apply it to BLI images, achieving thresholds that would meet PIVI criteria. Furthermore, they achieved a very good level of agreement in their responses. Inexperienced endoscopists applying BASIC post-training also achieved high sensitivity and NPV for adenoma diagnosis. Similar results have been demonstrated in studies of trainees taught to interpret NBI for which accuracy or NPV of >90% for adenomatous histology was achieved.[19,20] In our cohort, this was offset by a significant decrease in specificity (i.e. HPs were mistaken for adenomas) reflective of the degree of caution that inexperienced endoscopists may have in predicting HPs with high confidence. However, the learning curve of virtual chromoendoscopy is likely to improve over time with practice, as shown in a previous study in which accuracy rates of 94.3% were obtained when at least 89 polyp images had been viewed.[21] The sustainability of optical diagnosis results should also be reinforced by standardised and ongoing training.[22]

Training in BASIC also led to significant improvement in HDWL predictions, with overall sensitivity reaching 83%, NPV 84% and accuracy 88%. We believe that this is partly due to the unique surface morphology feature incorporated into the classification and the training delivered, which allowed the endoscopists to develop a structured method of distinguishing polyps.

Table 6. Interobserver agreement on BLI.

Observer group	Pre-training Kappa (95% CI)	Post-training Kappa (95% CI)	Difference[a] (95% CI)	*p* value
Experienced	0.67 (0.55, 0.80)	0.90 (0.82, 0.98)	0.23 (0.08, 0.38)	**0.003**
Trainee	0.66 (0.54, 0.79)	0.66 (0.52, 0.79)	0.00 (−0.19, 0.18)	0.97
All observers	0.68 (0.57, 0.79)	0.77 (0.69, 0.86)	0.09 (−0.04, 0.23)	0.18

BLI: Blue Light Imaging; CI: confidence interval.

While the use of BLI before training increased the cohort's confidence level, the adoption of BASIC further improved the proportion of high confidence BLI predictions from 69% to 84%. This encouraging finding lends weight to the importance of a structured training module with direct feedback to enhance the learning effect when using a novel technology. Nevertheless, we still have some way to go before optical diagnosis can be recommended for use in routine practice. A large multicentre study (DISCARD 2) demonstrated that optical diagnosis using NBI cannot currently be recommended for use outside academic medical centres because diagnostic accuracy parameters were low.[23]

Our study has several limitations. Primarily, it did not incorporate real-time in vivo characterisation of polyps. We used still images rather than videos to simulate real-life colonoscopy and the majority of endoscopists captured a still image when encountering a polyp to photograph and analyse its surface and vessel patterns without interference from movement artefact. The proportion of adenomatous histology in this cohort was higher than in an average surveillance population to validate both dichotomous responses though it is important to note that all participants were blinded to the proportion of histology. We did not include sessile-serrated polyps although BASIC does incorporate its descriptors because the overall prevalence is low in the general population and the training focus was on differentiating between adenomas and HPs. We used the same set of images both pre- and post-training but mitigated the effect of any recall bias by introducing a time gap between both phases in the study (three months) and assigning a different random order to the images in the post-training phase as well as keeping the endoscopists blinded to the true polyp histology until both phases were completed.

In conclusion, we have demonstrated that BLI is a useful tool in optical diagnosis of small and diminutive colorectal polyps and its utility can be improved by training and adoption of a recently developed bespoke classification system (BASIC). This study is the first validation of the only existing colorectal polyp classification for BLI. The overall post-training NPV of 93% and 97% respectively both in experienced and inexperienced endoscopists reaches the PIVI threshold for optical diagnosis. However, these results need to be validated in a prospective, multicentre, real-time, in vivo optical characterisation study before any recommendation can be made on its widespread adoption.

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Declaration of conflicting interests

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Ethical approval

Institutional review board approval was obtained (ICH 477/16, 1 December 2016) and the study was carried out in accordance with the 1975 Declaration of Helsinki.

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Informed consent

All patients consented for the polyp images from their procedure to be used anonymously for educational purposes.

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