Curr Treat Options Gastro (2019) 17:99–114
DOI 10.1007/s11938-019-00220-x

Optical Diagnosis of Colorectal Polyps: Recent Developments

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Published online: 12 February 2019

Electronic supplementary material
This article is part of the Topical Collection on *Colon*
The online version of this article (https://doi.org/10.1007/s11938-019-00220-x) contains supplementary material, which is available to authorized users.

Keywords Optical diagnosis · Endoscopy · Colonoscopy · Colorectal cancer · Colorectal polyps · Deep learning · Resect and discard

Abbreviations *AI* Artificial intelligence · *ASGE* American Society for Gastrointestinal Endoscopy · *CAD* Computer-aided diagnostic · *BLI* Blue light imaging · *ESGE* European Society of Gastrointestinal Endoscopy · *FICE* Fujinon intelligent color enhancement · *FIT* Fecal immunochemical test · *NBI* Narrow-band imaging · *NIHCE* National Institute for Health and Care Excellence · *NICE classification* NBI International Colorectal Endoscopic Classification · *NPV* Negative predictive value · *OE* Optivista optical enhancement · *SSP* Sessile serrated polyp · *SSA* Sessile serrated adenoma

Abstract

Purpose of review Optical diagnosis of diminutive colorectal polyps has been recently proposed as an alternative to histopathologic diagnosis. Recent developments in imaging techniques, new classification systems, and the use of artificial intelligence have allowed for increased viability of optical diagnosis. This review provides an up-to-date overview of optical diagnosis recommendations, classifications, outcomes, and recent developments.

Recent findings There are currently seven major classification systems and three major society recommendations for quality benchmarks for optical diagnosis of diminutive polyps. The NICE classification has been extensively studied and meets quality benchmarks for most imaging techniques but does not allow for the diagnosis of sessile serrated polyps (SSPs). The SIMPLE classification has met quality benchmarks for NBI and i-Scan and allows for the diagnosis of SSPs. Other classification systems need to be further studied to validate effectiveness. Computer-assisted diagnosis of colorectal polyps is a very promising recent development with first studies showing that society-recommended quality benchmarks for real-time colonoscopies on patients are being met. Limitations include a non-negligible percentage of failure to diagnose, low specificity, and low number of real-time diagnostic studies. More research needs to be performed to further understand the value of artificial intelligence for optical polyp diagnosis.

Summary Optical diagnosis of diminutive colorectal polyps is currently a viable strategy for experienced endoscopists using validated classifications and imaging-enhanced endoscopy. Artificial intelligence–based diagnosis could make optical diagnosis widely applicable but is currently in its early developmental stage.

Introduction

Histopathology examination for diminutive (smaller or equal to 5 mm) or small (smaller or equal to 10 mm) colon polyps is costly and time-consuming [1]. The malignancy potential of diminutive colon polyps is extremely low, with less than 2% having advanced histology, and approximately 0.05% of them containing high-grade dysplasia or neoplasia [2, 3]. Small colon polyps have a higher potential for malignancy with up to 7% showing advanced histology [2, 3]. Histological evaluation of such polyps could potentially be replaced with image-enhanced optical diagnosis to predict pathology for colon polyps during a colonoscopy exam. This approach is named *resect and discard strategy* and could provide significant cost savings for colonoscopy practice [1, 4]. Multiple gastroenterology societies have recommended the implementation of optical polyp diagnosis as long as specific requirements are being met (Table 1) [5••, 6••, 7••]. Optical diagnosis is done using validated classifications that use color, vascular pattern, and other criteria [8•, 9••, 10•, 11].

With the recent progress of image-enhanced endoscopy, classification systems and artificial intelligence optical diagnosis of polyps have potentially gained new traction for widespread clinical implementation. The purpose of this review is to provide an overview of the optical diagnosis classifications, outcomes, and recent developments in the field.

Society recommendations

Society recommendations are summarized in Table 1.

ASGE recommendations

For diminutive polyps to be discarded without histological assessment, the American Society for Gastrointestinal Endoscopy (ASGE) recommends a higher than 90% agreement with surveillance intervals based on pathology and a negative predictive value above 90% [5••]. Recent meta-analyses have shown that in the hands of experienced endoscopists, real-time optical diagnosis of colorectal polyps provides 93% agreement with surveillance intervals based on histopathology, and a negative predictive value of over 90% [12•, 13•]. A more recent randomized control trial following five endoscopists found that ASGE thresholds are met in the second half of their study for both standard-view and close-view colonoscopies for high-confidence diagnoses [14]. High-confidence diagnosis rate was 85.1% and 72.6% in the close-view and standard-view categories respectively.

Table 1. Society recommendations for optical diagnosis

Society	Imaging system	Quality benchmarks	Endoscopist requirements	Further recommendations
ASGE	NBI	"Diagnose and leave": NPV ≥ 90% "Resect and discard": Concordance with surveillance intervals ≥ 90%	-Trained in imaging technologies	-Diagnoses made with high confidence
ESGE	NBI i-Scan FICE	–	-Trained in optical diagnosis -Audited	-Extensive photo documentation
NIHCE	NBI i-Scan FICE	–	-Audited -Receive feedback on performance	-Diagnoses made with high confidence -HD virtual chromoendoscopy equipment

ASGE, American Society for Gastrointestinal Endoscopy; *ESGE*, European Society for Gastrointestinal Endoscopy; *NIHCE*, National Institute for Health and Care Excellence; *HD*, high definition

While overall ASGE recommendations are being met or surpassed, outcomes at the endoscopist level can be somewhat different. In the same study, one endoscopist did not reach ASGE recommendations for close-view colonoscopies and another did not meet recommendations for standard-view colonoscopies [15]. Results are similar in a recent prospective study ($N = 27$ endoscopists), where ASGE thresholds were met overall but only 59% of endoscopists managed to reach that threshold [15]. While overall results from adequately trained endoscopists are promising, the capacity to meet ASGE recommendations for adopting resect and discard strategies still varies widely based on endoscopist skill [14, 15]. It is therefore important to adequately train endoscopists in optical diagnosis and find ways to improve NPV and concordance with pathology before histopathological diagnosis can be replaced. Teaching modules have been found to be effective in improving untrained endoscopist skill and achieving required thresholds [16–18]. It would be possible to institute yearly training seminars for optical diagnosis or performance to ensure adequate outcomes. ASGE thresholds are currently being generally met when using NBI imaging. The ASGE currently recommends the use of NBI for optical diagnosis and resect and discard strategies [5••]. FICE and i-Scan show potential according to the ASGE, but the data is insufficient to make recommendations for their use [5••].

ESGE recommendations

The European Society of Gastrointestinal Endoscopy (ESGE) currently recommends the use of NBI, i-Scan, FICE, and conventional chromoendoscopy for the optical diagnosis of diminutive colorectal polyps as a replacement for histopathologic diagnosis [6••]. It further advises that optical diagnosis should only be done in strictly controlled environment by experienced, trained, and audited endoscopists using validated scales for diagnosis. Extensive photo documentation should also be performed when attempting optical diagnosis [6••]. No recommendations as to quality metrics such as accuracy or NPV were suggested by the ESGE.

National Institute for Health and Care Excellence recommendations

The National Institute for Health and Care Excellence (NIHCE) emitted recommendations in 2017 on the optical diagnosis of colorectal polyps [7••]. It recommends the use of NBI-, FICE-, or i-Scan-based diagnosis as a replacement for histopathology for high-confidence diagnoses using high-definition virtual chromoendoscopy equipment by endoscopists trained in the use of virtual chromoendoscopy. The endoscopists must also be audited and receive ongoing feedback on their performance [7••]. The recommendations did not include specific quality metrics for endoscopist performance. Following these recommendations, an optical diagnosis implementation group was formed joining the British Society of Gastroenterology, Joint Advisory Group and Association of Coloproctology of Great Britain and Ireland to implement these recommendations in the UK.

Diagnose and leave strategy for optical diagnosis

As opposed to "resect and discard" strategies where polyps are resected regardless of pathology, the "diagnose and leave" strategy involves refraining from removing benign rectosigmoid polyps. Benefits of this strategy include the elimination of need for pathology examination of polyps and reduction of the amount of interventions done on patients. The major downside is the potential for misdiagnosis leaving adenomas in patients. To avoid this, endoscopists would need to achieve high NPV for adenomas during diagnosis.

Regardless of guideline recommendations, this strategy is routinely used by endoscopists in clinical practice based on patients' clinical situation [19]. The ASGE states that for rectosigmoid polyps to be left in the colon without resection, diagnostic technologies should have a NPV ≥ 90% for adenomas. They further state that NBI diagnosis performs sufficiently well to support the use of "diagnose and leave" strategy for rectosigmoid polyps [5••]. No specific recommendations have been made by the ESGE and NIHCE for "diagnose and leave" strategy [6••, 7••].

Optical classifications of polyps

To standardize optical diagnosis of colorectal polyps, multiple classifications are used to categorize polyps during colonoscopy (Table 2). Newly developed imaging techniques have allowed for the creation of diagnostic criteria adapted to them. Differentiation between hyperplastic polyps, adenomas, and sessile serrated polyps (SSPs) has recently led to newer classification systems to recognize such lesions (Fig. 1) [20].

NICE classification

The NBI International Colorectal Endoscopic Classification was developed and validated in 2012 for the classification of diminutive and small colon polyps based on narrow-band imaging [9••]. It uses color and vascular and surface patterns to distinguish between adenomatous and hyperplasic polyps (Supplemental table 1). One limitation for the use of this classification is that it does not include criteria for the diagnosis of SSPs. When applied to FICE imaging technique, the NICE classification was shown to have lower overall concordance with pathology [21]. This can partly be explained by the color criterion of the NICE classification, poorly adapted for FICE imaging as suboptimal contrast

Table 2. Summary of classifications

Classification	Year	Imaging technique used	Includes SSP criteria	Can differentiate SSA from SSP
NICE	2012	NBI	No	No
WASP	2016	NBI	Yes	No
SIMPLE	2018	i-Scan, NBI	Yes	No
Hiroshima	2009	NBI	No	No
JNET	2016	High-magnification NBI	No	No
BASIC	2018	Blue light	No	No
SANO	2006	NBI	No	No

SSA, sessile serrated adenoma; *SSP*, sessile serrated polyp

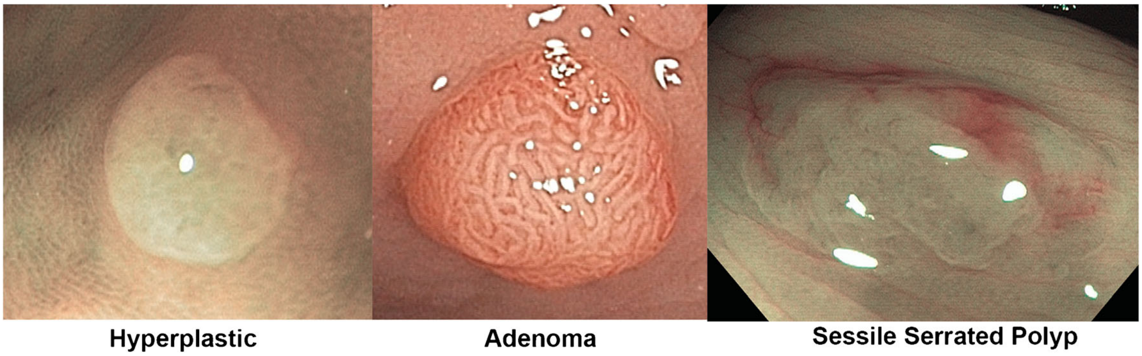

Fig. 1. Polyp appearance under HDWL.

does not show adenomas as much browner than their surroundings.

WASP classification

More recently, the Workgroup on serrAted polypS and Polyposis (WASP) developed a classification to help the endoscopic differentiation of hyperplastic polyps from SSPs [8•]. This method is based on pre-existing NICE classification criteria. As soon as one of three adenoma features of the NICE classification is recognized, a type 2 polyp diagnosis can be made. Thereafter, criteria for sessile serrated adenomas are used to distinguish SSPs from hyperplastic polyps and SSPs from adenomas respectively in type 1 and 2 polyps. The presence of two of these criteria (clouded surface, indistinctive border, irregular shape, dark spot inside crypts) is considered sufficient to diagnose SSPs (Fig. 2) [8•].

Diagnostic accuracy for high-confidence diagnoses after training and 6 months of classification usage reached 84% (95% CI, 81 to 88) with a NPV of 91% (95% CI, 83 to 96). Diagnostic accuracy for high-confidence diagnoses of serrated adenomas and polyps reached 91% (95% CI, 88 to 94) [8•]. The WASP classification provides a valid alternative to the NICE classification with the added benefit of high diagnostic accuracy for SSPs.

SIMPLE classification

A recent classification system was validated in 2018 on both i-Scan and NBI [10•]. This classification has the advantage of providing criteria for the diagnosis of SSPs such as irregular/indistinctive lesion border and open/dilated dark pits (Supplemental table 2). Overall accuracy reached 94% (95% CI, 89 to 97%) and NPV reached 91% (95% CI, 78 to 98%) meeting the ASGE thresholds after the endoscopists have been properly trained. For high-confidence diagnoses after training, diagnostic accuracy met ASGE thresholds but NPV fell slightly short at 89% (95% CI, 73 to 96%) [10•]. A third of polyps studied were SSPs, indicating that this classification potentially performs well when differentiating these polyps from hyperplastic histology.

Hiroshima classification

Published in 2009, this classification was developed using NBI and uses microvasculature and pit pattern to determine histological type of polyps [22]. The classification allows for the differentiation between hyperplastic polyps (type A), tubular adenoma (type B), and carcinoma (type C) but does not provide criteria for the diagnosis of SSPs (Supplemental table 3). The classification performs well for the diagnosis of hyperplastic polyps (type A) and carcinoma with submucosal massive invasion using the type C3 subtype but falls short on accuracy and NPV for types B, C1, and C2 [23, 24].

JNET classification

Published in 2016, this classification is developed using high magnification NBI based on the previously developed NICE classification. It differs mainly through the separation of low-grade dysplasia and high-grade dysplasia/shallow submucosal invasive cancer categories allowing for the differentiation between both lesion types (Supplemental table 4) [11]. The classification combines hyperplastic polyps and SSPs into a single category, and therefore does not allow for differentiation between these two types. Recent validation initiatives have shown that JNET performs well for the diagnosis of hyperplastic polyps/SSPs (type 1), low-grade intramucosal neoplasia (type 2A), and deep submucosal invasive cancer (type 3) [25, 26]. However, it performs poorly for the diagnosis of high-grade intramucosal neoplasia/superficial submucosal invasive cancer (type 2B) and should therefore not be used as a sole diagnostic method for these types of lesions [25, 26].

BASIC classification

Based on blue light imaging (BLI), the classification was published in 2018 to allow for the differentiation of hyperplastic polyps, adenomas, and neoplasia (Supplemental table 5) [27]. Initial study is restricted to evaluating interobserver agreement for the criteria for hyperplastic and adenomatous polyps. Further studies need to measure the in vivo accuracy and NPV of these criteria and further develop criteria for the diagnosis of SSPs and neoplastic lesions [27].

SANO classification

Developed as a follow-up to the KUDO classification, the SANO classification is based on NBI and uses capillary pattern to distinguish between hyperplastic polyps (type I), adenomas (type II), and carcinoma (type III) (Supplemental table 6) [28]. The classification does not allow for diagnosis of SSPs. The classification was further validated and able to attain high accuracy for experienced endoscopists for type II and II classifications but fails at reaching thresholds for type IIIA and type IIIB differentiation [29–32]. SANO classification also reaches thresholds for accuracy and NPV for the diagnosis of neoplastic vs non-neoplastic polyps [33].

Imaging techniques

Advancement in endoscopic imaging techniques has allowed for better diagnostic accuracy of polyps during colonoscopies. These imaging tools perform differently based on the classification system used for diagnosis (Table 3).

Near-focus viewing

Higher image magnification during endoscopy has allowed for better detail resolution when making

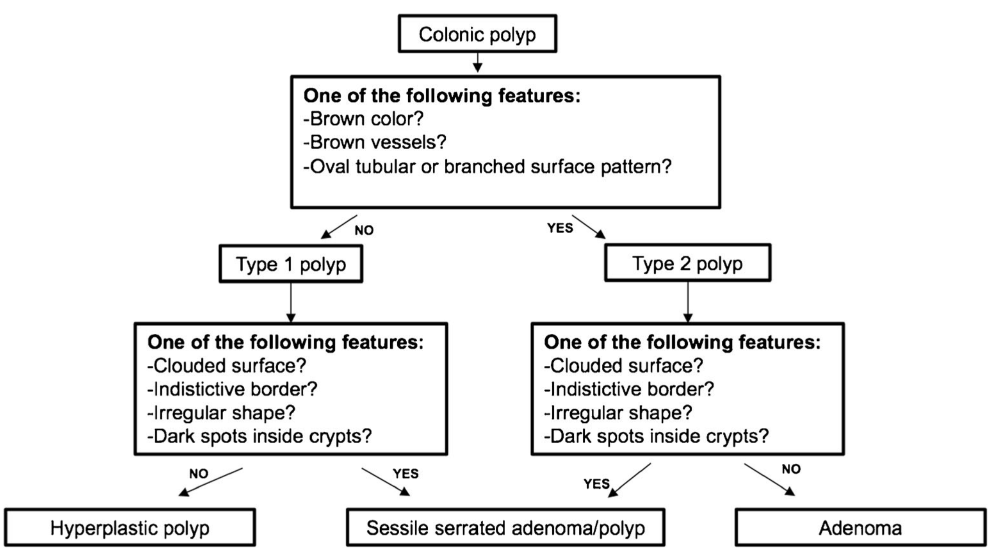

Fig. 2. WASP classification adapted from IJspeert et al., permission granted by BMJ Publishing Group.

Table 3. Quality benchmarks achievement (as defined by ASGE guidelines) for imaging techniques based on classification

Imaging technique	Quality benchmark achieved for specific classification?						
	NICE	**WASP**	**SIMPLE**	**Hiroshima**	**JNET**	**BASIC**	**SANO**
NBI	Yes [5••]	NPV only [8•]	Yes [10]	Partial‡ [23, 24]	Yes‡‡ [27]	–	Partial†† [29–33]
i-Scan	Yes [34, 35]	–	Yes [10]	–	–	–	–
FICE	No	–	–	–	–	–	–
BLI	Yes [36]	–	–	Accuracy only† [37]	NPV only [38]	–	–
Optivista OE	Yes [39]	–	–	–	–	–	–

‡Accuracy for type A; accuracy and NPV for type C3
‡‡Except for type 2B
†Except for types C1, C2
††Accuracy for types 2, 3; accuracy and NPV for neoplastic vs non-neoplastic differentiation

optical diagnoses. A 2015 single-blind randomized clinical study determined that endoscopists were more likely to make high-confidence optical diagnoses of diminutive polyps using near-focus view (× 65 magnification) when compared with standard view (× 35 magnification) [40]. Diagnoses were also more concordant with pathology-based surveillance guidelines (93.5%) and had higher negative predictive value (96.4%) using near-focus view [40].

Narrow-band imaging

Narrow-band imaging (NBI) involves the use of restricted light spectrum to observe intestinal mucosa. Red wavelength light is eliminated through optical filters while blue and green wavelengths remain. This allows for better visualization of vasculature on intestinal mucosa [41]. While in theory this should allow for improved diagnostic capacity during endoscopy, recent studies only show a slight superiority over standard endoscopy and no improved accuracy over high-definition endoscopy [42, 43]. NBI remains an important tool in the endoscopist's belt however as polyp diagnostic classifications such as NICE and WASP have been standardized using this imaging process (Fig. 3).

i-Scan

Developed by Pentax (Tokyo, Japan), this technology allows for the manipulation of red, blue, and green lights to highlight different aspects of surface mucosa. It can be used in three different modes: surface enhancement, contrast enhancement, and tone enhancement. Recent studies show that this technology is superior to high-definition white light for the diagnosis and detection of polyps and is capable of meeting ASGE guideline thresholds [44–46]. With the spread of this technology into mainstream endoscopy, newer optical classifications such as the SIMPLE classification have standardized their diagnostic criteria to this imaging technique [10•].

Optivista optical enhancement

A new optical enhancement technology developed by Pentax (Tokyo, Japan). It uses specific filters to restrict for light that matches hemoglobin wavelength emission pattern. This allows for high contrast between mucosa vasculature and its surrounding, potentially improving optical diagnosis. So far, one prospective multicenter trial has been published and showed that Optivista optical enhancement

(OE) reached ASGE guideline thresholds while using the NICE classification [39]. Further studies need to be performed to further validate this technology for optical diagnosis.

Fujinon intelligent color enhancement (FICE)

Also known as multi band imaging (MBI), this visualization technique foregoes the use of filters, instead processing the image through software algorithms. This allows for the selection of three specific wavelengths and reconstruction of the image by superimposing those wavelengths [41].

Blue laser imaging

Blue laser imaging technology utilizes two different lasers (blue, 410 nm, white, 450 nm) at different intensities to highlight polyp mucosa and vasculature. One multicenter study based on polyp images found moderate success with blue laser imaging (BLI) using the NICE classification (accuracy 85.3%, NPV 78.1%) [47]. For real-time diagnosis, BLI reached ASGE thresholds in one study and came close in another [36, 48]. The main limiting factor for studies testing BLI capabilities is the usage of classification systems such as NICE that are not optimized for blue light. Newer classification systems in development could provide potential improvements in the BLI diagnosis of polyps [27].

Fluorescence endoscopy

Recent developments in the field fluorescence endoscopy have allowed for the use of intravenous or topical fluorescent molecular binding agents that can link to specific genes expressed in neoplastic or preneoplastic colon cells. This fluorescent light would then be detected during endoscopy, and polyps emitting the light would be removed. In one instance, the c-MET gene was targeted for fluorescence and allowed for the identification of some adenomas that were not detectable using white light alone [49]. In another study, a topical fluorescent peptide targeting a BRAF gene mutation was used to distinguish sessile serrated polyps (SSPs) from hyperplastic polyps with an 89% sensitivity and 92% specificity [50]. The use of fluorescent molecular binding agents and the discovery of specific genes expressed in adenomatous and neoplastic colon cells would therefore allow for increased efficacy for the optical diagnosis of colorectal polyps and decreased rate of missed polyps. However, further research still needs to be performed to bring this emerging technique to maturity.

Automatic and computer-assisted diagnosis

Autofluorescence

New techniques are being developed utilizing laser-induced fluorescent spectroscopy for automatic optical diagnosis of polyps using special devices. Through this technique, a device (WavSTAT4, SpectraScience, San Diego, USA) integrated into a single-use biopsy forceps emits light that is absorbed by polyps and reemitted towards the device with an emission spectrum unique to the tissue. The device

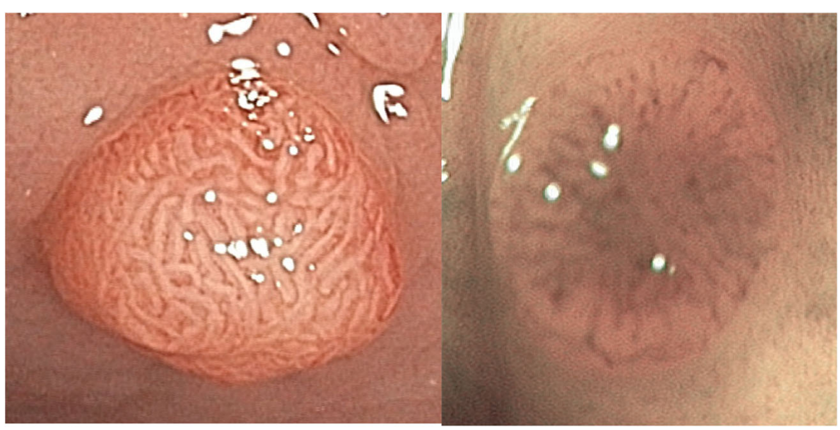

Fig. 3. Adenoma under NBI and HDWL.

Table 4. Characteristics of studies with artificial intelligence–assisted diagnosis

Studies	Imaging	Classification	Patients (*N*)	Polyps (*N*)	Videos/images/ real-time*	Cohort with HGD	Cohort with SSP	Can differentiate between LGD/HGD/SSP/SSA
Mori et al. 2015 [53]	EC	KUDO	152	176	Images	Yes	No	No
Kominami et al. 2016 [54•]	NF-NBI	Hiroshima**	41	118	Real-time	Unclear	No	No
Misawa et al. 2016 [55]	EC	Database learning	–	100	Images	Yes	No	No
Mori et al. 2016 [56]	EC	KUDO	123	205	Images	Yes	No	No
Byrne et al. 2017 [57]	NF-NBI	NICE***	–	125	Videos	Unclear	No	No
Komeda et al. 2017 [58]	WL, NBI, CRE	Database learning	–	10	Images	Unclear	No	No
Zhang et al. 2017 [59]	WL, NBI	NICE	–	150	Images	Unclear	No	No
Chen et al. 2018 [60]	NF-NBI	NICE***	193	284	Images	Yes	No	No
Mori et al. 2018 [61•]	EC, NBI	Database learning	325	466	Real-time	Yes	Yes	No

EC, endocytoscopy; *NF*, near focus; *NBI*, narrow-band imaging; *WL*, white light endoscopy; *CRE*, chromoendoscopy; *LGD*, low-grade dysplasia; *HGD*, high-grade dysplasia; *SSA*, sessile serrated adenoma; *SSP*, sessile serrated polyp

*Videos/images are defined as retrospective diagnosis on images or videos from previous colonoscopies. Real-time is defined as making diagnoses during colonoscopies

**Class B and C were combined for diagnosis

***Only polyp types 1 and 2 were used for diagnosis, type 3 was not used

Table 5. Performance for artificial intelligence–assisted diagnosis

Studies	Polyps (N)	Sensitivity (%)	Specificity (%)	Accuracy (%)	NPV (%)	Failed to diagnose (%)	Low confidence (%)
Mori et al. 2015 [53]	176	92.0	79.5	89.2	–	4.5	–
Kominami et al. 2016 [54•]	118	95.9	93.3	94.9	93.3	0	4.2
Misawa et al. 2016 [55]	100	84.5	97.6	90	82	0	35
Mori et al. 2016 [56]	205	89	88	89	76	3.4	20
Byrne et al. 2017 [57]	125	98	83	94	97	15	–
Komeda et al. 2017 [58]	10	–	–	70	–	0	–
Zhang et al. 2017 [59]	150	–	–	85.9	–	–	–
Chen et al. 2018 [60]	284	96.3	78.1	90.1	91.5	0	–
Mori et al. 2018 [61•]	466	92.7‡ 93.3‡‡	89.8‡ 91.0‡‡	91.6‡ 92.7‡‡	88.3‡ 89.9‡‡	1.9	–

‡Worst-case scenario NBI mode
‡‡Best-case scenario NBI mode

then analyses that spectrum and color codes adenomatous polyps in red and non-adenomatous polyps in green [51]. This technique therefore bypasses endoscopist training requirements for optical diagnosis as no interpretation of imaging is needed for the diagnosis to be made. Newer iterative designs have been found to almost meet ASGE thresholds for the optical diagnosis of polyps in a small prospective study with a NPV of 96.1% and agreement with surveillance guidelines of 88.9% [52]. Next steps would involve performing larger multicenter randomized control trials to better assess the accuracy of these techniques and validate current results. Limitations include the cost associated with the diagnostic probe, since its integration into single-use forceps means that a new device needs to be used for every patient. This technique nevertheless proves promising in eliminating the problem of endoscopist skill limitations for the real-time diagnosis of polyps if it can be validated.

Artificial intelligence/ deep learning

A recent development in the field of optical diagnosis involves the use of deep learning and artificial intelligence to process images and assist in diagnosing lesions (Tables 4 and 5). These neural networks are trained using tens of thousands of images of polyps from databases to differentiate between hyperplastic and adenomatous polyp characteristics. Current studies based on colonoscopy videos or still images reveal that these neural network models can predict polyp pathology with accuracies varying from 70 to 96%, with some models achieving NPVs of over 90% [53–60, 62]. Deep learning models are capable of identifying polyps that are missed during colonoscopies, potentially increasing adenoma detection rates and optical diagnosis accuracy for endoscopists while being largely operator independent [62].

Real-time diagnosis of polyps with artificial intelligence assistance has already been achieved in some studies, with one study reaching ASGE thresholds for the diagnosis of all polyps regardless of size and the diagnosis of only diminutive polyps [54•]. A larger ($N = 466$ polyps) prospective study performed real-time computer-aided diagnostic (CAD) colonoscopies using ×520 magnification endocytoscopes [61•]. Polyps lacking CAD or pathology diagnosis were considered as false positives in scenario A (worst-case scenario), and were excluded in scenario B (best-case). ASGE thresholds were met for rectosigmoid polyps in both scenarios; however, the device performed poorly for proximal-to-sigmoid polyps [61•]. These results are a promising start for in vivo diagnosis of rectosigmoid polyps but should be improved upon to allow for high diagnostic efficacy throughout the colon.

Yet, there are several limitations for the widespread adoption of this new diagnostic tool. Most current studies are based on pre-recorded videos and images of previously performed colonoscopies and few include real-time diagnosis during colonoscopies on actual patients. Diagnostic accuracy and NPV are calculated based on a small number of polyp diagnoses for most studies. Many studies excluded SSPs from their cohorts making computer-assisted diagnosis a poor choice for these lesions until it can be validated. Current technology does not allow for the differentiation of low-grade and high-grade dysplasias as they are combined in the "adenoma" category. Since surveillance intervals for low-grade dysplasia are different than those for high-grade dysplasia according to guidelines, it would be helpful to predict such high-risk features in the future [63]. There is also a lack of large randomized multicenter trials to further validate this method as a viable alternative for pathology-based diagnosis or endoscopist-based diagnosis. Deep learning is still in its nascent stage but could potentially revolutionize the optical diagnosis of polyps, leading to operator-independent diagnosis and widespread clinical implementation.

Discussion

The current practice for colorectal cancer screening colonoscopies is histopathologic evaluation of all resected polyps. Advancement in imaging techniques has allowed for optical diagnosis of polyps and adoption of "resect and discard" and "diagnose and leave" strategies. Current guidelines agree that optical diagnosis should be performed by trained endoscopists with high-confidence diagnoses. The need for frequent auditing and feedback has also been stated. The ASGE has also recommended further quality thresholds such as concordance with surveillance intervals and NPV above 90% for the elimination of the need for histopathologic evaluation of polyps. ASGE, ESGE, and NIHCE guidelines agree that optical polyp diagnosis can be performed with NBI; however, ESGE and NIHCE guidelines further state that i-Scan and FICE can be used.

The use of "resect and discard" strategy still faces several limitations. Widespread adoption is currently limited and achieving quality standards proves to be difficult for some endoscopists. Some classification systems do not allow for the diagnosis of SSPs and none allow to differentiate between low- and high-grade adenomas or SSP versus SSA. This proves to be a major limitation since surveillance intervals can be different based on these high-risk features and incorrect surveillance interval assignment will result from it. The ability to differentiate between low-grade and high-grade polyp histologies might also be more important for FIT-based cohorts since higher rates of advanced histology within the diminutive polyp group can be found. Deep learning–assisted and computer-assisted based strategies show potential in leveling the playing field for different endoscopist training levels and skills for optical diagnosis but are also currently unable to make the SSA versus SSPs, or low-grade versus high-grade adenoma differentiation. Most studies do not include real-time diagnosis during colonoscopies and do not meet ASGE thresholds for diagnosis. Specificity is also low in most studies. The use of computer-assisted diagnosis is currently limited but will expand with further research and development.

Conclusions

The field of optical diagnosis is advancing with new society guidelines, classifications, and imaging techniques in development. Quality metric thresholds are being reached for NBI with further research and training still required for other imaging techniques. Automatic computer-aided diagnosis of polyps is emerging with the rise of autofluorescence and artificial intelligence/deep learning–assisted optical diagnosis. Deep learning is still in its nascent stage and further research is needed to better understand its value for widespread clinical implementation of optical polyp diagnosis.

Author contributions

Roupen Djinbachian: literature review, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content.
Anne-Julie Dubé: analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content.
Daniel von Renteln: study concept and design, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content.

Compliance with Ethical Standards

Conflict of Interest
Roupen Djinbachian declares that he has no conflict of interest. Anne-Julie Dubé declares that she has no conflict of interest. Daniel von Renteln is supported by a "Fonds de Recherche du Québec Santé" career development award and has received consultation fees from Boston Scientific and research funding from ERBE, Ventage and Pentax.

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Papers of particular interest, published recently, have been highlighted as:

- • Of importance
- •• Of major importance

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