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Endoscopist factors that influence serrated polyp detection: a multicenter study

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ABSTRACT

Background Serrated polyps are important colorectal cancer precursors that are variably detected during colonoscopy. We measured serrated polyp detection rate (SPDR) in a large, multicenter, cross-sectional study of colonoscopy quality to identify drivers of SPDR variation.

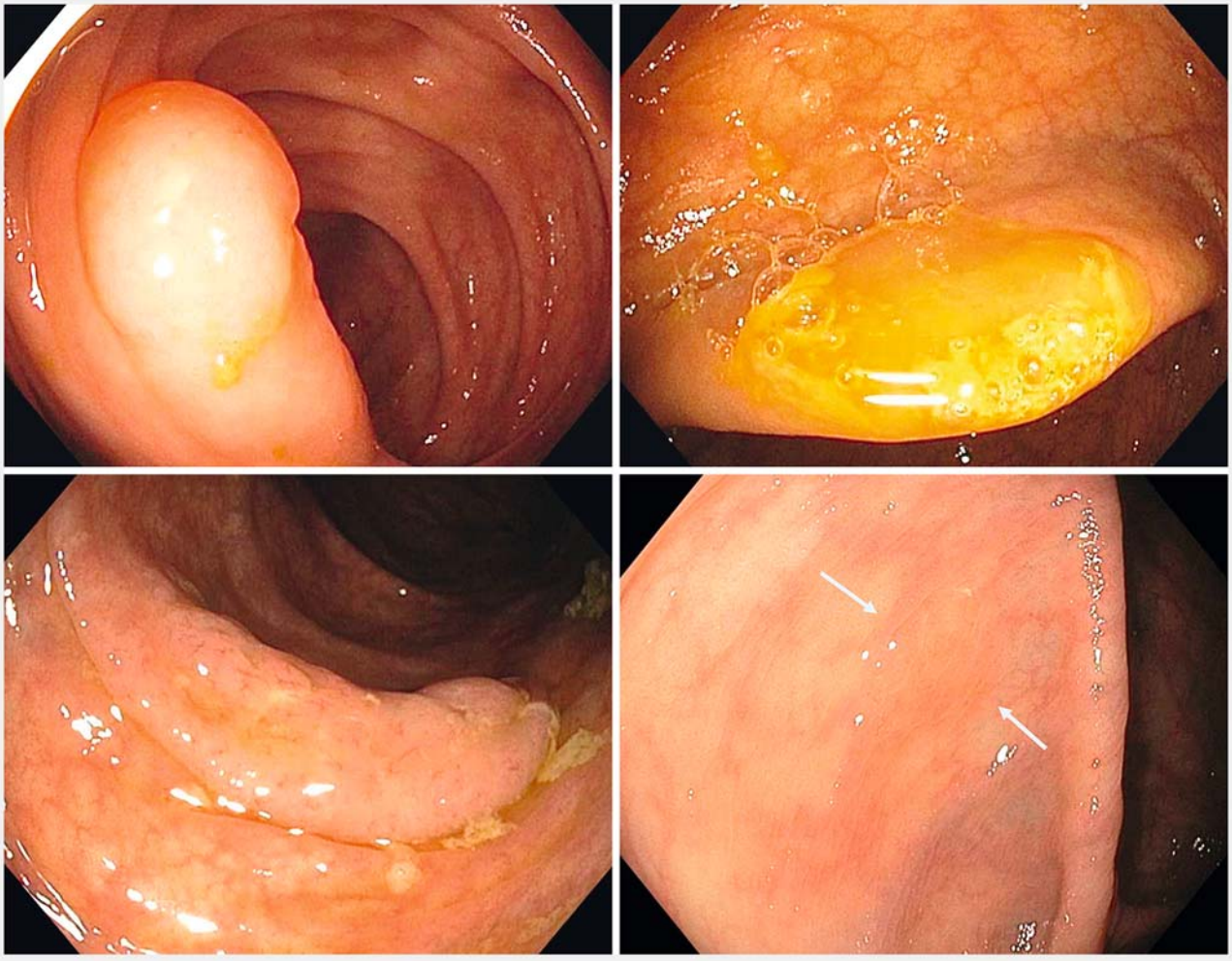
Methods Colonoscopy and pathology reports were collected for a 2-year period (10/2013-9/2015) from four sites across the United States. Data from reports, including size, location, and histology of polyps, were abstracted using a validated natural language processing algorithm. SPDR was defined as the proportion of colonoscopies with ≥ 1 serrated polyp (not including hyperplastic polyps). Multivariable logistic regression was performed to determine endoscopist characteristics associated with serrated polyp detection.

Results A total of 104 618 colonoscopies were performed by 201 endoscopists who varied with respect to specialty (86 % were gastroenterologists), sex (18 % female), years in practice (range 1 – 51), and number of colonoscopies performed during the study period (range 30 – 2654). The overall mean SPDR was 5.1 % (SD 3.8 %, range 0 – 18.8 %). In multivariable analysis, gastroenterology specialty training (odds ratio [OR] 1.89, 95 % confidence interval [CI] 1.33 – 2.70), fewer years in practice (≤ 9 years vs. ≥ 27 years: OR 1.52, 95 %CI 1.14 – 2.04)], and higher procedure volumes (highest vs. lowest quartile: OR 1.77, 95 %CI 1.27 – 2.46)] were independently associated with serrated polyp detection.

Conclusions Gastroenterology specialization, more recent completion of training, and greater procedure volume are associated with serrated polyp detection. These findings imply that both repetition and training are likely to be important contributors to adequate detection of these important cancer precursors. Additional efforts to improve SPDR are needed.

Introduction

Serrated polyps of the colorectum are responsible for up to 30 % of sporadic cases of colorectal cancer [1]. Among serrated polyps, sessile serrated polyps (SSPs) are of particular importance. SSPs are the most common premalignant serrated polyp, and are distinct from conventional adenomas in terms of their morphology and endoscopic features, histology, biology, and behavior [2]. SSPs are detected poorly by screening tests such as fecal immunochemical testing and computed tomography colonography [3], and colonoscopic detection is highly variable [4]. SSPs are believed to be important drivers of interval colo-



▶ **Fig. 1** Endoscopic images of four proximally located sessile serrated polyps, showing flat or sessile morphology and subtle surface features.

rectal cancers, supported by evidence that they share molecular features with these cancers [5–8], and are predominantly located in the proximal colon [9], where interval cancers are more likely to occur.

SSPs can be difficult to detect via colonoscopy because of their subtle endoscopic appearance [10] and proximal location (▶ **Fig. 1**). Multiple studies have demonstrated wide variation in the detection of SSPs both across endoscopists and centers [4, 11–13], but the determinants of this variation are unclear. Whereas some studies have linked SSP or proximal serrated polyp detection to procedural factors, such as withdrawal time [12] and bowel preparation [14], it is unclear to what extent physician factors, such as experience and procedure volume, may be responsible for differences in SSP detection. Better understanding of the drivers of poor SSP detection could help tailor colonoscopy quality improvement efforts.

We aimed to measure endoscopic detection rates of serrated polyps in a large, multicenter cross-sectional study of colonoscopy quality to assess possible contributors to variation in serrated polyp detection across physicians.

Methods

Study design and settings

This was a multicenter, cross-sectional study of colonoscopy quality at four US clinical sites that vary in geography, payment model, and academic vs. private affiliation. Kaiser Permanente Washington (KPW, formerly Group Health Cooperative) is a staff model health maintenance organization based in Washington State with 18 gastroenterologists on staff. Central Illinois Endoscopy (CIE) is a private endoscopy center with 11 gastroenterologists in Peoria, Illinois. The University of North Carolina (UNC) is an academic center with 53 gastroenterologists. University of Pittsburgh Medical Center (UPMC) is based in Western Pennsylvania, with 46 gastroenterologists in its three primarily academic hospitals, and 73 gastroenterologists in affiliate hospitals and private practices. This study was approved by the institutional review boards at all participating centers.

Colonoscopy and pathology reports

Colonoscopy and pathology reports were collected for a 2-year period (10/2013 – 9/2015) from all four sites. The study sample was limited to outpatient colonoscopies performed on patients aged ≥ 40 years without inflammatory bowel disease. We excluded colonoscopies performed by physicians who performed fewer than 30 colonoscopies over the study period.

Measurement of colonoscopy quality and serrated polyp detection

We extracted relevant data from the colonoscopy and pathology reports using a previously developed natural language processing (NLP) system [15, 16]. Relevant information from the colonoscopy and pathology notes were abstracted using a validated NLP algorithm, including histology, size, and location of polyps [16 – 18]. Detailed study methods have been published previously [17, 18]. The accuracy of the NLP system was confirmed by comparing specific data elements in 2127 colonoscopy and associated pathology reports, which were analyzed both by the NLP system and manually abstracted. The NLP system extracted multiple discrete variables from each colonoscopy report including family history of CRC, documentation of cecal intubation and visualization of the appendiceal orifice and ileocecal valve, whether there was a prior colonoscopy, indication for procedure (screening, surveillance, or diagnostic), quality of bowel preparation, whether a biopsy or polypectomy was performed, and size of the largest polyp identified. From the pathology reports, for each specimen bottle the NLP system identified the colonic location from which the specimen was obtained, presence of an adenoma, presence of a serrated polyp, and presence of villous changes, high grade dysplasia, or carcinoma in any specimen. Proximal colon was defined as proximal to the splenic flexure or > 50 cm from the anal verge, and distal colon was defined as between the splenic flexure and the anal verge or ≤ 50 cm from the anal verge.

Colonoscopies with serrated polyps were defined as any polyp in the pathology specimen that the pathologist described using the term "serrated." The serrated polyp detection rate (SPDR) was defined as the proportion of colonoscopies with ≥ 1 "serrated" polyp. The SPDR does not include reports where only hyperplastic polyps were identified and the term "serrated" was not used. We also conducted a sensitivity analysis of this definition using instead the paired terms "sessile serrated" (instead of "serrated" alone), which showed that 87 % of cases identified with the term "serrated" also included the pairing "sessile serrated." SPDR also included traditional serrated adenomas (TSAs), but because these are rare lesions (prevalence < 0.2 % in our sample) compared with SSPs, TSAs have a minimal impact on the SPDR measure. Based on manual review of a sample of these reports, our definition of SPDR had high overall accuracy (99 %), sensitivity (98 %), and positive predictive value (97 %) for SSPs [17]. SPDR in this study is analogous to the SSP detection rate reported in other studies [14, 19]. For the primary analysis, all colonoscopies were included in the denominator, but we also conducted a sensitivity analysis with the sample being limited to only screening colonoscopies.

We looked at the correlation between SPDR and other quality metrics to see whether they were similar. In addition to overall SPDR, we calculated the mean SPDR for the proximal and distal colon as the number of serrated polyps detected in that part of the colon divided by the total number of colonoscopies performed by the endoscopist. We also measured the large SPDR as the proportion of cases with one serrated polyp ≥ 10 mm in size. We calculated adenoma detection rate (ADR) as the proportion of colonoscopies where any adenoma or carcinoma was identified. We also calculated ADR in the proximal and distal colons, and the advanced adenoma detection rate, which was defined as the fraction of all colonoscopies where there was an adenoma with villous or high grade dysplastic changes, or, an adenoma at least 10 mm in size. We identified colonoscopies with an adenoma at least 10 mm in size as those where the largest polyp identified from the colonoscopy was 10 mm or greater and there was an adenoma identified on the pathology specimen. Finally, we calculated the TSA detection rate as the proportion of colonoscopies where the term "traditional serrated adenoma" was found in the associated pathology report.

Endoscopist attributes

Endoscopist attributes including age, sex, specialty, and years in practice were obtained from Doximity, a national database of physician characteristics that compiles data from the National Plan and Provider Enumeration System (NPPES), National Provider Identifier Registry, the Association of American Medical Colleges, the American Board of Medical Subspecialties (ABMS), and state licensing boards, as well as self-registered members and collaborating hospitals and medical schools. This database has been used in prior studies of the physician workforce [20, 21], and has been previously validated [22]. Furthermore, the NPPES and ABMS databases (which are used by Doximity to derive data on sex, specialty, and year of residency graduation) are considered to have high fidelity owing to obligatory participation, and have been shown to be accurate when compared with other physician databases [23, 24]. Years of practice was measured as the number of years since completion of residency, as of 2014. We stratified physicians into four roughly equal quartiles to categorize the years that they had been in practice (≤ 9 years, 10 – 18 years, 19 – 26 years, and 27 – 51 years). The rates of adequate bowel preparation were calculated as the proportion of colonoscopies that each endoscopist rated as excellent, good, fair, or adequate (vs. poor or inadequate). Procedure reports that did not include a description of bowel preparation were assumed to be adequate. Cecal intubation rate was calculated as the proportion of colonoscopies in which the endoscopist documented reaching the cecum. Bowel preparation adequacy and cecal intubation rate were dichotomized at 85 % and 95 %, respectively, according to established quality metric thresholds [25, 26].

Statistical analysis

Descriptive univariate statistics were calculated for overall SPDR, SPDR by colonic location, detection of large (≥ 10 mm) serrated polyps, and detection of TSAs. We used bivariate anal-

▶ **Table 1** Endoscopist characteristics – overall and those associated with serrated polyp detection rates above and below the median rate.

	Overall, n (%)	Below median SPDR,[1,2] n (%)	Above median SPDR,[3] n (%)	*P*
Total endoscopists	201 (100)	101 (50.3)	100 (49.8)	–
Sex				
▪ Male	164 (81.6)	84 (51.2)	80 (48.8)	0.56
▪ Female	37 (18.4)	17 (46.0)	20 (54.0)	
Primary specialty				
▪ Gastroenterology	172 (85.6)	81 (47.1)	91 (52.9)	0.03
▪ Other	29 (14.4)	20 (69.0)	9 (31.0)	
Years in practice				
▪ ≤9	53 (26.4)	26 (49.1)	27 (50.9)	0.60
▪ 10–18	49 (24.4)	22 (44.9)	27 (55.1)	
▪ 19–26	51 (25.4)	25 (49.0)	26 (51.0)	
▪ 27–51	48 (23.9)	28 (58.3)	20 (41.7)	
Number of colonoscopies per 2-year period				
▪ 30–115	51 (25.4)	39 (76.5)	12 (23.5)	<0.001
▪ 116–278	50 (24.9)	27 (54.0)	23 (46.0)	
▪ 279–771	50 (24.9)	21 (42.0)	29 (58.0)	
▪ 772–2654	50 (24.9)	14 (28.0)	36 (72.0)	
Rate of adequate bowel preparation				
▪ <0.85	8 (4.0)	4 (50.0)	4 (50.0)	0.99
▪ ≥0.85	193 (96.0)	97 (50.3)	96 (49.7)	
Cecal intubation rate				
▪ <0.95	62 (30.8)	39 (62.9)	23 (37.1)	0.02
▪ ≥0.95	139 (69.2)	62 (44.6)	77 (55.4)	

SPDR, serrated polyp detection rate.
[1] Low SPDR physicians are those with SPDR at or below the median physician SPDR (4.1 %).
[2] Percentages calculated as percentage of overall n value.
[3] Percentages calculated as percentage of overall n value.

ysis to describe the proportion of endoscopists that fell above or below the median SPDR in the sample, by endoscopist sex, specialty, years in practice, colonoscopy volume, rate of adequate bowel preparation, and cecal intubation rate. Multivariable analysis was conducted at the procedure level to identify which endoscopist characteristics were independently associated with a colonoscopy with one or more serrated polyps, after adjusting for patient characteristics and study site. Standard errors were adjusted for clustering by physician. This analysis used logistic regression to estimate odds ratios (ORs) and 95 % confidence intervals (CI) of a binary outcome of whether or not a particular colonoscopy had a serrated polyp detected. Model covariates included patient characteristics (age, sex, and colonoscopy indication), site fixed effects, as well as endoscopist characteristics (sex, specialty, years in practice, and colonoscopy volume, rate of adequate bowel preparation, and cecal intubation rate). We also conducted sensitivity analyses, limiting the sample to 1) only screening colonoscopies, and 2) only endoscopists with at least 100 procedures during the 2-year study period (≥50 per year). Finally, to determine the degree of correlation between polyp detection metrics, we calculated Pearson's correlation coefficients for each pair of outcome measures (e. g. SPDR and ADR).

Results

Study sample

A total of 104 618 colonoscopies were included in the sample, 44.8 % (46 918) of which were screening colonoscopies. The procedures were performed by 201 endoscopists of whom 85.6 % were gastroenterologists, and 14 % had training in either family medicine or general, thoracic, or colorectal surgery

▶ **Table 2** Serrated polyp detection rates across all endoscopists[1] – overall and by polyp location.

Measure, %	Mean ± SD	Median (IQR)	Range
Overall SPDR	5.1 ± 3.8	4.1 (2.4 – 7.0)	0 – 18.8
Proximal[2] SPDR	3.9 ± 3.3	3.3 (1.6 – 5.2)	0 – 15.2
Rectosigmoid SPDR	0.8 ± 0.9	0.6 (0 – 1.2)	0 – 3.9
Distal SPDR[3] (nonrectosigmoid)	0.4 ± 0.6	0.2 (0 – 0.7)	0 – 3.9
Large SPDR (≥ 1 cm)	1.0 ± 1.3	0.8 (0 – 1.5)	0 – 11.3
TSA detection rate	0.2 ± 0.3	0 (0 – 0.2)	0 – 3.1

IQR, interquartile range; SPDR, serrated polyp detection rate; TSA, traditional serrated adenomas.
[1] Mean SPDR values represent averaged SPDRs of all included individual endoscopist (n = 201).
[2] Proximal to the splenic flexure.
[3] Distal includes splenic flexure and descending colon, but excludes rectosigmoid, which is reported separately.

(▶ **Tab. 1**). The number of endoscopists from CIE, KPW, UNC, and UPMC were 11, 18, 53, and 119 respectively. Endoscopists varied with respect to sex (18.4 % female), years in practice (range 1 – 51), and number of colonoscopies performed during the study period (range 30 – 2654). The majority of endoscopists (n = 157, 78.1 %) performed at least 100 colonoscopies during the study period.

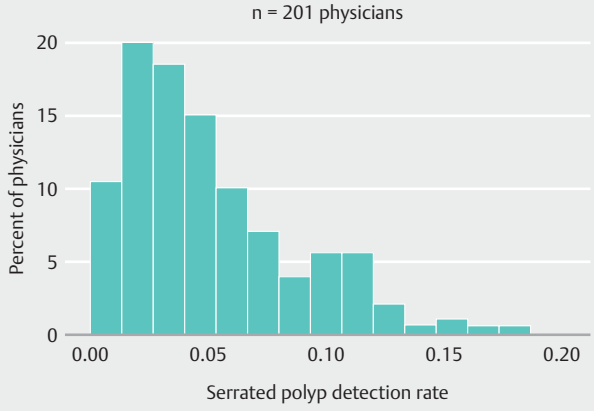
Serrated polyp detection

Across all colonoscopies in the sample, 6.3 % (n = 6622) had at least one serrated polyp. The overall mean SPDR across endoscopists was 5.1 % (SD 3.8 %, range 0 – 18.8 %) (▶ **Tab. 2**, ▶ **Fig. 2**). The majority of serrated polyps identified were located in the proximal colon (80.8 %). The mean proximal SPDR was 3.9 % (SD 3.3 %), and the mean large SPDR was 1.0 % (SD 1.3 %) (▶ **Tab. 2**). TSAs were rare; in total, there were 160 TSAs identified among all colonoscopies. At the physician level, 40 % of endoscopists detected at least one TSA. The mean SPDR also varied across sites from 4.4 % to 10.6 % (▶ **Supplementary Tab. e3**, available online).

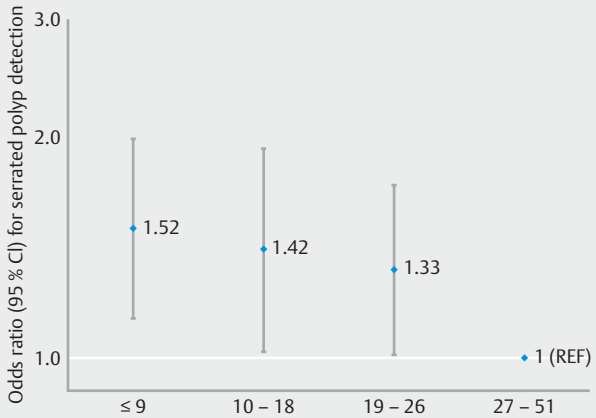
Bivariate analyses showed that a higher proportion of gastroenterologists had above-median SPDR than nongastroenterologists (52.9 % vs. 31.0 %; $P = 0.03$) (▶ **Tab. 1**). Additionally, endoscopists in higher quartiles of procedure volume were more likely to have above-median SPDR than endoscopists in the lower-volume quartiles ($P < 0.001$).

Multivariable analyses

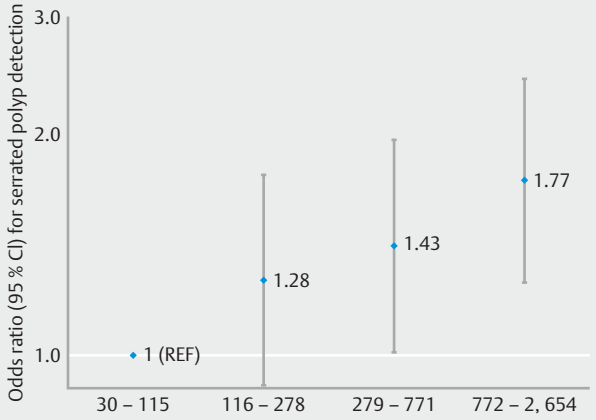
In a multivariable logistic regression at the colonoscopy level, we found several endoscopist factors that were independently associated with detecting a serrated polyp during colonoscopy, after controlling for patient characteristics (▶ **Tab. 4**). Colonoscopies performed by gastroenterologists had nearly twice the odds of detecting a serrated polyp than those performed by nongastroenterologists (OR 1.89, 95 %CI 1.33 – 2.70). Procedures performed by physicians with fewer years in practice (i. e. closer to residency or fellowship training) were also more likely to detect serrated polyps (≤ 9 years vs. ≥ 27 years: OR 1.52, 95 %CI 1.14 – 2.04) (▶ **Fig. 3a**). In addition, we found evidence of a linear trend with respect to procedure volume; compared with endoscopists in the lowest quartile, colonoscopies performed by endoscopists with higher procedure volumes were more likely to detect serrated polyps (for quartiles 2, 3, and 4 vs. 1: OR 1.28, 95 %CI 0.91 – 1.80; OR 1.43, 95 %CI 1.01 – 2.02; and OR 1.77, 95 %CI 1.27 – 2.46, respectively) (▶ **Fig. 3b**). Endoscopists with lower mean rates of adequate bowel preparation also had lower serrated polyp detection (for rates < 85 % vs. ≥ 85 %: OR 0.60, 95 %CI 0.38 – 0.97). There was no observed relationship between endoscopist sex or cecal intubation rate and serrated polyp detection. Restricting the sample to only screening colonoscopies showed similar results (▶ **Supplementary Tab. e5**, available online). Similarly, restricting the sample to higher-volume endoscopists (at least 100 colonoscopies per 2 years) did not substantially affect the trends observed, apart from a loss in precision (▶ **Supplementary Tab. e6**, available online). However, the effect of procedure volume was not statistically significant among the subset of higher-volume endoscopists (for quartile 4 vs. 1: OR 1.26, 95 %CI 0.93 – 1.71).



▶ **Fig. 2** Variation in serrated polyp detection rate among endoscopists (n = 201).



a



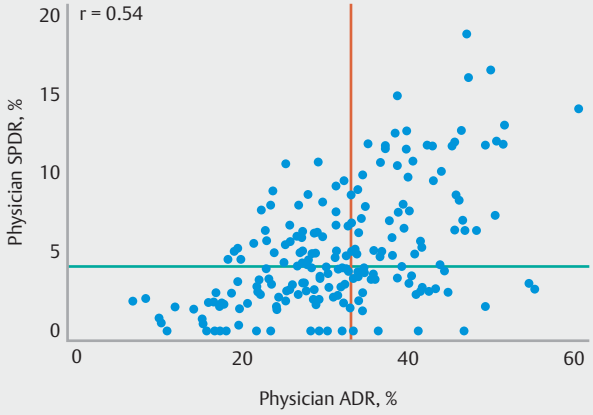
b

▶ **Fig. 3** Odds ratios for serrated polyp detection. **a** Years in practice. **b** Increasing endoscopist procedure volume.

	SPDR	Proximal SPDR	Large SPDR
SPDR	1		
Proximal SPDR	0.96	1	
Large SPDR	0.65	0.65	1
ADR	0.54	0.56	0.34
Advanced ADR	0.35	0.35	0.61

SPDR, serrated polyp detection rate;
ADR, adenoma detection rate.

▶ **Fig. 4** Correlation between outcome metrics. Darker blue shading indicates stronger correlation.



▶ **Fig. 5** Correlation between serrated polyp detection rate (SPDR) and adenoma detection rate (ADR). Green line indicates median SPDR and red line indicates median ADR.

Correlation with other quality metrics

There was a strong correlation between SPDR and proximal SPDR ($r = 0.96$) with a relatively weaker association between SPDR and ADR and advanced ADR ($r = 0.54$ and 0.35, respectively) (▶ **Fig. 4**). Whereas high ADR generally correlated with high SPDR, there was a substantial proportion of endoscopists who exhibited higher detection for one polyp type but not the other, or who performed below the 50th percentile for both measures (▶ **Fig. 5**).

Discussion

In this multicenter study comprising a large number of colonoscopies and endoscopists, we found evidence of substantial variation between physicians with respect to their detection of serrated polyps. Overall, there was a greater than 19-fold difference between the physicians with highest and lowest SPDRs. Endoscopist characteristics associated with higher serrated polyp detection included gastroenterology specialty training, more recent completion of training, higher colonoscopy procedure volume, and higher rate of adequate bowel preparation. The association between endoscopist characteristics and SPDR that we observed does not appear to be explained by differences in patient mix or study site.

These findings can be applied to quality improvement efforts. For example, the fact that nongastroenterologists and those further removed from training had lower serrated polyp detection rates suggests that some decrement in serrated polyp detection may be related to lack of awareness or knowledge about the importance of serrated polyps in colonoscopy screening. Therefore, educational interventions targeted at these groups could potentially improve serrated polyp detection. Our finding that procedure volume correlated with SPDR could indicate that, because SSPs are rarer than conventional adenomas, more procedures are needed to establish pattern recognition skills for polyp identification. Accordingly, video-based or other training interventions could be useful to improve the detection skills of lower-volume endoscopists who encounter SSPs less often [27]. Alternatively, higher-volume endoscopists may be achieving better examinations of the cecum and proximal colon, where SSPs are more frequently loca-

▶ **Table 4** Endoscopist factors associated with detecting a serrated polyp on colonoscopy.

Characteristics	Serrated polyp detection, OR* (95 %CI)
Endoscopist sex	
▪ Male	1.00 (Ref)
▪ Female	1.10 (0.84 – 1.44)
Primary specialty	
▪ Gastroenterology	1.89 (1.33 – 2.70)
▪ Other	1.00 (Ref)
Years in practice	
▪ ≤ 9	1.52 (1.14 – 2.04)
▪ 10 – 18	1.42 (1.02 – 1.97)
▪ 19 – 26	1.33 (1.01 – 1.75)
▪ 27 – 51	1.00 (Ref)
Number of colonoscopies performed over 2-year period	
▪ 30 – 115	1.00 (Ref)
▪ 116 – 278	1.28 (0.91 – 1.80)
▪ 279 – 771	1.43 (1.01 – 2.02)
▪ 772 – 2654	1.77 (1.27 – 2.46)
Rate of adequate bowel preparation	
▪ < 0.85	0.60 (0.38 – 0.97)
▪ ≥ 0.85	1.00 (Ref)
Cecal intubation rate	
▪ < 0.95	0.96 (0.75 – 1.22)
▪ ≥ 0.95	1.00 (Ref)

OR, odds ratio; CI, confidence interval.
* ORs estimated using multivariable logistic regression model adjusting for patient age, sex, colonoscopy indication, and site of colonoscopy procedure. Standard errors are clustered at the physician level.

ted. Therefore, emphasis on technique for examination of the right colon may be warranted. Additionally, the effect of procedure volume on serrated polyp detection was attenuated when we excluded low-volume colonoscopists, suggesting that endoscopists with very low procedure volumes may be at greatest risk of missing SSPs. We also found that endoscopists with lower rates of adequate bowel preparation were significantly less likely to find serrated polyps. This finding is consistent with other reports [14], and underscores the importance of optimal bowel preparation for detecting serrated polyps. Although we did not specifically examine the type of bowel preparation used, it is worth noting that split-dose bowel preparations, which cleanse the proximal colon more efficiently [28], are likely to be important for improving detection of SSPs in particular [29].

Similarly to other studies [11, 12, 30], we found that SPDR correlated with ADR. However, our analysis revealed that the correlation was relatively modest. In other words, some endoscopists excelled at detecting conventional adenomas, but did not detect serrated polyps well. These findings, in addition to those regarding the contribution of procedure volume and recent training may help to identify groups of endoscopists that may benefit from tailored interventions to improve SPDR.

Our findings on the dramatic variation in detection of serrated polyps are consistent with published literature demonstrating wide variation in detection of SSPs and proximal serrated polyps across endoscopists [4, 11, 12, 19] and clinical centers [13]. There is evidence that SSP detection is improving [4, 19], which is probably related to better recognition and interpretation of these lesions by endoscopists and pathologists. In contrast to ADR, there are no established targets for detection of premalignant serrated polyps, though some threshold values have been suggested. For example, Kahi et al. suggested a proximal SPDR of 5 % in average-risk patients [30]. However, the prevalence of SSPs has been reported to be as high as 13 % among patients undergoing screening and surveillance colonoscopy, so this may be a low bar [19].

Regarding determinants of SSP detection, most prior work has focused on patient or procedural factors. IJspeert et al. reported that SSPs were more commonly detected in patients with a colonoscopy indication of either surveillance or a positive family history as opposed to diagnostic procedures [19]. Other studies have demonstrated that age [31], female sex [9], and smoking history [31, 32] are risk factors for SSPs. In a single-center Dutch study of 1354 colonoscopies, deWijkerslooth et al. reported that longer withdrawal time was associated with improved detection of proximal serrated polyps. Another US study among veterans reported that SSPs were detected in a lower proportion of examinations with intermediate or poor bowel preparation [14]. In a single-center US study, Sanaka et al. reported no correlation between endoscopist specialty and SSP detection rate [33], though this study was substantially smaller than our sample (n = 65 endoscopists). Overall, there is a paucity of data on provider factors that may contribute to serrated polyp detection.

The strengths of this analysis are the large number of colonoscopies included, which contributes to the precision of our estimates. This is particularly important, as we were interested in an outcome of serrated polyps, which are substantially less common than conventional adenomas [34]. We also included data from multiple sites that were varied in terms of geography, practice type, and academic vs. private affiliation, contributing to the external validity of our findings.

Limitations that should be considered include the use of an NLP tool to abstract data on procedure and pathology details. Although the NLP algorithm was rigorously developed and tested, it is imperfect; the pipeline may have missed some serrated polyps, and may have flagged some polyps as serrated that were not actually SSPs or TSAs owing to differences in pathologist jargon. However, other non-NLP methods of measuring colonoscopy quality, such as manual review, are also subject to error. Second, we used a measure for SPDR that included all procedures where a polyp was removed and the pathologist included "serrated" in the report. Although this definition in the vast majority of cases resulted in identifying SSPs, it also included a

small number of TSAs, and some negation statements (e. g. "serrated polyp without definitive features of sessile serrated adenoma"). It is also worth noting that > 80 % of the serrated polyps identified by the SPDR measure were located in the proximal colon, which is consistent with the location distribution of SSPs reported in other studies [9]. For these reasons, we used the term "SPDR" instead of "SSP detection rate," though we believe the former to be an accurate estimate of the latter. Indeed, in a sensitivity analysis, we found that most cases identified as "serrated" were also identified by the term "sessile serrated." In addition, we did not have information on all endoscopist or procedural characteristics that could contribute to serrated polyp detection. In particular, withdrawal time, endoscopists' knowledge of the importance of or typical appearance of SSPs, visual gaze patterns, bowel preparation type, and use of narrow-band imaging or high definition endoscopy equipment were not available. Although we were able to evaluate the effect of physician specialty broadly, we were not able to perform any meaningful subgroup analyses given the small number of nongastroenterologists in our sample (n = 29 from four different specialties). We also did not have detailed patient-level information on factors that may be associated with the prevalence of serrated polyps, such as smoking or diet.

Another limitation is that we did not capture hyperplastic polyps in our measure of SPDR. First, this means that the SPDR metric is somewhat of a misnomer, as technically, hyperplastic polyps are also serrated polyps [35]. Second, some pathologists may misclassify SSPs as hyperplastic polyps [36], which may explain why hyperplastic polyps in the proximal colon are associated with higher risk [37 – 40]. Therefore, some of the variation we observe across endoscopists could be due to differences in pathologist readings, as has been described in other studies [13]. Ideally, we would have used a gold-standard pathology assessment of polyps, but in a large, retrospective study, central pathology review was neither practical nor possible. The degree to which this is a limitation is unclear given that an individual endoscopist will have their polyps read by many different pathologists and that this assignment is often random. Furthermore, all four sites had an SPDR of at least 4.4 %, which indicates that pathologists at each site were frequently diagnosing SSPs during the study period.

In summary, gastroenterology specialty training, more recent completion of training, and procedure volume were associated with improved serrated polyp detection. These findings imply that both repetition and training are likely to be important contributors to adequate detection of these important cancer precursors, though this requires further study. Additional efforts to improve SPDR are needed in order to optimize the cancer prevention benefit of screening colonoscopy.

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Competing interests

None

References

[1] Snover DC. Update on the serrated pathway to colorectal carcinoma. Hum Pathol 2011; 42: 1 – 10

[2] Crockett SD, Snover DC, Ahnen DJ et al. Sessile serrated adenomas: an evidence-based guide to management. Clin Gastroenterol Hepatol 2015; 13: 11 – 26.e11

[3] Crockett SD. Sessile serrated polyps and colorectal cancer. JAMA 2017; 317: 975 – 976

[4] Hetzel JT, Huang CS, Coukos JA et al. Variation in the detection of serrated polyps in an average risk colorectal cancer screening cohort. Am J Gastroenterol 2010; 105: 2656 – 2664

[5] Arain MA, Sawhney M, Sheikh S et al. CIMP status of interval colon cancers: another piece to the puzzle. Am J Gastroenterol 2010; 105: 1189 – 1195

[6] Sawhney MS, Farrar WD, Gudiseva S et al. Microsatellite instability in interval colon cancers. Gastroenterology 2006; 131: 1700 – 1705

[7] Stoffel EM, Erichsen R, Froslev T et al. Clinical and molecular characteristics of post-colonoscopy colorectal cancer: a population-based study. Gastroenterology 2016; 151: 870 – 878

[8] Nishihara R, Wu K, Lochhead P et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. N Engl J Med 2013; 369: 1095 – 1105

[9] Lash RH, Genta RM, Schuler CM. Sessile serrated adenomas: prevalence of dysplasia and carcinoma in 2139 patients. J Clin Pathol 2010; 63: 681 – 686

[10] Hazewinkel Y, Lopez-Ceron M, East JE et al. Endoscopic features of sessile serrated adenomas: validation by international experts using high-resolution white-light endoscopy and narrow-band imaging. Gastrointest Endosc 2013; 77: 916 – 924

[11] Kahi CJ, Hewett DG, Norton DL et al. Prevalence and variable detection of proximal colon serrated polyps during screening colonoscopy. Clin Gastroenterol Hepatol 2011; 9: 42 – 46

[12] de Wijkerslooth TR, Stoop EM, Bossuyt PM et al. Differences in proximal serrated polyp detection among endoscopists are associated with variability in withdrawal time. Gastrointest Endosc 2013; 77: 617 – 623

[13] Payne SR, Church TR, Wandell M et al. Endoscopic detection of proximal serrated lesions and pathologic identification of sessile serrated adenomas/polyps vary on the basis of center. Clin Gastroenterol Hepatol 2014; 12: 1119 – 1126

[14] Clark BT, Laine L. High-quality bowel preparation is required for detection of sessile serrated polyps. Clin Gastroenterol Hepatol 2016; 14: 1155 – 1162

[15] Harkema H, Chapman WW, Saul M et al. Developing a natural language processing application for measuring the quality of colonoscopy procedures. J Am Med Informatics Assoc 2011; 18: (Suppl. 01): i150 – 156

[16] Mehrotra A, Dellon ES, Schoen RE et al. Applying a natural language processing tool to electronic health records to assess performance on colonoscopy quality measures. Gastrointest Endosc 2012; 75: 1233 – 1239

[17] Carrell DS, Schoen RE, Leffler DA et al. Challenges in adapting existing clinical natural language processing systems to multiple, diverse health care settings. J Am Med Inform Assoc 2017; 24: 986 – 991

[18] Mehrotra A, Morris M, Gourevitch RA et al. Physician characteristics associated with higher adenoma detection rate. Gastrointest Endosc 2018; 87: 778 – 786.e5

[19] IJspeert JE, de Wit K, van der Vlugt M et al. Prevalence, distribution and risk of sessile serrated adenomas/polyps at a center with a high adenoma detection rate and experienced pathologists. Endoscopy 2016; 48: 740 – 746

[20] Blumenthal DM, Olenski AR, Yeh RW et al. Sex differences in faculty rank among academic cardiologists in the United States. Circulation 2017; 135: 506 – 517

[21] Goldstein MJ, Lunn MR, Peng L. What makes a top research medical school? A call for a new model to evaluate academic physicians and medical school performance Acad Med 2015; 90: 603 – 608

[22] Jena AB, Khullar D, Ho O et al. Sex differences in academic rank in US medical schools in 2014. JAMA 2015; 314: 1149 – 1158

[23] Rios-Diaz AJ, Metcalfe D, Singh M et al. Inequalities in specialist hand surgeon distribution across the United States. Plast Reconstr Surg 2016; 137: 1516 – 1522

[24] DesRoches CM, Barrett KA, Harvey BE et al. The results are only as good as the sample: assessing three national physician sampling frames. J Gen Intern Med 2015; 30: (Suppl. 03): S595 – S601

[25] Rex DK, Bond JH, Winawer S et al. Quality in the technical performance of colonoscopy and the continuous quality improvement process for colonoscopy: recommendations of the U.S. Multi-Society Task Force on Colorectal Cancer. Am J Gastroenterol 2002; 97: 1296 – 1308

[26] Johnson DA, Barkun AN, Cohen LB et al. Optimizing adequacy of bowel cleansing for colonoscopy: recommendations from the US multi-society task force on colorectal cancer. Gastroenterology 2014; 147: 903 – 924

[27] Rondagh EJ, Bouwens MW, Riedl RG et al. Endoscopic appearance of proximal colorectal neoplasms and potential implications for colonoscopy in cancer prevention. Gastrointest Endosc 2012; 75: 1218 – 1225

[28] Radaelli F, Paggi S, Hassan C et al. Split-dose preparation for colonoscopy increases adenoma detection rate: a randomised controlled trial in an organised screening programme. Gut 2017; 66: 270 – 277

[29] Horton N, Garber A, Hasson H et al. Impact of single- vs. split-dose low-volume bowel preparations on bowel movement kinetics, patient inconvenience, and polyp detection: a prospective trial. Am J Gastroenterol 2016; 111: 1330 – 1337

[30] Kahi CJ, Li X, Eckert GJ et al. High colonoscopic prevalence of proximal colon serrated polyps in average-risk men and women. Gastrointest Endosc 2012; 75: 515 – 520

[31] Anderson JC, Rangasamy P, Rustagi T et al. Risk factors for sessile serrated adenomas. J Clin Gastroenterol 2011; 45: 694 – 699

[32] Burnett-Hartman AN, Passarelli MN, Adams SV et al. Differences in epidemiologic risk factors for colorectal adenomas and serrated polyps by lesion severity and anatomical site. Am J Epidemiol 2013; 177: 625 – 637

[33] Sanaka MR, Gohel T, Podugu A et al. Adenoma and sessile serrated polyp detection rates: variation by patient sex and colonic segment but not specialty of the endoscopist. Dis Colon Rectum 2014; 57: 1113 – 1119

[34] O'Connell BM, Crockett SD. The clinical impact of serrated colorectal polyps. Clin Epidemiol 2017; 9: 113 – 125

[35] Snover DC, Ahnen D, Burt R, Odze RD. Serrated polyps of the colon and rectum and serrated polyposis. In: Bosman FT, Carneiro F, Hruban RH et al. eds. WHO classification of tumours of the digestive system. 4th edn. Lyon: IARC; 2010

[36] Gill P, Wang LM, Bailey A et al. Reporting trends of right-sided hyperplastic and sessile serrated polyps in a large teaching hospital over a 4-year period (2009–2012). J Clin Pathol 2013; 66: 655 – 658

[37] Alvarez C, Andreu M, Castells A et al. Relationship of colonoscopy-detected serrated polyps with synchronous advanced neoplasia in average-risk individuals. Gastrointest Endosc 2013; 78: 333 – 341

[38] Gao Q, Tsoi KK, Hirai HW et al. Serrated polyps and the risk of synchronous colorectal advanced neoplasia: a systematic review and meta-analysis. Am J Gastroenterol 2015; 110: 501 – 509

[39] Hazewinkel Y, de Wijkerslooth TR, Stoop EM et al. Prevalence of serrated polyps and association with synchronous advanced neoplasia in screening colonoscopy. Endoscopy 2014; 46: 219 – 224

[40] O'Connell B, Hafiz N, Crockett S. The serrated polyp pathway: is it time to alter surveillance guidelines? Curr Gastroenterol Rep 2017; 19: 52