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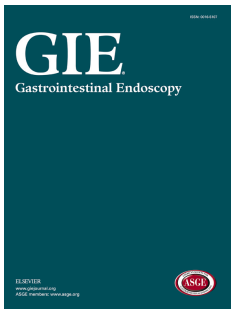

Validation of a new optical diagnosis training module to improve dysplasia characterization in inflammatory bowel disease: a multicenter international study

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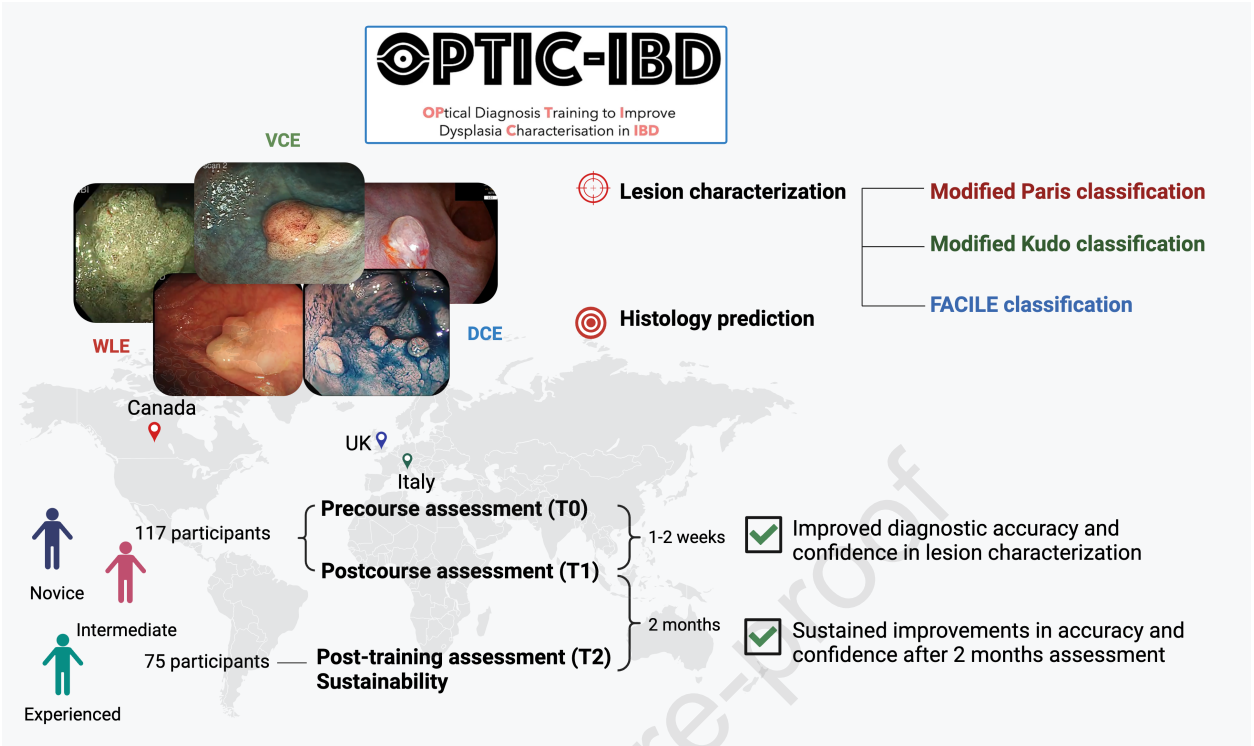

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Abbreviations

DCE, Dye Chromoendoscopy; FACILE, Frankfurt Advanced Chromoendoscopic IBD LEsions classification; HGD, high grade dysplasia; HP, hyperplastic; IBD, inflammatory bowel disease; IQR, interquartile range; i-Scan-OE, i-scan optical enhancement (PENTAX Medical); LCI/BLI, linked colour imaging and blue laser imaging (Fujifilm Corporation); LGD, low grade dysplasia; NBI, narrow band imaging (Olympus Medical); REDCap, Research Electronic Data Capture; SCENIC, Surveillance for Colorectal Endoscopic Neoplasia detection and management in Inflammatory bowel disease patients: international Consensus recommendations; SSL, sessile serrated lesion; VCE, Virtual Chromoendoscopy; UK, United Kingdom

Conference presentation

Previous publication with provisional data as abstracts (ECCO 2022, ESGE 2022, DDW 2022, BSG 2022). The manuscript represents original material and has not been submitted for publication elsewhere.

The authors confirm that all figures, images, illustrations, tables and videos are original work created fully by the co-authors for the purpose of this publication. Every component of illustrations that combines more than one element (e.g., pictograms, images, etc.), is the co-authors' own work. Confirm that the co-authors hold all rights of use for every submitted figure, table and video and no third party holds rights of use.

Data Availability Statement

Data available on request

Conflict of interest

The authors declare no conflict of interest relevant to the present study.

Authors contributions

MI conceived, designed and supervised the study, collected data, and wrote the manuscript; AB, SB, DP, IZ performed the statistical analysis and critically reviewed the manuscript for important intellectual content; RJMI, RC, NL, OMN, TLP, KS and SCLS collected and analyzed the data and drafted the manuscript; JGPF, GF, RK, RP, APB, MP, GET, TU critically reviewed the manuscript for important intellectual content; SG conceived the study and critically reviewed the manuscript for important intellectual content. All authors approved the final version of the manuscript.

Keywords

Inflammatory bowel disease; colorectal cancer; dysplasia; diagnosis and imaging; training

Funding

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Abstract

Background and aims

Inflammatory bowel disease (IBD) increases risk of dysplasia and colorectal cancer. Advanced endoscopic techniques allow for the detection and characterization of IBD dysplastic lesions, but specialized training is not widely available. We aim to develop and validate an online training platform to improve the detection and characterization of colonic lesions in IBD: OPTIC-IBD.

Methods

We designed a web-based learning module that includes surveillance principles, optical diagnostic methods, approach to characterization, classifications of colonic lesions, utilizing still images and videos. We invited gastroenterologists from Canada, Italy, and the UK, with a wide range of experience. Participants reviewed 24 educational videos of IBD colonic lesions, predicted histology, and rated their confidence. The primary endpoint was to improve accuracy in detecting dysplastic lesions following training on the platform. Furthermore, participants were randomized 1:1 to get additional training or not, with a final assessment occurring after 60 days. Diagnostic performance for dysplasia and rater confidence were measured.

Results

One hundred seventeen participants completed the study and were assessed for the primary endpoint. Diagnostic accuracy improved from 70.8% to 75.0% (p 0.002) following training, with the greatest improvements seen in less experienced endoscopists. Improvements in both accuracy and confidence were sustained after 2 months of assessment, although the group randomized to receive additional training did not improve further. Similarly, participants' confidence in characterizing lesions significantly improved between pre- and post-course ($p<0.001$), and it was sustained after 2 months of assessment.

Conclusions

The OPTIC-IBD training module demonstrated that an online platform could improve participants' accuracy and confidence in the optical diagnosis of dysplasia in patients with IBD. The training platform can be widely available and improve endoscopic care for people with IBD. Clinicaltrials.gov NCT04924543.

Introduction

Patients with inflammatory bowel disease (IBD) have an increased lifetime risk of colorectal cancer compared to the general population[1]. This risk is mainly determined by disease extent, disease duration, severity of inflammation, and by the presence of primary sclerosing cholangitis. Consensus guidelines recommend that patients with colitis should undergo regular surveillance colonoscopy at intervals determined by underlying risk factors.[2,3]

International consensus and major guidelines[2,4,5] recommend performing surveillance colonoscopy with dye chromoendoscopy (DCE) or virtual chromoendoscopy (VCE). VCE technologies such as Olympus Narrow-Band Imaging (NBI), Fujifilm Blue Light Imaging (BLI) and Linked Colour Imaging (LCI), Fujinon Intelligent Colour Enhancement (FICE) and Pentax i-SCAN, with or without optical magnification, are now widely available and in expert hands improve lesion detection, characterization and histology prediction.[6-8]

The European and the American Society of Gastrointestinal Endoscopy (ESGE and ASGE)[4] highlight the importance of dedicated IBD endoscopy training to assess lesions and effectively target biopsies. Indeed, previous studies have shown that even among experts using advanced endoscopy distinction between non-neoplastic and neoplastic lesions and characterization remains challenging.[9, 10]

Optical diagnosis training should include lesion classifications and self-learning with a minimum colonoscopy detection rate. As a validated training module is not yet available for optical diagnosis of colonic lesions in IBD, the ESGE curriculum[11] suggests attending an onsite training course with an expert to acquire lesion detection and characterization skills. They recommend performing at least 20 DCEs with at least 20 targeted biopsies and histological feedback, with four quadrant biopsies as backup during the learning process. The transition from DCE to VCE should be gradual after endoscopists achieve the learning goals and demonstrate competence. ESGE recommends IBD optical diagnosis competence as a dysplasia detection rate ≥10% in 20 pan-chromoendoscopy colonoscopies with targeted biopsies. Moreover, competence should be maintained by auditing≥10 IBD endoscopic lesions within 1 year.

As technology provides ever greater image resolution, adequate training is crucial. Mucosal distortion due to chronic inflammation and regenerative changes can conceal dysplasia and lead to misdiagnosis.[12] Hence training is needed to improve detection, recognize subtle changes, standardize reporting and guide clinical management. As IBD-associated lesions differ from those found in the general population, so do their respective classifications. The classifications used for IBD lesions are outlined in the SCENIC classification[5] that employs modified Paris descriptors, Kudo pit pattern[13] including the II-O adaptation[14], Hazewinkel criteria for sessile serrated adenoma/polyp (SSA/P)[15], the Frankfurt Advanced Chromoendoscopic IBD LEsions (FACILE)[16], and the Five S[17]. Despite the abundance of systems, their adoption in clinical practice remains modest, partially due to a lack of training.[5] The study's overall objective was to assess the feasibility of introducing OPTIC-IBD training module as a standard validated tool to improve the

diagnostic accuracy of IBD-associated dysplastic lesions. The primary aim was to design the OPTIC-IBD training module and measure its impact on the diagnostic accuracy of dysplastic lesion types in novice, intermediate compared with experienced endoscopists. The secondary aims were to assess the sustainability of training effect and confidence in the novice, intermediate compared with experienced endoscopists.

Methods

OPTIC-IBD is an international, multi-centre study evaluating the effectiveness of targeted endoscopy training intervention. This involved 1) an IBD dysplasia Training Module for all participants and 2) focused training with feedback for a 1:1 randomized cohort (ClinicalTrials.gov NCT04924543). The study flow is shown in Figure 1. OPTIC-IBD received research ethics committee approval from the University of Birmingham, UK (ERN18-022) and the University of Calgary, Canada (REB21-0409), with local approval at Italian centers (June 2021). All participants gave informed electronic consent. The study was sponsored by the University of Birmingham and supported by a grant from GutsUK (TRN2019-03).

Participants

Study participants were recruited from Calgary (Canada), Bari, Milan, Naples (Italy), the West Midlands and nationwide in the UK. Participants included gastroenterologists performing endoscopy in training programs, independent specialist physicians, surgeons and non-medical staff performing endoscopy. Participants were grouped *a priori* into novice endoscopists (< 100-lifetime colonoscopies) with no previous exposure bias to endoscopy training or practice, intermediate endoscopists (100-1000 lifetime colonoscopies), and experienced endoscopists (>1000 lifetime colonoscopies).

In addition, we invited an international panel of expert endoscopists in optical diagnosis and IBD. Experts were defined as specialists with at least 10 years in independent practice, at least 2000 lifetime colonoscopies, and at least 100 lifetime dye or virtual chromoendoscopies (JGPF, MI, RK, APB, GET, TU). A subgroup of the experienced participants also met these criteria, acting as a further positive control group.

Training Module

An expert group designed a self-directed, multi-modality Online Training Module (Figure 2). This included learning objectives, background, and principles of IBD surveillance, advantages of optical enhancement tools in virtual chromoendoscopy, lesion characterization and classification systems (5S[17], SCENIC recommendations including modified Paris[5], modified Kudo[13, 14], FACILE[16]) (see Appendix 1), worked example questions with multiple images and videos, and self-assessment questions. All training images were produced/redrawn for the Training Module to increase learning or adapted/reproduced with permission from the original publisher; for teaching purposes, some images were edited with arrows or lines to mark relevant features. However, they were only used as examples in the training module as animated features and not used in the evaluation sets.

Moreover, we asked participants to provide quantitative and qualitative feedback on the Training Module and the focused training.

Video Library

All endoscopic IBD colonic lesion videos used in the online Training Module and assessments were anonymized and recorded with the patient's consent for clinical education. All videos started with an initial assessment with WLE -HD following DCE and VCE. In all videos, virtual chromoendoscopy was performed to accurately characterize endoscopic features of colonic IBD lesions. Overall, 32 videos were used. Of them, 24 for the first validation phase (whole cohort) and 20 for the second validation phase (sustainability cohort), of which 8 new videos were included. [15 videos with iSCAN (Pentax), 15 videos with NBI (Olympus) and 2 videos with LCI/BLI (Fujifilm).

We included 12 non-dysplastic lesions (4 pseudopolyps/inflammatory, 4 hyperplastic [HP], 4 sessile serrated lesions [SSL]) and twenty dysplastic lesions (13 low-grade dysplasia [LGD], and 7 high-grade dysplasia [HGD] or invasive carcinoma). SSLs with dysplastic components were included under LGD. The gold standard to determine the correct optical diagnosis was the histopathological assessment by expert GI pathologists. In the case of LGD, we asked for a second opinion from another expert pathologist.

Lesions were characterized according to the SCENIC classification[5] (modified Paris descriptors, border, ulceration), modified Kudo classification[13, 14] (including II-O pit pattern) and FACILE classification[16] (morphology, surface architecture, vessel architecture, inflammation). (Appendix.1) The gold standard was based on consensus from the 6 international experts who supervised the study (MI, RK, APB, GET, TU, JF). All the experts agreed on the video, pictures pool, their quality initially selected by MI, TP RI and assessed the aforementioned classifications. Furthermore, they also predicted histology, being considered the gold standard. The raters assessed the pictures and videos according to the classification (Appendix 1), and they predicted histology.

Interventions and randomization

All participants received instruction using the study intervention, the online OPTIC-IBD Training Module, on study day 7 which they accessed at their own time and pace.

The first validation phase compared diagnostic performance between pre-course (T0) and post-course (T1) assessments. Participants were also randomly selected to receive or not receive our additional study intervention (focused training with feedback) delivered 14 days after completing the post-course (T1) assessment. Feedback was given after each assessment to increase confidence.

The second validation phase assessed long-term learning post-training (T2) at 60 days. Randomization was 1:1, unblinded and stratified by country of clinical practice using an external allocation grid with block size 4. The focused training recapped information on the endoscopic classification systems to reinforce the features of each lesion type. The feedback provided the

correct optical diagnoses with participant answers for a randomized subset of 12 videos used in pre- and post-course assessments and 8 videos new, stratified by lesion type.

The control group did not receive focused training and continued the study until the long-term post-training (T2) assessment (after 60 days). Feedback on all the endoscopic videos was provided to all participants who completed the study six weeks after the post-training (T2) assessment.

Survey and video assessments

All participants and invited experts completed an initial survey at baseline. This collected data on basic demographics, country of clinical practice, training status and speciality, time in training or independent practice, colonoscopy experience, and experience with IBD surveillance.

All participants were asked to complete the same pre-course (T0), post-course (T1), and post-training (T2) assessments. These were completed at baseline, after days 7-14 and after 60 days from the post-course (T1) assessment.

Participants were asked to grade their baseline confidence in IBD-associated lesion characterization (7-step Likert scale from no to high confidence) and, for each lesion, the video quality (high or low), endoscopic classifications (SCENIC, Kudo and FACILE), the overall optical diagnosis and confidence in their prediction (high or low).

The course assessment comprised 24 videos, 8 with non-dysplastic and 16 with dysplastic lesions (3 inflammatory, 2 HP, 3 SSL, 12 LGD, 4 HGD/cancer). The same 24 videos in the pre-course and post-course assessments were randomized and assessed after a minimum of 7 to 14 days to reduce recall bias.

After 60 days, all participants, regardless of randomization, were invited to the long-term post-training (T2) assessment to measure the sustainability of the training interventions, including any additional impact of the focused training with feedback. The feedback was about a randomized subset of half of the 24 videos. Therefore, the post-course assessment included 20 videos (3 inflammatory, 3 HP, 2 SSL, 9 LGD, 3 HGD/cancer), 8 new and 12 of the initials not used in the feedback.

Outcome measures

The primary outcome measure was the impact of the OPTIC-IBD Training Module on the diagnostic accuracy (including sensitivity and specificity) of optical diagnosis for dysplastic lesion types between the pre-(T0) and post-course (T1) assessments among novice, intermediate and experienced endoscopists.

The secondary outcome was to assess the sustainability of training over a longer period (at least 2 months), a surrogate measure to estimate the lasting effect of the course. In detail, we compared the accuracy of optical diagnosis between the pre-course (T0), post-course (T1), and long-term post-

training (T2) assessments. For the additional randomized intervention of focused training with feedback, we compared the performance of the intervention and control groups.

The tertiary outcome was to investigate participants' confidence in characterizing lesion between pre- and post-course and in the sustainability cohort, focusing mainly on the possible differences between novice, intermediate and experienced endoscopists.

Statistical analysis

Study data were collected and managed using the REDCap data capture tool, a secure, web-based platform hosted at the University of Birmingham.

Accuracy, sensitivity, specificity, and confidence (Likert scale) were summarized with median and interquartile range (IQR).

Continuous variables were compared with the non-parametric Wilcoxon matched-pairs signed-ranks test or the two-sample Wilcoxon rank-sum (U Mann-Whitney) test, as appropriate. The number of participants was calculated based on the primary endpoint (change of diagnostic accuracy in characterizing dysplastic lesions following training on the platform). We estimated that 128 participants were needed to provide a power of 80% to detect a change of 5% between the pre- and post-course assessments, assuming the standard deviation of the change to be 20% (alpha = 0.05, two-sided). To account for potential dropouts, we increased the sample size (by 40%) to 180 participants. As for the number of educational videos, practical considerations such as time and cost were considered.

Statistical analysis was completed in SPSS (SPSS Inc., Chicago, IL, USA). A two-sided p-value <0.05 was considered statistically significant.

Results

Participants

Participant characteristics are shown in Table 1. 182 participants consented to participate in OPTIC-IBD. A total of 33 (18%) and 32 (18%) did not complete the pre- (T0) and post-course (T1) assessments, respectively and were withdrawn. There were 117 participants in the primary endpoint cohort, having completed the Training Module and the initial assessments. Of these, 42 (36%, 23% overall) did not complete the final post-training (T2) assessment. The median time between the first assessments was 21 days (IQR 17-65 days).

Most participants were trainees (65.8%) and 70.9% were less experienced endoscopists (novice [35.0%] and intermediate [35.9%]).

There were 75 participants in the sustainability cohort, having completed all phases of the study protocol, including those randomized to brief focused training with feedback (intervention 33 [44%], control 42 participants [56%]). The median time from post-course (T1) to post-training (T2) assessment was 10 weeks (69 days, IQR 65-75 days). 70.7% and 72% were trainee and less experienced endoscopists, respectively.

First validation phase (whole cohort)

117 participants completed the first validation phase.

Diagnostic performance in primary endpoint cohort and the impact of Training Module in the accuracy, sensitivity, and specificity for dysplasia characterization in IBD colonic lesion are shown in Table 2.

Diagnostic accuracy improved significantly from the pre- (T0) to the post-course (T1) (from 70.8% [IQR 58.3-79.2] to 75.0% [IQR 64.6-79.2], p 0.002).

Although the sensitivity for dysplasia remained stable, there was a significant increase in specificity (from 62.5% [IQR 50.0-75.0] to 75.0% [IQR 62.5-87.5], p<0.001).

Subgroup analyses

A significant improvement of diagnostic accuracy was noted in less experienced endoscopists (novice: 62.5% [IQR 54.2-66.7] to 66.7% [58.3-72.9], p 0.041; intermediate: 70.8% [IQR 61.5-76.0] to 75.0% [IQR 66.7-79.2], p 0.032). Improvements were due to an increase in specificity. As an aspirational target and control, the group invited experts achieved overall accuracy, sensitivity, and specificity of 85.4% (IQR 78.1-92.7), 88.2% (IQR 77.9-95.6) and 78.6% (IQR 71.4-100) respectively, with a similar performance by expert participants.

There was an improvement in diagnostic accuracy, sensitivity, and specificity when considering participants of all countries. Accuracy increased in particular among UK participants (from 66.7%

[IQR 56.3-77.1] to 70.1% [62.5-79.2], p 0.002); whilst the specificity increased especially in Canada (from 62.5% [IQR 56.3-75.0] to 75.0% [IQR 75.0-93.8], p 0.016) and the UK participants (from 62.5% [50.0-87.5] to 75.0% [IQR 62.5-87.5], p 0.002).

Confidence in histological prediction

There was an increase in participants' confidence to characterize correctly IBD-associated lesions.

A median of 8 (IQR 1-13) and 12 (IQR 4-17) videos were rated as at high-confidence during pre-(T0) and post-course (T1), respectively.

According to the 7-point Likert scale, the confidence in histological prediction significantly increased overall and in trainees, independent endoscopists and less experienced endoscopists (Supplementary Table 1).

Second validation phase (Sustainability cohort)

75 participants completed the sustainability phase.

Diagnostic performance in the sustainability cohort and the impact of randomized focused training with feedback comparing the intervention and control group are shown in Table 3.

Improvements in diagnostic accuracy for dysplasia were sustained at least 2 months to the final post-training (T2) assessment (pre-course [T0] 66.7% (IQR 58.3-75.0), post-course [T1] 70.8% (IQR 60.0-79.2) and post-training [T2] 70.0% (IQR 60.0-80.0), [T0 vs T2] p 0.014).

Subgroup analyses

Improvement in accuracy was sustained in all groups except for novice (from 62.5% [IQR 54.2-66.7] T0 to 66.7% [60.4-70.8] T1 to 60.0 [IQR 50.0-72.5], [T0 vs T2] p 0.010).

There was an improvement in diagnostic accuracy in all country participants, which was sustained for Canada and UK but not for Italy (from 66.7% [IQR 62.5-75.0] T0 to 70.8 [IQR 66.7-79.2] T1 to 65.0 [IQR 55.0-75.0].

Confidence in histological prediction

Participants' confidence in characterizing correctly IBD-associated lesions increased significantly.

A median of 7 (IQR 2-13), 11 (IQR 5-17) and 10 (IQR 4-14) videos were rated as at high confidence during pre-(T0), post-course (T1) and post-training (T2), respectively. According to 7-point Likert scale, the confidence in histological prediction significantly increased overall and, in all groups, except for the expert group. Confidence was maintained in the post-training phase. (Supplementary table 2).

Differences between intervention and control group

Among the 75 participants of the sustainability cohort, 33 (44%) were randomized to receive additional focused training intervention with feedback and 42 (56%) represented the control group.

There was no significant difference in overall and subgroup diagnostic accuracy between the intervention and control groups (Table 3). However, the randomization was not stratified by endoscopic experience, so the control group included a slightly higher proportion of novice (35.0% vs 38.7%) and intermediate endoscopists (35.9% vs 33.3%) than the intervention group. In addition, there was a higher dropout among participants randomized to the intervention.

Confidence in histological prediction did not differ significantly between the two groups, except for an increase among independent and experienced endoscopists in the intervention group (4 [IQR 4-5] vs 3 [IQR 3-3], p 0.004 and 4 [IQR 4-5] vs 3 [IQR 3-3] p 0.006; respectively) (Supplementary table 2).

Inter-observer agreement was fair, with Fleiss' Kappa ranging from 0.23 (95% CI: 0.10–0.35), before the training course, to 0.24 (95% CI: 0.12–0.37) after the course. While, the Fleiss'Kappa agreement was moderate or substantial for the experienced /experts ranging from 0.54(95% CI:0.41-0.66) before the training course to 0.68 (95% CI: 0.55-0.80).

Feedback from participants

Most participants found the Training Module to be effective (90.9% agree or strongly agree) and relevant (94.7%) and would recommend it (91.0%). Roughly half of the respondents provided additional feedback; among the most appreciated features were the wealth of visual (image/video) content and the ability to self-assess; consistently, the most common suggestion for improvement was to increase the number of examples and questions. Among those randomized to focused training, more than three quarters thought it was relevant and helpful in consolidating knowledge, and all respondents recommend including refresher training in the course. Additional feedback was provided by around a third of the participants, appreciating the concise format, and focused notions and recommending more self-assessment examples.

Discussion

Performing endoscopy in patients with IBD requires a subset of endoscopic skills and advanced knowledge rarely acquired in core gastroenterology training. Currently, in the absence of standard curricula, acquiring the necessary skills and knowledge relies on local expertise and/or dedicated postgraduate courses[18]. This variation often results in gaps and heterogeneity of needed competence. Clinically, this leads to misclassification of non-dysplastic lesions as dysplastic and a low interobserver agreement for lesion histopathology prediction, which can result in significant consequences for patients.[19] Often the opportunity to have enough experience in detection and characterization of dysplastic lesions in IBD and distinguish from non-neoplastic lesions is limited. Hence the need for new training avenues in IBD optical diagnosis is crucial.

Web-based education represents a valuable tool for filling the gap. This type of instructions has been successfully employed in the characterization of sporadic lesions.[20-22] The OPTIC-IBD training module was designed as a comprehensive training platform to track the key principles needed for competency in the optical diagnosis in IBD lesions characterization and provide enough examples and self-assessment, all in a practical form. It can be completed in a short amount of time; with most participants completing the module in one hour.

In this prospective multicenter international study, we demonstrated how participation in the web-based course OPTIC-IBD led to significant improvement in diagnostic accuracy of lesion type and specificity of dysplasia detection in IBD-associated colorectal lesions. Training increased overall accuracy from 70.8% to 75.0% (p 0.002) and specificity from 62.5% to 75.0% (p<0.001), with benefits particularly evident among less experienced endoscopists. Such benefits may be of value to improve surveillance colonoscopy skills in IBD.

The primary analysis focused on recognising and distinguishing between dysplastic and non-dysplastic lesions. As a secondary analysis, we looked at confidence in diagnosis, which correlates with clinical decision-making. Predictably, confidence significantly increased in all groups.

The course improvements were sustained over time almost in all groups and were not significantly influenced by receiving or not receiving additional refresher training. Hence the initial course (T0-T1) resulted in a lasting benefit for participants, while gains from refresher training (T2) appeared modest..

This might be related to the nature of the training. In fact, the key principles of optical diagnosis are easily remembered once a framework for assessment (for example, the “five S”) is provided. We believe the main teaching of the course is the methodological approach to lesions that stands to the test of time better than other notions. In addition, using animation for training contributes significantly to strengthening learning and keeping it simple and effective.

Despite general improvement, benefits could not be maintained in some trainees and novice endoscopists, suggesting that further training or additional videos may be needed in this subset of participants. No formal maintaining competence in the optical diagnosis of IBD dysplasia data is yet

to be available. Further studies should be conducted to clarify if annual sustainability refresher courses may be needed to maintain competencies.

The inter-observer agreement between raters was fair before and after the training course. In contrast, it was moderate or substantial for the experienced /experts. This was rather expected due to the participants' diverse backgrounds and varying levels of experience, which could have influenced their interpretations.

Overall, OPTIC-IBD was evaluated as effective, relevant and recommended by nearly all the participants. Respondents appreciated its image-based teaching and the presence of concise and focused notions. Although a longer course might have further improved performance, we limited the length not to overwhelm trainees and lose engagement. A positive reception is fundamental to ensuring a successful rollout. The feasibility of OPTIC-IBD was tested by its launch on the European Crohn's Colitis Organisation (ECCO) platform. This was enthusiastically received, and we are optimistic that the OPTIC-IBD system can be disseminated though other gastroenterology societies and furthermore in clinical practice without a specific purchase fee.

A major strength of the present study is its multicenter randomized design. This provided a large sample size compared to other studies and allowed some sub-group analysis.

Moreover, enrolling participants across three countries and multiple institutions mitigated selection bias and increased results generalizability. Furthermore, the randomization in different groups provides robust evidence that additional training did not further improve results. To the best of our knowledge, this represents the first published training model for a colorectal lesion in IBD to date. Only a few studies focused on disease assessment[18] but none on dysplasia/non-dysplasia characterization. As treatment for IBD improves, colectomy rates decrease, and the population ages, the share of patients with "long-standing" disease increases, and so does the importance of surveillance quality.

Despite all the positive feedback, our study has some limitations. First, assessments were limited to videos on lesions characterization and did not cover decision-making skills, e.g., the management plan for polyps, which is important in daily practice. Second, because the assessments were self-administered, cheating cannot be excluded. However, none of the images or videos was publicly available, limiting the hints found on the internet. Obviously, voluntary participation and withdrawal could have skew selection towards more motivated participants, but this was unavoidable. Timing intervals were chosen arbitrarily and might not be adequate to detect information retention. Finally, training interventions' efficacy relies on their design, content, and application of learning theory. This could explain the lack of benefit seen with refresher training, which can be improved in future iterations of OPTIC-IBD.

The advent of artificial intelligence (AI) could help improve the characterization of IBD lesions. However, this will not replace the need for training as only an endoscopist competent in optical diagnosis will have sufficient confidence to rely on AI characterization.

Conclusion

We propose OPTIC-IBD as a basis for future IBD endoscopy educational initiatives under the patronage of gastroenterology societies. We pledge to make it available immediately, free of charge, and open for improvement of competencies for trainees and gastroenterologists. With this interactive training module, we seek to offer a first tool to disseminate knowledge on IBD endoscopy, which should be included in the IBD curriculum and ideally be followed by hands-on practice in specialized centers. Furthermore, optimizing report quality and concurrent aligned training curricula are warranted in designing new training modules in IBD endoscopy to promote standardization and dissemination of common language between gastroenterologists to drive better patient outcomes.

In conclusion, OPTIC-IBD, a self-directed web-based training module, which effectively augments optical diagnosis and dysplasia characterization in IBD, particularly among trainees.

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Table 1 – Participant characteristics

		Primary endpoint cohort (T1)	Sustainability cohort (T2)		
			Overall	Intervention	Control
Total participants (n)		117	75	33	42
Female (n, %)		55 (47.0%)	34 (45.3%)	16 (48.5%)	18 (42.8%)
Age (n, %)	25–34 years	66 (56.4%)	43 (57.3%)	17 (51.5%)	26 (61.9%)
	35–44 years	36 (30.8%)	23 (30.7%)	10 (30.3%)	13 (31.0%)
	45–54 years	8 (6.8%)	2 (2.7%)	1 (3.0%)	1 (2.4%)
	≥ 55 years	7 (6.0%)	7 (9.3%)	5 (15.2%)	2 (4.8%)
Country of clinical practice (n, %)	Canada	13 (11.1%)	6 (8.0%)	2 (6.1%)	4 (9.5%)
	Italy	51 (43.6%)	35 (46.7%)	15 (45.5%)	20 (47.6%)
	UK	53 (45.3%)	34 (45.3%)	16 (48.5%)	18 (42.9%)
Training status (n, %)	Trainee	77 (65.8%)	53 (70.7%)	21 (63.6%)	32 (76.2%)
	Independent	40 (34.2%)	22 (29.3%)	12 (36.4%)	10 (23.8%)
Endoscopic experience level (n, %)	Novice	41 (35.0%)	29 (38.7%)	10 (30.3%)	19 (45.2%)
	Intermediate	42 (35.9%)	25 (33.3%)	12 (36.4%)	13 (31.0%)
	Experienced	34 (29.1%)	21 (28.0%)	11 (33.3%)	10 (23.8%)

Table 2 – Diagnostic performance in primary endpoint cohort and impact of Training Module in the accuracy, sensitivity and specificity for dysplasia in IBD colonic lesions

		n	**Accuracy for dysplasia** (median, IQR)			**Sensitivity for dysplasia** (median, IQR)			**Specificity for dysplasia** (median, IQR)		
			Pre-course (T0)	**Post-course (T1)**	***P***	**Pre-course (T0)**	**Post-course (T1)**	***P***	**Pre-course (T0)**	**Post-course (T1)**	***P***
Overall		117	70.8 (58.3–79.2)	75.0 (64.6–79.2)	0.002	75.0 (59.4–81.3)	75.0 (62.5–81.3)	0.38	62.5 (50.0–75.0)	75.0 (62.5–87.5)	<0.001
Confidence in diagnosis	High	*	75.0 (66.7–79.2)	75.0 (66.7–83.3)	0.71	75.0 (68.8–87.5)	81.3 (62.5–87.5)	0.79	75.0 (62.5–87.5)	75.0 (62.5–81.3)	0.72
	Low	*	64.6 (54.2–75.0)	70.8 (58.3–75.0)	0.28	68.8 (50.0–81.3)	68.8 (54.2–75.0)	0.75	62.5 (46.9–75.0)	75.0 (50.0–75.0)	0.018
Country of clinical practice	Canada	13	75.0 (66.7–79.2)	75.0 (68.8–85.4)	0.10	81.3 (68.8–81.3)	81.3 (71.9–87.5)	0.50	62.5 (56.3–75.0)	75.0 (75.0–93.8)	0.016
	Italy	51	70.8 (62.5–79.2)	75.0 (62.5–79.2)	0.66	75.0 (62.5–87.5)	75.0 (62.5–87.5)	0.83	62.5 (50.0–75.0)	62.5 (50.0–75.0)	0.39
	UK	53	66.7 (56.3–77.1)	70.1 (62.5–79.2)	0.002	68.8 (50.0–81.3)	68.8 (62.5–81.3)	0.31	62.5 (50.0–87.5)	75.0 (62.5–87.5)	0.002
Training status	Trainee	77	66.7 (58.3–75.0)	66.7 (62.5–75.0)	0.009	68.8 (56.3–81.3)	68.8 (62.5–81.3)	0.29	62.5 (50.0–75.0)	75.0 (50.0–75.0)	0.027
	Independent	40	77.1 (70.8–83.3)	79.2 (71.9–86.5)	0.076	81.3 (75.0–93.8)	81.3 (75.0–87.5)	0.87	62.5 (53.3–75.0)	75.0 (62.5–87.5)	0.004
Endoscopic experience level	Novice	41	62.5 (54.2–66.7)	66.7 (58.3–72.9)	0.041	68.8 (46.9–81.3)	68.8 (56.3–81.3)	0.20	62.5 (50.0–75.0)	62.5 (54.2–66.7)	0.16
	Intermediate	42	70.8 (61.5–76.0)	75.0 (66.7–79.2)	0.032	71.9 (60.1–81.3)	68.8 (62.5–81.3)	0.68	62.5 (50.0–75.0)	75.0 (62.5–87.5)	0.010
	Experienced	34	79.2 (70.8–83.3)	79.2 (74.0–87.5)	0.37	81.3 (75.0–93.8)	81.3 (75.0–87.5)	0.27	62.5 (59.4–75.0)	75.0 (62.5–90.6)	0.035
Expert group	Participants	5	87.5 (77.1–95.8)	91.7 (85.4–93.8)	0.46	93.8 (87.5–93.8)	87.5 (87.5–93.8)	0.71	75.0 (56.3–100)	100 (75.0–100)	0.18
	Invited	6	85.4 (78.1–92.7)		n/a	88.2 (77.9–95.6)		n/a	78.6 (71.4–100)		n/a

Footnotes:

* pre-course median 8 videos of 24 rated as high confidence (IQR, 1–13) and post-course 12 of 24 (IQR, 4–17); pre-course median 16 videos of 24 rated as low confidence (IQR, 11–23) and post-course 12 of 24 (IQR, 7–20).

Comparisons were performed using the Wilcoxon matched-pairs signed-ranks test.

Abbreviations: IQR, interquartile range; n/a, not applicable.

Table 3. Diagnostic performance (accuracy) in sustainability cohort and impact of randomized focused training with feedback comparing the intervention and control group.

		n	**Accuracy of optical diagnosis for dysplasia** (median, IQR)									
			Pre-course (T0)	**Post-course (T1)**	**Post-training (T2)**	***P***		**Post-training (T2) by randomised group**				
						1 vs. 3	2 vs. 3	**n**	**Intervention**	**n**	**Control**	***P***
Overall		75	66.7 (58.3–75.0)	70.8 (60.0–79.2)	70.0 (60.0–80.0)	0.014	0.47	33	70.0 (60.0–80.0)	42	70.0 (60.0–80.0)	0.97
Confidence in diagnosis	High	*	65.0 (60.0–75.0)	75.0 (66.7–83.3)	75.0 (65.0–80.0)	0.011	0.77	**	75.0 (65.0–82.5)	**	80.0 (70.0–80.0)	0.69
	Low	*	62.5 (54.2–70.8)	70.8 (58.3–75.0)	70.8 (55.0–75.0)	0.022	0.62	**	62.5 (48.8–75.0)	**	60.0 (55.0–72.5)	0.64
Country of clinical practice	Canada	6	72.9 (60.4–79.2)	75.0 (64.6–83.3)	75.0 (65.0–82.5)	0.60	0.92	2	72.5 (65.0–80.0)	4	75.0 (66.3–87.5)	0.80
	Italy	35	66.7 (62.5–75.0)	70.8 (66.7–79.2)	65.0 (55.0–75.0)	0.69	0.018	15	65.0 (60.0–80.0)	20	67.5 (55.0–75.0)	0.54
	UK	34	66.7 (57.3–79.2)	68.8 (62.5–79.2)	72.5 (60.0–80.0)	0.24	0.22	16	72.5 (56.3–80.0)	18	72.5 (60.0–81.3)	0.72
Training status	Trainee	53	62.5 (58.3–75.0)	66.7 (62.5–75.0)	65.0 (55.0–75.0)	0.70	0.028	21	65.0 (57.5–75.0)	32	65.0 (55.0–75.0)	0.83
	Independent	22	77.1 (69.8–80.2)	81.2 (70.8–87.5)	80.0 (73.8–85.0)	0.49	0.34	12	77.5 (66.3–80.0)	10	80.0 (80.0–86.3)	0.14
Endoscopic experience level	Novice	29	62.5 (54.2–66.7)	66.7 (60.4–70.8)	60.0 (50.0–72.5)	0.99	0.010	10	60.0 (43.0–75.0)	19	60.0 (55.0–70.0)	0.81
	Intermediate	25	66.7 (62.5–77.1)	70.8 (66.7–79.2)	70.0 (65.0–80.0)	0.37	0.64	12	65.0 (61.3–78.8)	13	70.0 (65.0–80.0)	0.61
	Experienced	21	75.0 (70.8–81.3)	79.2 (72.9–87.5)	80.0 (72.5–85.0)	0.78	0.40	11	80.0 (70.0–85.0)	10	80.0 (76.3–86.3)	0.65
Expert group	Participants	4	87.5 (76.0–95.8)	91.7 (85.4–94.8)	85.0 (76.3–90.0)	0.59	0.07	2	82.5 (75.0–90.0)	2	85.0 (80.0–90.0)	0.67
	Invited	6	85.4 (78.1–92.7)		80.0 (76.3–88.8)	n/a	n/a					

Footnotes:

* pre-course median 7 videos of 24 rated as high confidence (IQR, 2–13), post-course 11 of 24 (IQR, 5–17) and post-training 10 of 20 (IQR, 4–14); pre-course median 17 videos of 24 rated as low confidence (IQR, 11–23), post-course 13 of 24 (IQR, 7–20), and post-training 10 of 20 (IQR, 6–16).

** intervention median 11 videos of 20 rated as high confidence (IQR, 3–16) and control 8 of 20 (IQR, 4–13); intervention median 9 videos of 20 rated as low confidence (IQR, 4–17) and control 13 of 20 (IQR, 7–16).

Comparisons were performed using the Wilcoxon matched-pairs signed-ranks test, and the two-sample Wilcoxon rank-sum (Mann-Whitney) test.

Abbreviations: IQR, interquartile range; n/a, not applicable.

Supplementary table 1. Participants' confidence to correctly characterize IBD-associated lesions.

		n	Pre-course (T0)	Post-course (T1)	*P*
			Participant self-ratings overall (median, IQR)		
		117	2 (1–3)	3 (2–4)	<0.001
Training status	Trainee	77	1 (0–3)	3 (2–3)	<0.001
	Independent	40	3 (2–4)	4 (3–4)	0.001
Participant self-ratings by endoscopic experience level	Novice	41	1 (0–1)	2 (1–3)	<0.001
	Intermediate	42	2 (2-3)	3 (3-4)	<0.001
	Experienced	34	3 (2–4)	3 (3–4)	0.004
	Expert group – participants	5	5 (4–5)	4 (3.5–5.5)	0.56
	Expert group – invited	6	5 (3.75–5)		

Footnote: Comparisons were performed using the Wilcoxon matched-pairs signed-ranks test.
Abbreviations: IQR, interquartile range; n/a, not applicable.

Supplementary Table 2. Participant confidence to correctly characterize IBD-associated lesions (sustainability cohort).

		n	**Participant self-ratings overall** (median, IQR)									
			Pre-course (T0)	**Post-course (T1)**	**Post-training (T2)**	***P***		**Post-training (T2) by randomized group**				
						1 vs. 3	2 vs. 3	**n**	**Intervention**	**n**	**Control**	***P***
Overall		75	2 (1–3)	3 (2–4)	3 (2–4)	<0.001	0.58	33	3 (2.5–4)	42	3 (2–3)	0.08
Training status	Trainee	53	1 (0–3)	3 (2–3)	3 (2–3)	<0.001	0.36	21	3 (2–3)	32	3 (2–3)	0.97
	Independent	22	3 (2–4)	4 (3–4)	3.5 (3–5)	0.003	0.53	12	4 (4–5)	10	3 (3–3)	0.004
Endoscopic experience level	Novice	29	0 (0–1)	2 (1–3)	2 (2–3)	<0.001	0.42	10	2.5 (2–3.25)	19	2 (2–3)	0.54
	Intermediate	25	2 (2–3)	3 (3–4)	3 (3–4)	0.002	0.61	12	3 (2.25–3.75)	13	3 (3–4)	0.35
	Experienced	21	3 (2–4)	4 (3–4)	4 (3–5)	0.003	0.53	11	4 (4–5)	10	3 (3–3)	0.006
	Expert group - Participants	4	5 (3.5–5)	4.5 (3.25–5.75)	5 (3.5–5)	1	1	2	5 (5–5)	2	4 (3–5)	0.67
	Expert group - Invited	6	5 (3.75–5)									

Footnote: Comparisons were performed using the Wilcoxon matched-pairs signed-ranks test, and the two-sample Wilcoxon rank-sum (Mann-Whitney) test.
Abbreviation: IQR, interquartile range.

Figure Legends

Figure 1 – OPTIC-IBD study design

In addition to an initial survey (yellow circle), there were three assessments with endoscopic videos (blue circles; 1, pre-course (T0) at baseline; 2, post-course (T1) at least 7 days from pre-course; 3, post-training (T2) at least 60 days from post-course). There were two online training interventions (red circles): a Training Module received by all participants on study day 7, and brief focused training with feedback received by half the participants (randomized 1:1 stratified by country of practice) on day 14 after post-course assessment. This feedback provided the correct optical diagnoses with participant answers for half of the videos in the pre- and post-course assessments (T0-T1). These videos were not used in the post-training (T2) assessment. Feedback on all the endoscopic videos was provided to all participants who completed the study (grey circle).

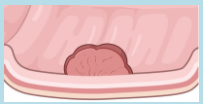
Figure 2 – OPTIC-IBD Training Module

Some slides from the online Training Module: A) the objectives of the online Training Module; B) the approach to a colonic lesion; in particular describe the site, surrounding area, size, shape and surface; C) an example of a question about to a colonic lesion: it has been asked to each participant to define the modified Paris classification, Kudo pit pattern and predict histology; D) an example of video showed in the Training Module: each video explained to participants how to characterize a colonic lesion with help from shapes and arrows. Created with 'Biorender.com'.

Appendix 1. Colonic Lesions Classifications

Appendix 1

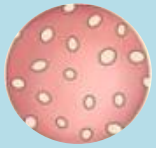
Modified Paris classification

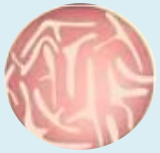
	Endoscopic appearance	Diagram		Description
Paris classifi-cation	**Polypoid**	Ip		Pedunculated polyps
		Isp		Sub-pedunculated polyps
		Is		Sessile polyps
	Nonpolypoid	IIa		Superficial elevated
		IIb		Flat
		IIc		Slightly depressed

Ulceration	**Present**			
	Absent			
Borders	**Distinct**			
	Indistinct			

The SCENIC International Consensus proposed a system to characterize IBD polyps. It considers the modified Paris Classification (polypoid and nonpolypoid lesions), the presence of ulcerations and the borders of lesions (distinct or indistinct). [5] Images created with 'Biorender.com'

Modified Kudo classification

Type	Diagram	Description	Histology
I		Round	Normal
II		Stellar	HP

II-O		Open	SSL
IIIs		Round (smaller than usual pits)	LGD
IIIL		Tubular (larger than usual pits)	
IV		Branch/gyrus	
V		Irregular	HGD/cancer

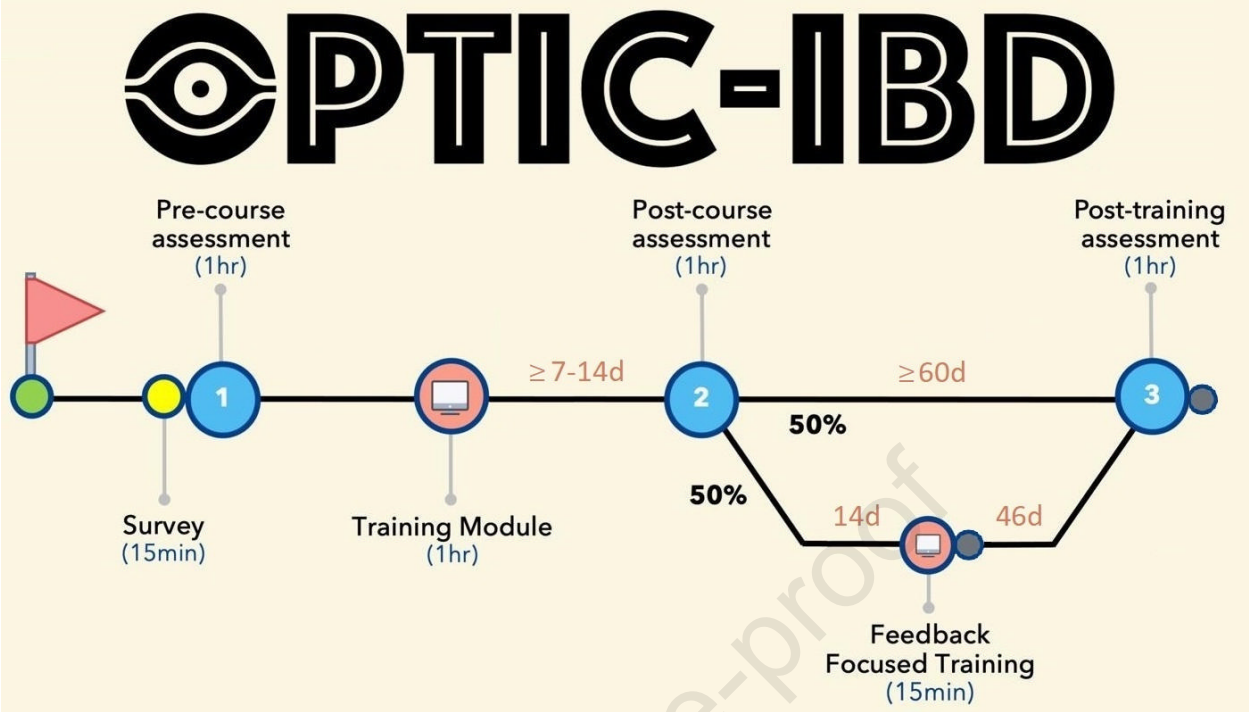
Kudo classification characterize lesions and predicts histology according to pit pattern. *HP: hyperplastic; SSL: sessile serrated lesions; LGD: low-grade dysplasia; HGD: high-grade dysplasia.* [13,14]

Frankfurt **A**dvanced **C**hromoendoscopic **I**BD **LE**sions **(FACILE)** classification

Endoscopy Findings	**SSLs**	**Inflammatory/ Pseudopolyps**	**Dysplasia LGD/HGD**	**Cancer**

Morphology • **Polypoid** • **Nonpolypoid**	Is	Ip	IIa	IIa+IIc
Surface architecture • **Roundish** • **Villous regular** • **Villous irregular** • **Irregular/Non structural**	Roundish	Roundish	Villous Irregular	Irregular/ Non structural
Vessel architecture	Non visible	Regular	Irregular	Irregular/ Non structural
Inflammation within the lesion **Yes/No**	No	Yes	Yes	Yes

The FACILE (Frankfurt Advanced Chromoendoscopic IBD Lesions) classification was developed and validated to assess IBD lesions using virtual chromoendoscopy. It evaluates four characteristics (morphology, surface architecture, vessel architecture, inflammation within the lesion) which can be applied together to predict histology. *Abbreviations: SSLs: sessile serrated lesions; LGD: low-grade dysplasia; HGD: high-grade dysplasia.* [16]



OPTIC-IBD OBJECTIVES

Welcome
Surveillance
Characterization
Examples
Videos
Questions
Feedback

Welcome to OPTIC-IBD!

OPTIC-IBD is an online training module.

The aim is to improve your ability to endoscopically characterise colonic dysplasia and polyps in IBD patients.

By the end of this training module, you should be able to:

1. Describe endoscopic lesions in IBD using validated classification systems
2. Recognize the role for virtual chromoendoscopy (optical diagnosis)
3. Improve your ability to predict histology

Back Next

OPTIC-IBD study info

APPROACH

'Five S'

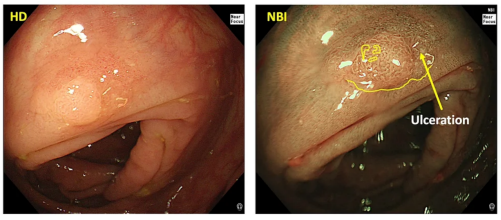
Site and **Surrounding** → **Size** → **Shape** and **Surface**

- In a segment with colitis or inflammatory lesions
- In a segment without colitis → Sporadic lesion

VCE ✓ **SCENIC modified Paris**
VCE ✓ **Kudo pit pattern**
VCE ✓ **FACILE**

✓ compatible or enhanced by virtual chromoendoscopy (VCE)

QUESTIONS



Answers:

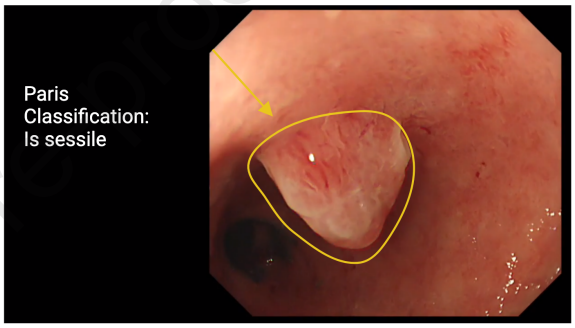
Paris classification*	Ulceration*	Borders*	Kudo*
Polypoid - Sessile (0-Is)	Present	Distinct	IIIL - tubular/round

Predicted histology*
Low grade dysplasia


Is


Type IIIL

VIDEO 2



Appendix 1

Modified Paris classification

	Endoscopic appearance	Diagram		Description
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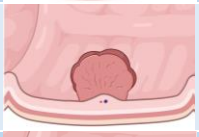
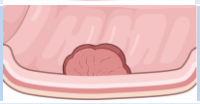
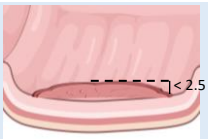
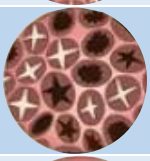
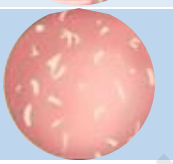
		Isp		Sub-pedunculated polyps
		Is		Sessile polyps
	Nonpolypoid	IIa		Superficial elevated
		IIb		Flat
		IIc		Slightly depressed
Ulceration	**Present**			
	Absent			
Borders	**Distinct**			
	Indistinct			

The SCENIC International Consensus proposed a system to characterize IBD polyps. It considers the modified Paris Classification (polypoid and nonpolypoid lesions), the presence of ulcerations and the borders of lesions (distinct or indistinct). [5] Images created with 'Biorender.com'

Modified Kudo classification

Type	Diagram	Description	Histology
I		Round	Normal
II		Stellar	HP
II-O		Open	SSL
IIIs		Round (smaller than usual pits)	LGD
IIIL		Tubular (larger than usual pits)	
IV		Branch/gyrus	
V		Irregular	HGD/cancer

Kudo classification characterize lesions and predicts histology according to pit pattern. *HP: hyperplastic; SSL: sessile serrated lesions; LGD: low-grade dysplasia; HGD: high-grade dysplasia.* [13,14]

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Vessel architecture	Non visible	Regular	Irregular	Irregular/ Non structural
Inflammation within the lesion Yes/No	No	Yes	Yes	Yes

The FACILE (Frankfurt Advanced Chromoendoscopic IBD Lesions) classification was developed and validated to assess IBD lesions using virtual chromoendoscopy. It evaluates four characteristics (morphology, surface architecture, vessel architecture, inflammation within the lesion) which can be applied together to predict histology. *Abbreviations: SSLs: sessile serrated lesions; LGD: low-grade dysplasia; HGD: high-grade dysplasia.* [16]

Abbreviations

DCE, Dye Chromoendoscopy; FACILE, Frankfurt Advanced Chromoendoscopic IBD LEsions classification; HGD, high grade dysplasia; HP, hyperplastic; IBD, inflammatory bowel disease; IQR, interquartile range; i-Scan-OE, i-scan optical enhancement (PENTAX Medical); LCI/BLI, linked colour imaging and blue laser imaging (Fujifilm Corporation); LGD, low grade dysplasia; NBI, narrow band imaging (Olympus Medical); REDCap, Research Electronic Data Capture; SCENIC, Surveillance for Colorectal Endoscopic Neoplasia detection and management in Inflammatory bowel disease patients: international Consensus recommendations; SSL, sessile serrated lesion; VCE, Virtual Chromoendoscopy; UK, United Kingdom