

A comparison of endoscopic localization error rate between operating surgeons and referring endoscopists in colorectal cancer

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Abstract

Background Colonoscopy for colorectal cancer (CRC) has a localization error rate as high as 21 %. Such errors can have substantial clinical consequences, particularly in laparoscopic surgery. The primary objective of this study was to compare accuracy of tumor localization at initial endoscopy performed by either the operating surgeon or non-operating referring endoscopist.

Methods All patients who underwent surgical resection for CRC at a large tertiary academic hospital between January 2006 and August 2014 were identified. The exposure of interest was the initial endoscopist: (1) surgeon who also performed the definitive operation (operating surgeon group); and (2) referring gastroenterologist or general surgeon (referring endoscopist group). The outcome measure was localization error, defined as a difference in at least one anatomic segment between initial endoscopy and final operative location. Multivariate logistic regression was used to explore the association between localization error rate and the initial endoscopist.

Results A total of 557 patients were included in the study; 81 patients in the operating surgeon cohort and 476 patients

in the referring endoscopist cohort. Initial diagnostic colonoscopy performed by the operating surgeon compared to referring endoscopist demonstrated statistically significant lower intraoperative localization error rate (1.2 vs. 9.0 %, $P = 0.016$); shorter mean time from endoscopy to surgery (52.3 vs. 76.4 days, $P = 0.015$); higher tattoo localization rate (32.1 vs. 21.0 %, $P = 0.027$); and lower preoperative repeat endoscopy rate (8.6 vs. 40.8 %, $P < 0.001$). Initial endoscopy performed by the operating surgeon was protective against localization error on both univariate analysis, OR 7.94 (95 % CI 1.08–58.52; $P = 0.016$), and multivariate analysis, OR 7.97 (95 % CI 1.07–59.38; $P = 0.043$).

Conclusions This study demonstrates that diagnostic colonoscopies performed by an operating surgeon are independently associated with a lower localization error rate. Further research exploring the factors influencing localization accuracy and why operating surgeons have lower error rates relative to non-operating endoscopists is necessary to understand differences in care.

Keywords Colorectal cancer · Colonoscopy · Endoscopy · Tumor localization

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Colorectal cancer is the third most commonly diagnosed malignancy in North America, with approximately 136,830 new diagnoses and 50,310 patients dying of the disease in 2014 [1]. Although colorectal cancer remains relatively common, its incidence and mortality rate have steadily decreased over the past several decades [2]. This decline has been largely attributed to improved utilization of screening programs that involve fecal occult blood tests, imaging, and colonoscopy [3]. Colonoscopy remains the gold standard technique for detecting pre-cancerous and

cancerous lesions of the colon and rectum, with an estimated sensitivity of 94.7 % [4, 5].

Although colonoscopy is considered the cornerstone method for detection of colorectal lesions, its ability to provide accurate localization information is less clear. The tumor localization error rate is estimated to range from 4.0 to 20.8 % [6–12]. The trend toward laparoscopic management of colorectal malignancies over the past decade magnifies the importance of accurate preoperative localization [13], as the lack of tactile sensation in laparoscopy makes intraoperative localization of small endoluminal lesions very difficult. Such errors in localization can have dramatic clinical consequences, including intraoperative changes to the surgical plan, intraoperative colonoscopy, conversion from laparoscopic to open approach, and in extreme circumstances, removal of incorrect segments of colon.

To prevent localization-based errors and unanticipated events at the time of surgery, many surgeons perform preoperative repeat endoscopy to ensure accurate tumor localization. In a recent study, the preoperative repeat endoscopy rate for colorectal cancer was estimated to be 40.5 %; a procedure used in the vast majority of cases for the purpose of tattoo localization or surgical planning [14]. While tattooing has been associated with a decreased likelihood of repeat endoscopy by the operating surgeon [14], its utilization at initial endoscopy remains relatively low [15, 16].

Repeat endoscopy by the operating surgeon for referred colorectal cancer cases has been shown to be protective against localization error and its consequences [17]. However, repeat endoscopy is an invasive procedure that is costly [18], time-consuming and has inherent risks [19], and therefore accurate tumor localization at initial colonoscopy is important. However, it remains unclear whether patients who have their initial endoscopy performed by the operating surgeon compared to a referring endoscopist have reduced localization errors. Furthermore, the rate of repeat endoscopy in these two patient populations is unknown.

Given the aforementioned high rate of endoscopy-based localization errors, the propensity for localization-based intra-operative complications, and inherent risks of repeat endoscopy, our study aims to identify endoscopic factors that may be associated with lower localization errors. Although previous studies have assessed factors associated with endoscopic localization error [11], differences in localization accuracy between surgeons and referring endoscopists have not been defined. Previous studies have demonstrated clear differences between endoscopy operators (e.g., surgeons, gastroenterologists, and general internists) with regard to post-colonoscopy colorectal cancer rates, a surrogate endoscopy quality indicator [20, 21].

However, no studies have assessed differences between surgeons and referring endoscopists with regard to tumor localization and its possible downstream complications. Given that surgeons have an intimate understanding of surgical anatomy, and appreciate the critical importance of accurate localization in operative planning, especially in laparoscopic cases, it is plausible that they may demonstrate a greater emphasis in determining accurate localization at initial endoscopy.

To extend the empirical literature on endoscopic localization errors and its complications, we conducted a retrospective cohort study to identify factors associated with lower error rates. The primary objective of this study was to compare accuracy of tumor localization for endoscopies performed by the operating surgeon compared to those conducted by referring endoscopists. The secondary objective of this study was to compare surgical deviations and complications as a result of localization errors between operating surgeons and referring endoscopists. We hypothesized that having the initial diagnostic colonoscopy performed by the operating surgeon would be protective against localization error and localization-based deviations in surgical plan.

Materials and methods

Study population

A retrospective chart review was conducted at a large tertiary care center in Toronto, Canada, between January 2006 and August 2014. All patients who underwent elective resection for colorectal cancer and who had a screening or diagnostic colonoscopy were eligible for inclusion in the study. Patients were excluded if they underwent emergency surgery ($n = 104$), had a diagnosis of anal cancer ($n = 2$), or if they had missing documentation of localization on the primary endoscopy report or final localization on the operative report ($n = 76$). Patients with prior localization of their malignancy or radiologic findings suggestive of malignancy prior to the initial endoscopy were also excluded to limit bias ($n = 77$). A total of 557 patients were included in the study. This study was approved by the institutional research ethics board of the University Health Network, Toronto, Canada.

Study measures

Demographic information, initial and repeat endoscopy reports, surgeon letters, radiologic reports, operating room notes, and pathological reports were obtained for every patient using the institution's Electronic Patient Record system. For the purposes of this study, *initial endoscopy*

was defined as the endoscopic procedure leading to the diagnosis of the index colorectal malignancy resected in this study. Repeat endoscopy was defined as any endoscopic procedure following the previously defined initial endoscopy and prior to operative intervention. The initial endoscopy report was used to determine the indication for endoscopy, institution at which the endoscopy was performed (internal vs. external to the operating institution), use of tattoo localization, and tumor location. Repeat endoscopy reports were used to determine indication and tumor location. The definitive tumor location was categorized as the intraoperative location as dictated in the operative note and verified using the pathological report and surgeon labeling of the pathological specimen. Localization was divided into colonic segments: right colon (including cecum), hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid colon, and rectum.

Exposures, outcomes, and statistical analysis

The primary exposure of interest was the operator of the initial endoscopy, dividing patients into two cohorts: (1) patients who had their initial diagnostic or screening endoscopy completed by the same surgeon who performed the definitive operation (operating surgeon group); and (2) patients who had their initial diagnostic or screening endoscopy completed by a referring gastroenterologist or general surgeon (non-operating endoscopist group). Confounding factors as identified by the literature were: patient age, patient sex, previous colorectal cancer diagnosis, previous colectomy, institution of initial endoscopy (internal vs. external to the operating institution), tattooing on initial endoscopy, and tumor location [11, 17]. The primary outcome measure was localization error, defined as a difference in at least one anatomic segment between localization on the initial endoscopy report and the final operative note. Secondary outcome measures included localization-based complications, including change in surgical plan, use of intraoperative endoscopy, conversion from laparoscopic to open procedure for the purpose of localization, and resection of incorrect segments of colon.

Categorical data were compared using the chi-squared test. Continuous data were compared using the independent samples *t* test or Mann–Whitney *U* test based on data normality. Univariate analysis was used to assess predictors of endoscopic localization error, using the primary exposure and confounding variables. A multivariate analysis was conducted using a logistic regression model that included all of the variables in the univariate analysis, with the exception of the previous colorectal cancer diagnosis covariate, which was found to be collinear with the previous colectomy covariate. Similarly, the institution of the

primary endoscopy was excluded as a covariate as it demonstrated collinearity with the operator variable; all initial endoscopies performed by the operating surgeon were conducted internally. Statistical significance level for all group comparisons was set at a *P* value of <0.05. Data were analyzed using Statistical Program for Social Sciences software (SPSS), version 21.0.

Results

Baseline patient demographics and initial endoscopy characteristics stratified by study cohort are presented in Table 1. A total of 816 patients who underwent colorectal cancer surgery during the study period were identified. Five hundred and fifty-seven patients, who met the inclusion/exclusion criteria for the study, were included in the final sample. The mean age of patients was 65.8 years, and 56.0 % (*n* = 323) of patients were male. The operating surgeon performed 14.5 % (*n* = 81) of the initial diagnostic endoscopies, while 57.1 % (*n* = 318) were conducted by a referring surgeon and 28.4 % (*n* = 158) by a referring gastroenterologist. Compared with the referring endoscopist group, the operating surgeon group had a significantly higher rate of patients with a prior colorectal cancer diagnosis or previous colectomy (*P* < 0.001 and *P* < 0.001, respectively). In the operating surgeon group, 11 patients had a prior diagnosis of CRC, all 11 of which received prior segmental colectomies. A subsequent patient in the operating surgeon group had a prior colectomy for complications resulting from inflammatory bowel disease. No significant differences were observed between groups with respect to patient age, patient sex, indication for the initial endoscopy, and tumor location at endoscopy. Figure 1 depicts the specific tumor locations based on the operator of the initial endoscopy. Half (*n* = 238) of the diagnostic endoscopies in the non-operating endoscopist group were conducted at an external institution, whereas all of the endoscopies in the operating surgeon group were conducted internally. The operating surgeon group had a lower rate of repeat endoscopy than compared to the referring endoscopist group (8.6 vs. 40.8 %, *P* < 0.001). A total of seven patients in the operating surgeon group required repeat endoscopy; five patients had repeat endoscopy for tattoo localization prior to operative intervention and two patients had repeat therapeutic attempt. Furthermore, the operating surgeon group had a higher rate of tattoo localization on the primary endoscopy compared to the non-operating endoscopist group (32.1 vs. 21.0 %, *P* = 0.027). Group analysis between the three endoscopist groups (operating surgeon, referring surgeon, and referring gastroenterologists) was conducted with regard to tattoo localization rates at initial endoscopy. Rate of tattoo

Table 1 Patient demographics and characteristics of initial endoscopy

	Operating surgeon	Non-operating endoscopist	<i>P</i> value
N = 557	81	476	
Age, mean (SD)	67.79 (12.90)	65.45 (12.28)	0.122
Sex			
Male	43 (53.1)	269 (56.5)	0.566
Female	38 (46.9)	207 (43.5)	
First CRC diagnosis			
Yes	70 (86.4)	467 (98.1)	<0.001*
No	11 (13.6)	9 (1.9)	
Previous colectomy			
Yes	12 (14.8)	14 (2.9)	<0.001*
No	69 (85.2)	462 (97.1)	
Indication for initial endoscopy			
Screening	45 (55.6)	242 (50.8)	0.407
Symptomatic complaint	36 (44.4)	226 (47.5)	
Other	0 (0.0)	8 (1.7)	
Site of first endoscopy			
Internal	81 (100.0)	238 (50.0)	
External		238 (50.0)	
Lesion tattooed on initial endoscopy			
Yes	26 (32.1)	100 (21.0)	0.027*
No	55 (67.9)	376 (79.0)	
Repeat endoscopy performed			
Yes	7 (8.6)	194 (40.8)	<0.001*
No	74 (91.4)	282 (59.2)	
Surgical approach			
Laparoscopic	51 (63.0)	276 (58.1)	0.412
Open	30 (37.0)	199 (41.9)	
Tumor location			
Right	36 (44.4)	204 (42.9)	0.871
Left	21 (25.9)	117 (24.6)	
Rectum	24 (29.6)	155 (32.6)	

Values presented as number (percent), unless otherwise indicated

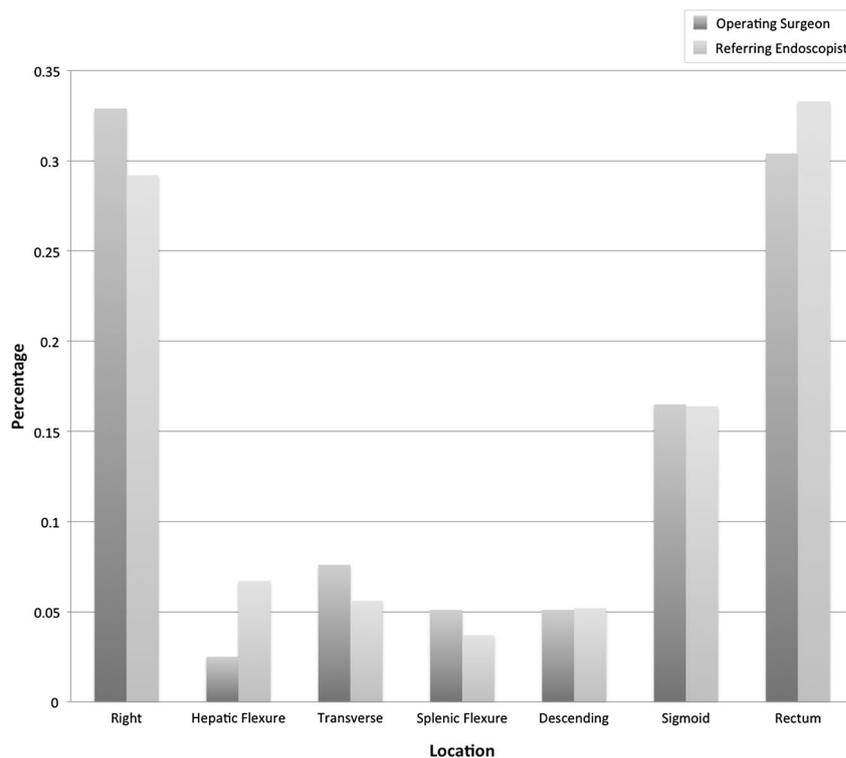
CRC colorectal cancer, SD standard deviation

* Statistical significance ($P < 0.05$)

localization at initial endoscopy was significantly higher for referring surgeons ($n = 89$, 28.0 %) compared to referring gastroenterologists ($n = 11$, 7.0 %), $P < 0.001$. There was no statistical difference in tattoo rates between operating surgeons and referring surgeons (32.1 vs. 28.0 %, $P = 0.466$).

Univariate analyses for predictors of endoscopic localization error are highlighted in Table 2. Having the initial endoscopy performed by a non-operating endoscopist was associated with a 7.94 times increased risk of localization error compared to having the initial endoscopy performed by the operating surgeon (95 % CI 1.08–58.52; $P = 0.016$). No other predictors of localization error were found to be statistically significant. Additionally, we

compared the endoscopy error rate between referring general surgeons ($n = 318$) and referring gastroenterologists ($n = 158$). There was no propensity for higher rate of localization error whether the initial endoscopy was performed by a referring gastroenterologist or general surgeon (OR 1.03, 95 % CI 0.53–2.01, $P = 0.926$). Similarly, in this subgroup analysis, age ($P = 0.812$), sex ($P = 0.287$), previous colectomy ($P = 0.802$), location of initial endoscopy ($P = 0.631$), laparoscopic approach ($P = 0.514$), and tumor location ($P = 0.108$) did not predict higher localization error. Comparison analysis between operating surgeons and referring endoscopists excluding patients with prior colectomies and previous CRC diagnoses was also conducted: Initial endoscopy performed by a referring

Fig. 1 Segmental tumor location based on endoscopy operator**Table 2** Univariate analysis for predictors of endoscopic localization error

	No localization error	Localization error	Crude OR (95 % CI)	<i>P</i> value
N	513	44		
Age, mean (SD)	65.78 (12.43)	65.93 (11.67)	1.00 (0.98–1.03)	0.936
Male	290 (56.5)	22 (50.0)	1.30 (0.70–2.41)	0.402
First CRC diagnosis	494 (96.3)	43 (97.7)	0.60 (0.08–4.63)	0.624
Previous colectomy	25 (4.9)	1 (2.3)	2.20 (0.29–16.65)	0.712
Specialty of initial endoscopist				
Non-operating endoscopist	433 (84.4)	43 (97.7)	7.94 (1.08–58.52)	0.016*
Operating surgeon	80 (15.6)	1 (2.3)		
Initial endoscopy performed internally	298 (58.1)	21 (47.7)	0.66 (0.35–1.22)	0.182
Lesion tattooed on initial endoscopy	115 (22.4)	11 (25.0)	0.87 (0.42–1.77)	0.694
Tumor location				
Right—reference group	222 (43.3)	18 (40.9)	1.00	
Left	122 (23.8)	16 (36.4)	1.62 (0.80–3.29)	0.184
Rectum	169 (32.9)	10 (22.7)	0.73 (0.33–1.62)	0.439

CI confidence interval, CRC colorectal cancer, OR odds ratio, SD standard deviation

Values presented as number (percent), unless otherwise indicated

* Statistical significance ($P < 0.05$)

endoscopist ($n = 462$) was associated with a 6.80 (95 % CI 0.92–50.23; $P = 0.03$) increased odds of localization error compared to having the initial endoscopy conducted by the operating surgeon ($n = 69$) in this subgroup.

To assess for independent predictors of localization error, a multivariate analysis using clinically significant

covariates was conducted (Table 3). Age, sex, previous colectomy, and lesions tattooed on initial endoscopy did not predict localization error; $P > 0.05$. Similar to the univariate analysis, having the initial endoscopy performed by a non-operating endoscopist was independently associated with a 7.97-fold increased risk of localization error

Table 3 Multivariate analysis for predictors of endoscopic localization error

	OR	95 % CI	P value
Age	1.002	0.977–1.028	0.872
Male	0.739	0.394–1.375	0.336
Previous colectomy	0.579	0.074–4.550	0.603
Non-operating initial endoscopist	7.966	1.069–59.382	0.043*
Lesion tattooed on initial endoscopy	0.854	0.409–1.783	0.674
Tumor location			0.134
Right—referent group	1.000		
Left	1.672	0.817–3.423	0.160
Rectum	0.737	0.327–1.661	0.462

CI confidence interval, CRC colorectal cancer, OR odds ratio

* Statistical significance ($P < 0.05$)

over endoscopies performed by the operating surgeon (95 % CI 1.07–59.38; $P = 0.043$).

A total of 44 (7.9 %) localization errors were identified intraoperatively. Table 4 highlights the surgical outcomes in these patients based on the operator of the initial diagnostic endoscopy. The operating surgeon group had an endoscopic localization error rate of 1.2 % ($n = 1$), compared to 9.0 % ($n = 43$) in the non-operating endoscopist group ($P = 0.016$). Of the 44 patients who experienced an error at the initial endoscopy, 20 patients underwent preoperative repeat endoscopy by the operating surgeon. Tumor localization was corrected by the repeat endoscopy in 75 % ($n = 15$) of cases. Five patients had localization error despite repeat endoscopy. Of these five patients, four had tattoo localization at repeat endoscopy; all tattoos were identified at operative intervention. three of these five

patients had no change in surgical plan. One patient had change from sigmoidectomy to low anterior resection (LAR) and one patient had a change from sigmoidectomy to subtotal colectomy. In total, 29 patients (65.9 %) had a change in surgical plan either preoperatively or intraoperatively as a result of a localization error: ten from sigmoidectomy to LAR; eight from right-hemicolectomy to left-hemicolectomy; four from LAR to left-hemicolectomy; three from left-hemicolectomy to right-hemicolectomy; two from right hemi-colectomy to subtotal colectomy; one from sigmoidectomy to subtotal colectomy; and one from left-hemicolectomy to LAR. One patient had an incorrect segment of colon resected. Four patients (9.1 %) required intraoperative endoscopy to accurately localize the lesion, and five patients (11.3 %) required conversion from laparoscopy to an open approach

Table 4 Surgical outcomes of localization errors based on operator of initial endoscopy

	Operating surgeon	Non-operating endoscopist
N	81	476
Localization error [^]	1 (1.2)	43 (9.0)
Change in surgical plan [*]	0 (0.0)	29 (6.1)
Sigmoidectomy to LAR ^a	–	10 (23.3)
Right-hemicolectomy to Left-hemicolectomy ^a	–	8 (18.6)
LAR to Left-hemicolectomy ^a	–	4 (9.3)
Left-hemicolectomy to Right-hemicolectomy ^a	–	3 (7.0)
Right hemi-colectomy to Subtotal colectomy ^a	–	2 (4.6)
Sigmoidectomy to Subtotal colectomy ^a	–	1 (2.3)
Left-hemicolectomy to LAR ^a	–	1 (2.3)
Incorrect segment resection ^a	0 (0.0)	1 (2.3)
Intraoperative endoscopy ^a	0 (0.0)	4 (9.3)
Conversion to open ^a	0 (0.0)	5 (11.6)
Days to definitive surgery, mean (SD) [#]	52.27 (75.47)	76.37 (81.04)

LAR low anterior resection, SD standard deviation

[^] $P = 0.016$; ^{*} $P = 0.022$; [#] $P = 0.016$

^a Percentage reported from subgroup of patients ($n = 43$) that had localization error at time of OR

for the purpose of localization. Initial endoscopy performed by the non-operating endoscopist group was associated with a statistically higher rate of deviation in surgical plan (6.1 vs. 0.0 %, $P = 0.022$). In addition, the mean time from initial endoscopy to definitive surgery in the referring endoscopist group was 76.37 (SD 81.04) days compared with 52.27 (SD 75.47) days in the operating surgeon group ($P = 0.016$).

Discussion

This study demonstrates that initial diagnostic colonoscopies performed by an operating surgeon compared to a referring endoscopist (referring general surgeon or gastroenterologist) are associated with lower localization errors on both univariate ($P = 0.016$) and multivariate ($P = 0.043$) analysis. Surgeon-performed endoscopies were also associated with a lower rate of localization-based operative complications ($P = 0.022$). Furthermore, having the initial colonoscopy performed by the operating surgeon was associated with a higher tattoo localization rate, lower rate of preoperative repeat endoscopy, and decreased time to definitive surgery.

Our study observed an overall localization error rate of 7.9 %, which is consistent with previous studies reporting error rates ranging from 4.0 to 20.8 % [6–12, 22]. We demonstrated a 9.0 % localization error rate when the initial endoscopy was performed by a non-operating endoscopist, compared to a 1.2 % error rate when the colonoscopy was performed by the operating surgeon. Furthermore, initial endoscopy performed by a referring endoscopist was associated with a 7.9-fold increased risk of error on univariate analysis ($P = 0.016$), and 8.0-fold increased risk of error on multivariate analysis ($P = 0.043$). To our knowledge, no previous studies have compared error rates between referring endoscopists and operating surgeons. In a study by Piscatelli et al. [11], a trend toward lower endoscopic error rates was demonstrated when the initial endoscopy was performed by a surgeon; however, it did not reach statistical significance (OR 0.47, $P = 0.07$). It is important to note that the study by Piscatelli et al. did not distinguish between referring surgeons and operating surgeons. We conducted a subgroup analysis comparing referring surgeons and gastroenterologists and, similar to Piscatelli et al., we did not find any statistically significant difference with regard to localization error (OR 1.032, $P = 0.926$).

Accurate tumor localization is of upmost clinical importance in the surgical management of colorectal cancer, as errors may lead to complications in the intraoperative setting. Our study identified a total of 44 errors (7.9 %), of which 30 (68.2 %) resulted in a deviation in

clinical care; either a change in surgical plan or intra-operative complication. Piscatelli et al. [11] demonstrated a change in surgical plan in 8.5 % of cases experiencing a localization error. Similarly, we found that in 5.4 % of all cases a change in surgical plan was required. Our study also demonstrated that 9.1 % of localization errors necessitated intraoperative endoscopy, similar to a study by Cho et al. [10], which demonstrated an intraoperative endoscopy rate of 8.7 %. Furthermore, we found that 11.3 % of errors resulted in conversion from laparoscopy to an open approach, and that 2.3 % of errors resulted in wrong-segment surgery. Notably, our study showed that while one error occurred in the operating surgeon group, no surgical deviation resulted from this error, in comparison with 6.1 % of cases in the referring endoscopist cohort where there was a change in surgical plan. These findings highlight the fact that localization errors can have significant adverse effects on patient care, and given the difference in rates for such events between surgeons and referring endoscopists, an effort must be made to elucidate differences in localization practices between these two groups.

Differences in endoscopy quality between surgeons and gastroenterologists have been debated in the literature. Some studies have demonstrated that endoscopies performed by gastroenterologists are associated with a lower post-colonoscopy colorectal cancer rate [20] and lower colorectal cancer mortality [23], while others have failed to demonstrate this association [21, 24]. Although the impact of the endoscopy operator on colonoscopy quality indicators has been assessed, there is a paucity of research examining tumor localization accuracy between endoscopy operators; a crucial factor in the effective surgical management of colorectal cancer. To our knowledge, this is the first study that has assessed tumor localization error rates between operating surgeons and referring endoscopists.

The finding that operating surgeons have lower localization error rates and localization-based operative complications compared to non-operating endoscopists may be partly explained by differences in localization practices and specialty training within these groups. Surgeons who perform both the diagnostic endoscopy and the definitive surgical operation are highly invested in ensuring accurate localization, with an emphasis on ultimate surgical planning and minimizing any localization-based complications. Such differences in localization practices between surgeons and referring endoscopists are supported by our study finding of higher tattoo localization rates at initial endoscopy in the surgeon group ($P = 0.027$) and higher repeat endoscopy rates for referred cases ($P < 0.001$). Notably, our subgroup analysis demonstrated that both referring surgeons and operating surgeons are more likely to tattoo localize a lesion at initial endoscopy than gastroenterologists; 28 versus 11 %, $P < 0.001$, and 32 versus 11 %, $P < 0.001$.

$P < 0.001$, respectively. This markedly low rate of tattoo localization in the gastroenterologist group is contrary to established American Association of Gastrointestinal Endoscopy (ASGE) guidelines that advocate tattooing suspicious polyps and tumors [25]. Clinically, this is important as tattoo localization is considered the most accurate localization technique [26, 27] and is often cited as a leading reason for a surgeon to perform a repeat endoscopy [28], as it allows easy intra-operative visualization and localization of the tumor site. A recent retrospective cohort study demonstrated that for colorectal cancer not diagnosed by the operating surgeon, the repeat endoscopy rate was over 40 %, with over 80 % of repeat endoscopies used specifically for tattoo localization or operative planning [14]. It is clear that surgeons who are referred colorectal cancer cases perceive inadequate localization as a key reason to perform a repeat endoscopy, a practice that has demonstrated protection against errors [17]. This is further compounded by the fact that there is a lack of standardization with regard to documentation and reporting of localization information between endoscopists. Although a higher rate of tattoo localization in the operating surgeon group and tendency to repeat endoscopy in referred cases may in part explain differences in localization error rates between the study groups, additional research is needed to further elucidate variation in endoscopic practices among specialties.

Our study findings should be interpreted in the context of the following limitations. First, although our institution is a large multicenter academic hospital, the results of this study represent a single Canadian context, and therefore our findings may not be generalizable to other colorectal cancer patient populations. Furthermore, our study demonstrated an uneven spread of patients between the three groups of endoscopists (operating surgeon, referring surgeon, and referring gastroenterologists), a factor of the regional and local referral practices at our institution. The majority of the endoscopy time at our institution is earmarked for urgent cases with little elective time, leading to a smaller sample size of operating surgeons ($n = 81$) compared to referring endoscopists. As a Canadian tertiary care center, the majority of colorectal cancer cases are referred from external referring surgeons and gastroenterologists and thus given the differences in healthcare systems in the USA and Canada, additional research may be needed to explore these findings in a US healthcare setting. Second, due to the retrospective nature of our study, we are at risk of confounding by unmeasured factors. Although we felt that important measurable confounders were included, other possible confounding factors such as patient ethnicity, endoscopist subspecialty training, endoscopist experience, or volume of cases performed were not included due to restrictions in the data collection.

Prior knowledge of patient anatomy is an important confounder as is the case for patients with prior colectomy and colorectal cancer diagnoses. As expected, there was a higher percentage of patients in the operating surgeon group compared with the referring endoscopist group with prior colectomies; a factor that may potentially bias the operating surgeon group. In multivariate analysis, our study did not demonstrate this factor to be protective against localization error. Exclusion of these patients in subgroup analysis revealed maintained propensity for localization error in referring endoscopist group compared to operating surgeon group. Furthermore, a study by Piscatelli et al. [11] demonstrated that prior colorectal procedure was the only factor associated with higher propensity for localization error, entertaining the idea that prior colonic operations may potentially make identifying classical endoscopic landmarks used in localization more difficult. Further research is required to assess this study finding and its potential impact on accurate endoscopic localization. Thirdly, our study was limited by the lack of standardized endoscopy reports from external referring institutions. We were not able to assess the role of other localization techniques (e.g., distance from anal verge or image capture) given the low rate of reporting of such techniques.

Our study reveals that diagnostic and screening colonoscopies performed by an operating surgeon are associated with a lower localization error rate and localization-based operative complications compared to colonoscopies performed by referring endoscopists. Further research exploring the factors influencing localization accuracy and why operating surgeons have lower error rates relative to referring endoscopists is necessary to understand differences in care.

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Compliance with ethical standards

Disclosures Drs. Azin, Saleh, Cleghorn, Yuen, Jackson, Okrainec, and Quereshy have no conflicts of interest or financial ties to disclose.

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