**Name of Journal:** *World Journal of Gastrointestinal Endoscopy*

**Manuscript NO:** 79564

**Manuscript Type:** ORIGINAL ARTICLE

***Retrospective Study***

**Impact of looping on premalignant polyp detection during colonoscopy**

Toyoshima O *et al*. Colonoscope looping on premalignant polyp detection

Osamu Toyoshima, Toshihiro Nishizawa, Shuntaro Yoshida, Tatsuya Matsuno, Toru Arano, Ryo Kondo, Kazunori Kinoshita, Yuki Yasumi, Yosuke Tsuji, Mitsuhiro Fujishiro

**Osamu Toyoshima, Shuntaro Yoshida, Tatsuya Matsuno, Toru Arano, Ryo Kondo,** Department of Gastroenterology, Toyoshima Endoscopy Clinic, Tokyo 157-0066, Japan

**Toshihiro Nishizawa,** Department of Gastroenterology and Hepatology, International University of Health and Welfare, Narita Hospital, Narita 286-8520, Japan

**Kazunori Kinoshita,** Department of Obstetrics and Gynecology, Seijo Kinoshita Hospital, Tokyo 157-0066, Japan

**Yuki Yasumi,** Department of Internal Medicine, Yasumi Hospital, Morioka 028-4125, Japan

**Yosuke Tsuji, Mitsuhiro Fujishiro,** Department of Gastroenterology, Graduate School of Medicine, The University of Tokyo, Tokyo 113-8655, Japan

**Author contributions:** Toyoshima O, Nishizawa T, Yoshida S and Fujishiro M designed the study; Toyoshima O, Nishizawa T, Yoshida S, Matsuno T, Arano T, and Kondo R contributed to the endoscopic diagnosis; Toyoshima O wrote the article; Toyoshima O and Yoshida S were responsible to the statistical analysis; Nishizawa T edited the article; Yoshida S, Matsuno T, Arano T, Kondo R, Kinoshita K, Yasumi Y, Tsuji Y, and Fujishiro M involved in the critical review; and all authors approved the final manuscript.

**Corresponding author: Toshihiro Nishizawa, MD, PhD, Professor,** Department of Gastroenterology and Hepatology, International University of Health and Welfare, Narita Hospital, 852 Hatakeda, Narita 286-8520, Japan. nisizawa@iuhw.ac.jp

**Received:** September 5, 2022

**Revised:** October 20, 2022

**Accepted:** November 6, 2022

**Published online:** November 16, 2022

**Abstract**

BACKGROUND

The presence of premalignant polyps on colonoscopy is an indicator of metachronous colorectal cancer. Looping during colonoscopy is associated with old age, female sex, and colonoscopy insertion time. However, the clinical significance of looping is not fully understood. We aimed to clarify the effect of looping on colorectal premalignant polyp detection.

AIM

To assess the effects of looping on premalignant polyp detection using logistic regression analyses.

METHODS

We retrospectively investigated patients who underwent colonoscopy at Toyoshima Endoscopy Clinic between May, 2017 and October, 2020. From the clinic’s endoscopy database, we extracted data on patient age, sex, endoscopist-assessed looping, colonoscopy duration, endoscopist experience, detection rate, and number of premalignant polyps.

RESULTS

We assessed 12259 patients (mean age, 53.6 years; men, 50.7%). Looping occurred in 54.3% of the patients. Mild and severe looping were noted in 4399 and 2253 patients, respectively. The detection rates of adenomas, advanced adenomas, high-risk adenomas, clinically significant serrated polyps (CSSPs), and sessile serrated lesions (SSLs) were 44.7%, 2.0%, 9.9%, 8.9%, and 3.5%, respectively. The mean numbers of adenomas and SSLs were 0.82 and 0.04, respectively. The detection rates of adenomas, high-risk adenomas, and CSSPs increased with looping severity (all *P* < 0.001). The number of adenomas increased with looping severity (*P* < 0.001). Multivariate analyses found that detection of adenomas, high-risk adenomas, and CSSPs was associated with severe looping (*P* < 0.001, *P* < 0.001, and *P* = 0.007, respectively) regardless of age, sex, time required for colonoscope insertion and withdrawal, and endoscopist experience.

CONCLUSION

Looping severity was independently associated with high detection rates of premalignant polyps. Therefore, looping may predict the risk of metachronous colorectal cancer. Endoscopists should carefully examine the colorectum of patients with looping.

**Key Words:** Looping; Colorectal polyp; Colonoscopy; Adenoma; Serrated polyp; Colorectal neoplasm

**©The** **Author(s) 2022.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Citation:** Toyoshima O, Nishizawa T, Yoshida S, Matsuno T, Arano T, Kondo R, Kinoshita K, Yasumi Y, Tsuji Y, Fujishiro M. Impact of looping on premalignant polyp detection during colonoscopy. *World J Gastrointest Endosc* 2022; 14(11): 694-703

**URL:** <https://www.wjgnet.com/1948-5190/full/v14/i11/694.htm>

**DOI:** https://dx.doi.org/10.4253/wjge.v14.i11.694

**Core Tip:** This study aimed to clarify the effect of colonic looping on colorectal premalignant polyp detection during colonoscopy. We retrospectively investigated 12259 patients who underwent colonoscopies. Looping occurred in 54.3% (35.9% and 18.4% with mild and severe looping, respectively) of the cases. The detection rates of adenomas (44.7%), high-risk adenomas (9.9%), and clinically significant serrated polyps (CSSPs) (8.9%) increased with the looping severity. The number of adenomas per colonoscopy (0.82) increased with the looping severity. Multivariate analyses found that detection of adenomas, high-risk adenomas, and CSSPs was associated with severe looping regardless of age, sex, time required for colonoscope insertion and withdrawal, and endoscopist experience.

**INTRODUCTION**

Colorectal cancer mainly occurs because of adenomas or serrated polyps[1-3]. Colonoscopy is the gold standard for cancer screening and detection of premalignant polyps. The prevalence of metachronous colorectal cancer is high in patients with adenomas, especially high-risk adenomas, removed during colonoscopy[4]. Similarly, individuals with colonoscopically resected clinically significant serrated polyps (CSSPs) have a long-term risk of colorectal cancer[5-7]. Thus, the detection of adenomas and CSSPs on colonoscopy is a surrogate marker for the risk of metachronous colorectal cancer. Factors related to premalignant polyp detection include patient characteristics, such as age and sex[8,9], endoscopic procedure-related factors, such as cecal intubation time[10] and withdrawal time[11-14], and endoscopist experience[8].

Colonic looping is a common obstacle during routine colonoscopy[15,16]. Looping is associated with a redundant colon, older age, female sex, and cecal intubation time[17-20]. However, the clinical significance of looping is poorly understood. Therefore, this study aimed to clarify the effect of looping on colorectal premalignant polyp detection by using multivariate analysis to control for potential confounding factors.

**MATERIALS AND METHODS**

***Study design and overview***

This retrospective study was conducted at a single institute, Toyoshima Endoscopy Clinic, a representative outpatient endoscopy-specialized clinic located in an urban area of Japan. Toyoshima Endoscopy Clinic performs 10000 endoscopies annually. The study design was described in a protocol prepared at Toyoshima Endoscopy Clinic and approved by the Certified Institutional Review Board of Yoyogi Mental Clinic on July 16, 2021 (Approval no. RKK227). We published this study’s protocol on our institute’s website ([www.ichou.com](http://www.ichou.com)). Thus, patients could opt out of the study if desired. All the authors approved the final manuscript. No funding was received for this study.

***Patients***

Patients who underwent colonoscopy at Toyoshima Endoscopy Clinic between May, 2017 and October, 2020 were enrolled in this study. The indications for colonoscopy included the examination of symptoms and abnormal findings, screening, and surveillance for colorectal diseases. Patients undergoing treatment, such as polypectomy and hemostasis, those with poor bowel preparation[21,22], and those with a history of colorectal surgery were excluded. Cases of colonoscopies with incomplete cecal intubation, withdrawal time of < 6 min[11], and those performed with an ultrathin colonoscope were also excluded[23].

***Definition of looping***

Common colonic looping patterns observed during colonoscopy have been described previously. Loops occur in the transverse and sigmoid colons, and sigmoid loops include alpha and N shapes[19,24]. When forming a loop, there is no one-to-one relationship between the transmission of the colonoscope shaft movement and colonoscope tip motion. In the case of looping, further insertion of the scope results in a larger loop size without de-looping the scope[24,25].

Cecal insertion without loop formation was defined as the absence of looping. Cecal insertion that required straightening of the colonic loop once was defined as mild looping. Cecal insertion that required straightening of the colonic loop two or more times was defined as severe looping.

***Colonoscopy***

Small and gentle shaking and jiggling of the colonoscope shaft were performed. Right-turn shortening maneuvers for straightening the shaft were used for colonoscope insertion. Water-assisted, carbon dioxide-assisted, and cap-assisted chromoendoscopies with sedation were performed[26]. Position changes and rectal retroflexion were performed[8,27]. When looping was formed, we usually controlled the colonoscope by changing the patient’s position to supine or right lateral, and manual abdominal compression was performed by the assistant[15].

Thirty endoscopists with various levels of experience performed the colonoscopies[28,29]. This study defined experienced endoscopists as those with > 15 years of experience in performing endoscopy. We used a combination of the Elite system and CF-HQ290ZI, CF-HQ290I, or PCF-H290ZI colonoscopes (Olympus Corporation, Tokyo, Japan). Poor bowel preparation was defined as at least one colon segment that could not be examined because of the presence of remnant solid stool[9,16,27].

***Colorectal polyps***

All polyps suspected to be cancerous, adenomatous, or CSSP were removed or biopsied. All polyps were histologically diagnosed by an experienced gastrointestinal pathologist using the resected specimens and biopsy samples. Advanced adenomas included adenomas ≥ 10 mm in size, villous adenomas, and adenomas with high-grade dysplasia. A high-risk adenoma was defined as the presence of advanced adenoma and/or three or more adenomas. CSSPs comprise all sessile serrated lesions (SSLs), all traditional serrated adenomas, hyperplastic polyps of size ≥ 10 mm anywhere in the colorectum, and hyperplastic polyps of size ≥ 5 mm located between the cecum and descending colon[30-33].

***Outcomes***

We extracted data from the endoscopy database of Toyoshima Endoscopy Clinic, including patient age, sex, endoscopist-assessed looping, colonoscope insertion time, withdrawal time, endoscopists, detection rates of adenomas, advanced adenomas, high-risk adenomas, CSSPs, and SSLs, and numbers of adenomas and SSLs. Withdrawal time was defined as the time required to examine the colorectal mucosa and remove the polyps. The polyp detection rate was defined as the rate of colonoscopies that detected at least one polyp.

***Statistical analysis***

The significance of any orderly increase or decrease along the three stratifications (*i.e.,* no, mild, and severe looping) was assessed using Cochran-Armitage trend test or Jonckheere-Terpstra trend test for categorical and continuous variables, respectively. Because of the significant association between looping severity and polyp detection in the trend test, the effect of subject characteristics on polyp detection was analyzed using a multivariate analysis. Furthermore, a subgroup analysis, limited to experienced endoscopists, was performed. Multivariate analysis was performed using a binomial logistic regression model, with no, mild, and severe looping scores of 0, 1, and 2, respectively. Statistical significance was defined as a *P*-value < 0.05. The calculations were performed using Bell Curve for Excel version 3.22 (Social Survey Research Information Co., Ltd., Tokyo, Japan) and R version 4.1.2 (R Core Team 2021, R Foundation for Statistical Computing, Vienna, Austria).

**RESULTS**

***Patients***

During the study period, colonoscopies were performed on 13315 patients. We excluded 236 patients undergoing treatment, such as polypectomy and hemostasis, 77 with poor bowel preparation, 217 with previous colorectal surgery, 20 with incomplete cecal insertion (including 8 with stenosis caused by colorectal tumor and 6 with colonic looping), 22 with withdrawal time < 6 min, and 484 who were examined using an ultrathin colonoscope. Ultimately, 12259 patients were enrolled in this study. A patient flowchart is shown in Figure 1.

The mean patient age was 53.6 years. Men accounted for 50.7% of the participants. Looping occurred in 54.3% of the patients. There were 4399 and 2253 patients with mild and severe looping, respectively. The mean insertion and withdrawal times were 4.6 and 13.9 min, respectively. Experienced endoscopists performed 70.4% of the colonoscopies. The polyp detection rates for adenomas, advanced adenomas, high-risk adenomas, CSSPs, and SSLs were 44.7%, 2.0%, 9.9%, 8.9%, and 3.5%, respectively. The mean number of adenomas and SSLs was 0.82 and 0.04, respectively (Table 1).

***Subject characteristics based on looping***

Patients with severe looping tended to be older and more likely to be female (both *P* < 0.001). Cecal insertion and withdrawal times tended to be longer in severe looping (both *P* < 0.001). Experienced endoscopists performed cases with severe looping more often. The polyp detection rates of adenomas (*P* < 0.001), advanced adenomas, high-risk adenomas (*P* < 0.001), CSSPs (*P* < 0.001), and SSLs tended to increase with looping severity. However, the tendency of advanced adenoma and SSL detection rates were not statistically significant (*P* = 0.166 and *P* = 0.064, respectively). The number of adenomas increased with looping severity (*P* < 0.001, Table 2).

***Multivariate analysis of effect on polyp detection***

We investigated the effect of subject characteristics on the detection of adenomas, high-risk adenomas, and CSSPs using multivariate analyses. The detection of adenomas and high-risk adenomas was independently associated with severe looping (both *P* < 0.001), old age, male sex, short insertion time, long withdrawal time, and endoscopist experience. CSSP detection was independently associated with severe looping (*P* = 0.007), female sex, short insertion time, long withdrawal time, and endoscopist experience (Table 3).

***Subgroup analysis limited to experienced endoscopists***

We performed a subgroup analysis that was limited to experienced endoscopists. Multivariate analyses showed similar results to the all-case analyses, that is, severe looping was independently associated with high detection rates of adenomas, high-risk adenomas, and CSSPs (*P* < 0.001, *P* < 0.001, and *P* = 0.008, respectively; Table 4).

**DISCUSSION**

In this study, we found that the severity of looping during colonoscopy was positively associated with high detection rates of adenomas, high-risk adenomas, and CSSPs, independent of other confounding factors, such as patient age, sex, colonoscope insertion and withdrawal times, and endoscopist experience. To the best of our knowledge, this is the first study to demonstrate a relationship between looping and polyp detection. Adenomas, high-risk adenomas, and CSSPs are precancerous lesions[2]. Recent studies have also shown that adenoma, high-risk adenoma, and CSSP detection rates are associated with a high risk of metachronous colorectal cancer[4,6]. Therefore, looping may predict a high frequency of metachronous colorectal cancer; however, further analysis is needed. Colonoscopists should carefully examine the colorectal region of patients with looping considering the high premalignant polyp detection rate.

Magnetic endoscopic imaging, computed tomographic colonoscopy, and autopsy revealed that looping was more common in older adults and women. Loop formation is also associated with prolonged cecal insertion time[17-20]. In our study, looping severity was associated with older age, female sex, and longer insertion time. Our results were consistent with those of previous studies. Looping during colonoscopy mainly occurs in the intraperitoneal segments of the colon, such as the transverse and sigmoid colon[15,17,19,20,34,35]. Barium enema and computed tomographic colonoscopy revealed that older adults and women had longer colons and larger colonic surface areas than younger adults and men, respectively. Differences in the total length and surface area are predominantly due to differences in the transverse colon[36-38]. The increased length and surface area of the colon may contribute to the formation of loops and high frequency of premalignant polyps.

Colonic redundancy is a major cause of looping during colonoscopy[39]. Colonic elongation and tortuosity appear to be related to redundancy of the colon, such as in the transverse and sigmoid colon[40,41]. Older adults and women often present with colonic redundancy and looping[41]. Raahave *et al*[42] reported that colonic transit time is associated with redundant colonic loops. Constipation increases the risk of colorectal cancer[43]. This causes prolonged contact between the colonic mucosa and carcinogens in the stool.

Our study showed that adenoma detection was associated with old age, male sex, short insertion time, long withdrawal time, and endoscopist experience. These results are consistent with those of previous studies[8,10-12]. Female sex and longer withdrawal time, but not older age, were associated with CSSPs in our study. These findings are also concordant with those of previous studies[44-46]. The consistency of these results strengthens the credibility of this study.

***Limitations***

This study had several limitations. First, this study was retrospectively conducted at a single institution; however, medical data were well-controlled. Second, although patients’ body mass index, family history of colorectal cancer, and gynecological surgery are associated with the presence of premalignant polyps and looping[25,47], they were not examined. Third, since mucosal exposure can affect adenoma detection rate[48], the shape of looping, de-looping method, and successful de-looping after cecal intubation should be evaluated, not only the degree of looping during insertion. However, our data do not contain this information. Further verification is required in the future.

**CONCLUSION**

In conclusion, the severity of looping during colonoscopy was strongly associated with high detection rates of premalignant polyps, such as adenomas, high-risk adenomas, and CSSPs. Therefore, looping may predict the risk of metachronous colorectal cancer; however, further investigation is needed. Endoscopists should be more careful when examining for colorectal polyps in patients with looping.

**ARTICLE HIGHLIGHTS**

***Research background***

Colonic looping is a common obstacle during routine colonoscopy.

***Research motivation***

Looping is associated with a redundant colon, older age, female sex, and cecal intubation time. However, the clinical significance of looping is not fully understood.

***Research objectives***

We aimed to clarify the effect of looping on colorectal premalignant polyp detection.

***Research methods***

We extracted data from the clinic’s endoscopy database on patient age, sex, endoscopist-assessed looping, colonoscopy duration, endoscopist experience, and premalignant polyp detection. The effects of looping on premalignant polyp detection were assessed using logistic regression analyses.

***Research results***

The detection rates of adenomas, high-risk adenomas, and clinically significant serrated polyps (CSSPs) increased with the severity of looping (all *P* < 0.001). The number of adenomas increased with looping severity (*P* < 0.001). Multivariate analyses found that detection of adenoma, high-risk adenoma, and CSSP was associated with severe looping (*P* < 0.001, *P* < 0.001, and *P* = 0.007, respectively) regardless of age, sex, and the time required for colonoscope insertion and withdrawal, and endoscopist experience.

***Research conclusions***

Looping severity was independently associated with high detection rates of premalignant polyps.

***Research perspectives***

Looping may predict the risk of metachronous colorectal cancer; however, further investigation is needed.

**ACKNOWLEDGEMENTS**

We would like to thank Dr. Hidenobu Watanabe for conducting histological diagnosis. We would like to thank Shido Inc. (www.Shido.co.jp) for the statistical analysis. We would like to thank clinical laboratory engineer Tadahiro Yamakawa for managing the endoscopy database of Toyoshima Endoscopy Clinic.

**REFERENCES**

1 **Bevan R**, Rutter MD. Colorectal Cancer Screening-Who, How, and When? *Clin Endosc* 2018; **51**: 37-49 [PMID: 29397655 DOI: 10.5946/ce.2017.141]

2 **Nagtegaal I**, Arends, MJ, Odeze, RD, Lam, AK. Tumours of the colon and rectum. In: WHO Classification of Tumours Editorial Board. Digestive System Tumours: WHO Classification of Tumours (Medicine) 5th Edition. Lyon: World Health Organization, 2019: 157-191

3 **Sehgal A**, Aggarwal S, Mandaliya R, Loughney T, Mattar MC. Improving sessile serrated adenoma detection rates with high definition colonoscopy: A retrospective study. *World J Gastrointest Endosc* 2022; **14**: 226-234 [PMID: 35634484 DOI: 10.4253/wjge.v14.i4.226]

4 **Duvvuri A**, Chandrasekar VT, Srinivasan S, Narimiti A, Dasari C, Nutalapati V, Kennedy KF, Spadaccini M, Antonelli G, Desai M, Vennalaganti P, Kohli D, Kaminski MF, Repici A, Hassan C, Sharma P. Risk of Colorectal Cancer and Cancer Related Mortality After Detection of Low-risk or High-risk Adenomas, Compared With No Adenoma, at Index Colonoscopy: A Systematic Review and Meta-analysis. *Gastroenterology* 2021; **160**: 1986-1996.e3 [PMID: 33524401 DOI: 10.1053/j.gastro.2021.01.214]

5 **Kahi CJ**. Screening Relevance of Sessile Serrated Polyps. *Clin Endosc* 2019; **52**: 235-238 [PMID: 30625264 DOI: 10.5946/ce.2018.112]

6 **He X**, Hang D, Wu K, Nayor J, Drew DA, Giovannucci EL, Ogino S, Chan AT, Song M. Long-term Risk of Colorectal Cancer After Removal of Conventional Adenomas and Serrated Polyps. *Gastroenterology* 2020; **158**: 852-861.e4 [PMID: 31302144 DOI: 10.1053/j.gastro.2019.06.039]

7 **Tan YY**, Tay GSK, Wong YJ, Li JW, Kwek ABE, Ang TL, Wang LM, Tan MTK. Clinical Features and Predictors of Dysplasia in Proximal Sessile Serrated Lesions. *Clin Endosc* 2021; **54**: 578-588 [PMID: 33915614 DOI: 10.5946/ce.2020.198]

8 **Toyoshima O**, Nishizawa T, Yoshida S, Sekiba K, Kataoka Y, Hata K, Watanabe H, Tsuji Y, Koike K. Expert endoscopists with high adenoma detection rates frequently detect diminutive adenomas in proximal colon. *Endosc Int Open* 2020; **8**: E775-E782 [PMID: 32490163 DOI: 10.1055/a-1136-9971]

9 **Toyoshima O**, Yoshida S, Nishizawa T, Yamakawa T, Arano T, Isomura Y, Kanazawa T, Ando H, Tsuji Y, Koike K. Simple feedback of colonoscopy performance improved the number of adenomas per colonoscopy and serrated polyp detection rate. *Endosc Int Open* 2021; **9**: E1032-E1038 [PMID: 34222627 DOI: 10.1055/a-1393-5469]

10 **von Renteln D**, Robertson DJ, Bensen S, Pohl H. Prolonged cecal insertion time is associated with decreased adenoma detection. *Gastrointest Endosc* 2017; **85**: 574-580 [PMID: 27590962 DOI: 10.1016/j.gie.2016.08.021]

11 **Barclay RL**, Vicari JJ, Doughty AS, Johanson JF, Greenlaw RL. Colonoscopic withdrawal times and adenoma detection during screening colonoscopy. *N Engl J Med* 2006; **355**: 2533-2541 [PMID: 17167136 DOI: 10.1056/NEJMoa055498]

12 **Kashiwagi K**, Inoue N, Yoshida T, Bessyo R, Yoneno K, Imaeda H, Ogata H, Kanai T, Sugino Y, Iwao Y. Polyp detection rate in transverse and sigmoid colon significantly increases with longer withdrawal time during screening colonoscopy. *PLoS One* 2017; **12**: e0174155 [PMID: 28328936 DOI: 10.1371/journal.pone.0174155]

13 **Cavicchi M**, Tharsis G, Burtin P, Cattan P, Venezia F, Tordjman G, Gillet A, Samama J, Nahon-Uzan K, Karsenti D. Difference in Physician- and Patient-Dependent Factors Contributing to Adenoma Detection Rate and Serrated Polyp Detection Rate. *Dig Dis Sci* 2019; **64**: 3579-3588 [PMID: 31471862 DOI: 10.1007/s10620-019-05808-y]

14 **Kim SH**, Kim JH. When should we perform colonoscopy to increase the adenoma detection rate? *World J Gastrointest Endosc* 2021; **13**: 619-627 [PMID: 35070023 DOI: 10.4253/wjge.v13.i12.619]

15 **Shah SG**, Saunders BP, Brooker JC, Williams CB. Magnetic imaging of colonoscopy: an audit of looping, accuracy and ancillary maneuvers. *Gastrointest Endosc* 2000; **52**: 1-8 [PMID: 10882954 DOI: 10.1067/mge.2000.107296]

16 **Toyoshima O**, Nishizawa T, Sakitani K, Yamakawa T, Yoshida S, Fukagawa K, Hata K, Ishihara S, Suzuki H. Colonoscopy using back brace support belt: A randomized, prospective trial. *JGH Open* 2020; **4**: 441-445 [PMID: 32514451 DOI: 10.1002/jgh3.12276]

17 **Shah SG**, Brooker JC, Thapar C, Williams CB, Saunders BP. Patient pain during colonoscopy: an analysis using real-time magnetic endoscope imaging. *Endoscopy* 2002; **34**: 435-440 [PMID: 12048623 DOI: 10.1055/s-2002-31995]

18 **Eickhoff A**, Pickhardt PJ, Hartmann D, Riemann JF. Colon anatomy based on CT colonography and fluoroscopy: impact on looping, straightening and ancillary manoeuvres in colonoscopy. *Dig Liver Dis* 2010; **42**: 291-296 [PMID: 19502116 DOI: 10.1016/j.dld.2009.04.022]

19 **Lam J**, Wilkinson J, Brassett C, Brown J. Difference in real-time magnetic image analysis of colonic looping patterns between males and females undergoing diagnostic colonoscopy. *Endosc Int Open* 2018; **6**: E575-E581 [PMID: 29756015 DOI: 10.1055/a-0574-2478]

20 **Lam J**, Wilkinson J, Brown J, Spear M, Brassett C. Exploration of colonic looping patterns in undisturbed cadaveric specimens. *Clin Anat* 2021; **34**: 1016-1021 [PMID: 33191505 DOI: 10.1002/ca.23702]

21 **Ell C**, Fischbach W, Bronisch HJ, Dertinger S, Layer P, Rünzi M, Schneider T, Kachel G, Grüger J, Köllinger M, Nagell W, Goerg KJ, Wanitschke R, Gruss HJ. Randomized trial of low-volume PEG solution versus standard PEG + electrolytes for bowel cleansing before colonoscopy. *Am J Gastroenterol* 2008; **103**: 883-893 [PMID: 18190651 DOI: 10.1111/j.1572-0241.2007.01708.x]

22 **Hong SN**, Sung IK, Kim JH, Choe WH, Kim BK, Ko SY, Lee JH, Seol DC, Ahn SY, Lee SY, Park HS, Shim CS. The Effect of the Bowel Preparation Status on the Risk of Missing Polyp and Adenoma during Screening Colonoscopy: A Tandem Colonoscopic Study. *Clin Endosc* 2012; **45**: 404-411 [PMID: 23251889 DOI: 10.5946/ce.2012.45.4.404]

23 **Sofi AA**, Nawras A, Khan MA, Howden CW, Lee WM. Meta-analysis of the performance of ultrathin vs. standard colonoscopes. *Endoscopy* 2017; **49**: 351-358 [PMID: 27852099 DOI: 10.1055/s-0042-117110]

24 **Cheng WB**, Moser MA, Kanagaratnam S, Zhang WJ. Overview of upcoming advances in colonoscopy. *Dig Endosc* 2012; **24**: 1-6 [PMID: 22211405 DOI: 10.1111/j.1443-1661.2011.01181.x]

25 **Cheng WB**, Moser MA, Kanagaratnam S, Zhang WJ. Analysis of and mathematical model insight into loop formation in colonoscopy. *Proc Inst Mech Eng H* 2012; **226**: 858-867 [PMID: 23185956 DOI: 10.1177/0954411912453263]

26 **Passi M**, Rahman F, Gurram S, Kumar S, Koh C. Identifying who best tolerates moderate sedation: Results from a national database of gastrointestinal endoscopic outcomes. *World J Gastrointest Endosc* 2021; **13**: 97-110 [PMID: 33959232 DOI: 10.4253/wjge.v13.i4.97]

27 **Toyoshima O**, Yoshida S, Nishizawa T, Yamakawa T, Sakitani K, Hata K, Takahashi Y, Fujishiro M, Watanabe H, Koike K. CF290 for pancolonic chromoendoscopy improved sessile serrated polyp detection and procedure time: a propensity score-matching study. *Endosc Int Open* 2019; **7**: E987-E993 [PMID: 31367679 DOI: 10.1055/a-0953-1909]

28 **Qayed E**, Vora R, Levy S, Bostick RM. Colonoscopy procedural volume increases adenoma and polyp detection rates in gastroenterologytrainees. *World J Gastrointest Endosc* 2017; **9**: 540-551 [PMID: 29184610 DOI: 10.4253/wjge.v9.i11.540]

29 **Lee AHH**, Lojanapiwat N, Balakrishnan V, Chandra R. Is there a difference in adenoma detection rates between gastroenterologists and surgeons? *World J Gastrointest Endosc* 2018; **10**: 109-116 [PMID: 29988847 DOI: 10.4253/wjge.v10.i6.109]

30 **Rex DK**, Ahnen DJ, Baron JA, Batts KP, Burke CA, Burt RW, Goldblum JR, Guillem JG, Kahi CJ, Kalady MF, O'Brien MJ, Odze RD, Ogino S, Parry S, Snover DC, Torlakovic EE, Wise PE, Young J, Church J. Serrated lesions of the colorectum: review and recommendations from an expert panel. *Am J Gastroenterol* 2012; **107**: 1315-29; quiz 1314, 1330 [PMID: 22710576 DOI: 10.1038/ajg.2012.161]

31 **Anderson JC**, Butterly LF, Weiss JE, Robinson CM. Providing data for serrated polyp detection rate benchmarks: an analysis of the New Hampshire Colonoscopy Registry. *Gastrointest Endosc* 2017; **85**: 1188-1194 [PMID: 28153571 DOI: 10.1016/j.gie.2017.01.020]

32 **Li D**, Woolfrey J, Jiang SF, Jensen CD, Zhao WK, Kakar S, Santamaria M, Rumore G, Armstrong MA, Postlethwaite D, Corley DA, Levin TR. Diagnosis and predictors of sessile serrated adenoma after educational training in a large, community-based, integrated healthcare setting. *Gastrointest Endosc* 2018; **87**: 755-765.e1 [PMID: 28843582 DOI: 10.1016/j.gie.2017.08.012]

33 **Klair JS**, Ashat M, Johnson D, Arora S, Onteddu N, Machain Palacio JG, Samuel R, Bilal M, Buddam A, Gupta A, Gunderson A, Guturu P, Soota K, Chandra S, Murali AR. Serrated polyp detection rate and advanced adenoma detection rate from a US multicenter cohort. *Endoscopy* 2020; **52**: 61-67 [PMID: 31739370 DOI: 10.1055/a-1031-5672]

34 **Asai S**, Fujimoto N, Tanoue K, Akamine E, Nakao E, Hashimoto K, Ichinona T, Nambara M, Sassa S, Yanagi H, Hirooka N, Mori T, Ogawa M, Ogawa A. Water immersion colonoscopy facilitates straight passage of the colonoscope through the sigmoid colon without loop formation: randomized controlled trial. *Dig Endosc* 2015; **27**: 345-353 [PMID: 25413483 DOI: 10.1111/den.12406]

35 **Bruce M**, Choi J. Detection of endoscopic looping during colonoscopy procedure by using embedded bending sensors. *Med Devices (Auckl)* 2018; **11**: 171-191 [PMID: 29849469 DOI: 10.2147/MDER.S146934]

36 **Sadahiro S**, Ohmura T, Yamada Y, Saito T, Taki Y. Analysis of length and surface area of each segment of the large intestine according to age, sex and physique. *Surg Radiol Anat* 1992; **14**: 251-257 [PMID: 1440190 DOI: 10.1007/bf01794949]

37 **Saunders BP**, Fukumoto M, Halligan S, Jobling C, Moussa ME, Bartram CI, Williams CB. Why is colonoscopy more difficult in women? *Gastrointest Endosc* 1996; **43**: 124-126 [PMID: 8635705 DOI: 10.1016/s0016-5107(06)80113-6]

38 **Khashab MA**, Pickhardt PJ, Kim DH, Rex DK. Colorectal anatomy in adults at computed tomography colonography: normal distribution and the effect of age, sex, and body mass index. *Endoscopy* 2009; **41**: 674-678 [PMID: 19670134 DOI: 10.1055/s-0029-1214899]

39 **Ritter EM**, Cox TC, Trinca KD, Pearl JP. Simulated Colonoscopy Objective Performance Evaluation (SCOPE): a non-computer-based tool for assessment of endoscopic skills. *Surg Endosc* 2013; **27**: 4073-4080 [PMID: 23860607 DOI: 10.1007/s00464-013-3063-8]

40 **Hanson ME**, Pickhardt PJ, Kim DH, Pfau PR. Anatomic factors predictive of incomplete colonoscopy based on findings at CT colonography. *AJR Am J Roentgenol* 2007; **189**: 774-779 [PMID: 17885044 DOI: 10.2214/ajr.07.2048]

41 **Cuda T**, Gunnarsson R, de Costa A. The correlation between diverticulosis and redundant colon. *Int J Colorectal Dis* 2017; **32**: 1603-1607 [PMID: 28932890 DOI: 10.1007/s00384-017-2894-5]

42 **Raahave D**, Christensen E, Loud FB, Knudsen LL. Correlation of bowel symptoms with colonic transit, length, and faecal load in functional faecal retention. *Dan Med Bull* 2009; **56**: 83-88 [PMID: 19486620]

43 **Sundbøll J**, Thygesen SK, Veres K, Liao D, Zhao J, Gregersen H, Sørensen HT. Risk of cancer in patients with constipation. *Clin Epidemiol* 2019; **11**: 299-310 [PMID: 31118818 DOI: 10.2147/CLEP.S205957]

44 **Chen H**, Li N, Ren J, Feng X, Lyu Z, Wei L, Li X, Guo L, Zheng Z, Zou S, Zhang Y, Li J, Zhang K, Chen W, Dai M, He J; group of Cancer Screening Program in Urban China (CanSPUC). Participation and yield of a population-based colorectal cancer screening programme in China. *Gut* 2019; **68**: 1450-1457 [PMID: 30377193 DOI: 10.1136/gutjnl-2018-317124]

45 **Meester RGS**, van Herk MMAGC, Lansdorp-Vogelaar I, Ladabaum U. Prevalence and Clinical Features of Sessile Serrated Polyps: A Systematic Review. *Gastroenterology* 2020; **159**: 105-118.e25 [PMID: 32199884 DOI: 10.1053/j.gastro.2020.03.025]

46 **Anwar S**, Cock C, Young J, Young GP, Meng R, Simpson K, Coats M, Huang J, Bampton P, Fraser R, Symonds EL. Features associated with high-risk sessile serrated polyps at index and follow-up colonoscopy. *J Gastroenterol Hepatol* 2021; **36**: 1620-1626 [PMID: 33140867 DOI: 10.1111/jgh.15328]

47 **Adams C**, Cardwell C, Cook C, Edwards R, Atkin WS, Morton DG. Effect of hysterectomy status on polyp detection rates at screening flexible sigmoidoscopy. *Gastrointest Endosc* 2003; **57**: 848-853 [PMID: 12776031 DOI: 10.1016/s0016-5107(03)70019-4]

48 **McGill SK**, Rosenman J, Wang R, Ma R, Frahm JM, Pizer S. Artificial intelligence identifies and quantifies colonoscopy blind spots. *Endoscopy* 2021; **53**: 1284-1286 [PMID: 33540438 DOI: 10.1055/a-1346-7455]

**Footnotes**

**Institutional review board statement:** This study was approved by the Certificated Review Board, Yoyogi Mental Clinic on July 16, 2021 (approval no. RKK227).

**Informed consent statement:** Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent. For full disclosure, the details of the study are published on the home page of Toyoshima Endoscopy Clinic.

**Conflict-of-interest statement:** Fujishiro M received research grant and honoraria from Olympus Corporation.

**Data sharing statement:** No additional data are available.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

**Provenance and peer review:** Unsolicited article; Externally peer reviewed

**Peer-review model:** Single blind

**Peer-review started:** September 5, 2022

**First decision:** October 12, 2022

**Article in press:** November 6, 2022

**Specialty type:** Gastroenterology and hepatology

**Country/Territory of origin:** Japan

**Peer-review report’s scientific quality classification**

Grade A (Excellent): A

Grade B (Very good): B

Grade C (Good): C

Grade D (Fair): D

Grade E (Poor): 0

**P-Reviewer:** Hu B, China; Ko J, South Korea; Mohamed SY, Egypt; Sharaf MM, Syria **S-Editor:** Wang JJ **L-Editor:** A **P-Editor:** Wang JJ

**Figure Legends**



**Figure 1 Patient flowchart.**

**Table 1 Characteristics of the study subjects**

|  |  |
| --- | --- |
| **Characteristics** |  |
| *n* | 12259 |
| Age, mean (SD), yr | 53.6 (12.2) |
| Male sex, % | 50.7 |
| Looping, none/mild/severe, *n* | 5532/4399/2253 |
| Insertion time, mean (SD), min | 4.57 (2.66) |
| Withdrawal time, mean (SD), min | 13.87 (4.19) |
| Experienced endoscopist, % | 70.4 |
| Polyp detection |
| Adenoma DR, % | 44.7 |
| Advanced adenoma DR, % | 2.0 |
| High-risk adenoma DR, % | 9.9 |
| CSSP DR, % | 8.9 |
| SSL DR, % | 3.5 |
| Number of adenomas, mean (SD), *n* | 0.82 (1.25) |
| Number of SSLs, mean (SD), *n* | 0.04 (0.24) |

SD: Standard deviation; DR: Detection rate; CSSP: Clinically significant serrated polyp; SSL: Sessile serrated lesion.

**Table 2** **Subject characteristics based on looping severity**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **No looping** | **Mild looping** | **Severe looping** | ***P* value** |
| *n* | 5532 | 4399 | 2253 |  |
| Age, mean (SD), yr | 51.5 (11.5) | 54.2 (12.2) | 56.7 (13.0) | < 0.001 |
| Male sex, % | 62.8 | 44.6 | 33.4 | < 0.001 |
| Insertion time, mean (SD), min | 3.53 (1.89) | 4.95 (2.41) | 6.38 (3.44) | < 0.001 |
| Withdrawal time, mean (SD), min | 13.70 (4.30) | 14.17 (4.29) | 13.74 (3.66) | < 0.0011 |
| Experienced endoscopist, % | 61.1 | 73.7 | 87.6 | < 0.001 |
| Polyp detection |
| Adenoma DR, % | 42.2 | 45.0 | 50.2 | < 0.001 |
| Advanced adenoma DR, % | 1.8 | 2.1 | 2.3 | 0.166 |
| High-risk adenoma DR, % | 8.4 | 9.8 | 13.5 | < 0.001 |
| CSSP DR, % | 7.8 | 9.5 | 10.3 | < 0.001 |
| SSL DR, % | 3.2 | 3.7 | 3.9 | 0.064 |
| Number of adenomas, mean (SD), *n* | 0.74 (1.16) | 0.81 (1.25) | 1.03 (1.44) | < 0.001 |
| Number of SSLs, mean (SD), *n* | 0.04 (0.22) | 0.05 (0.26) | 0.05 (0.26) | 0.553 |

1There were 22065005 and 19833488 combinations of increasing and decreasing trends, respectively.

*P* values were calculated using Cochran–Armitage trend test and Jonckheere-Terpstra test for categorical and continuous variables, respectively. SD: Standard deviation; DR: Detection rate; CSSP: Clinically significant serrated polyp; SSL: Sessile serrated lesion.

**Table 3 Multivariate analysis of the effect on polyp detections**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Odds ratio** | **95% confidence interval** | **DOF** | ***P* value** |
| **Adenoma** |
| Looping1 | 1.13 | 1.06-1.20 | 1 | < 0.001 |
| Age | 1.05 | 1.04-1.05 | 1 | < 0.001 |
| Male sex | 1.39 | 1.28-1.50 | 1 | < 0.001 |
| Insertion time | 0.94 | 0.92-0.96 | 1 | < 0.001 |
| Withdrawal time | 1.14 | 1.13-1.15 | 1 | < 0.001 |
| Endoscopist experience | 1.68 | 1.53-1.85 | 1 | < 0.001 |
| **High-risk adenoma** |
| Looping1 | 1.25 | 1.13-1.38 | 1 | < 0.001 |
| Age | 1.05 | 1.05-1.06 | 1 | < 0.001 |
| Male sex | 1.527 | 1.33-1.74 | 1 | < 0.001 |
| Insertion time | 0.90 | 0.87-0.93 | 1 | < 0.001 |
| Withdrawal time | 1.20 | 1.18-1.21 | 1 | < 0.001 |
| Endoscopist experience | 3.91 | 3.17-4.82 | 1 | < 0.001 |
| **Clinically significant serrated polyp** |
| Looping1 | 1.14 | 1.04-1.26 | 1 | 0.007 |
| Age | 1.00 | 0.99-1.01 | 1 | 0.999 |
| Male sex | 0.60 | 0.52-0.68 | 1 | < 0.001 |
| Insertion time | 0.92 | 0.88-0.95 | 1 | < 0.001 |
| Withdrawal time | 1.16 | 1.14-1.17 | 1 | < 0.001 |
| Endoscopist experience | 2.04 | 1.71-2.43 | 1 | < 0.001 |

1No, mild, and severe looping were scored 0, 1, and 2, respectively.

*P* value was calculated using binomial logistic regression model. DOF: Degree of freedom.

**Table 4 Multivariate analysis of the effect on polyp detections in the sub-analysis of experienced endoscopists**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Odds ratio** | **95% confidence interval** | **DOF** | ***P* value** |
| **Adenoma** |
| Looping1 | 1.14 | 1.07-1.23 | 1 | < 0.001 |
| Age | 1.05 | 1.05-1.05 | 1 | < 0.001 |
| Male sex | 1.42 | 1.29-1.56 | 1 | < 0.001 |
| Insertion time | 0.93 | 0.91-0.95 | 1 | < 0.001 |
| Withdrawal time | 1.13 | 1.11-1.14 | 1 | < 0.001 |
| **High-risk adenoma** |
| Looping1 | 1.27 | 1.14-1.41 | 1 | < 0.001 |
| Age | 1.05 | 1.05-1.06 | 1 | < 0.001 |
| Male sex | 1.56 | 1.35-1.81 | 1 | < 0.001 |
| Insertion time | 0.89 | 0.85-0.92 | 1 | < 0.001 |
| Withdrawal time | 1.18 | 1.16-1.20 | 1 | < 0.001 |
| **Clinically significant serrated polyp** |
| Looping1 | 1.15 | 1.04-1.28 | 1 | 0.008 |
| Age | 1.00 | 1.00-1.01 | 1 | 0.627 |
| Male sex | 0.66 | 0.57-0.77 | 1 | < 0.001 |
| Insertion time | 0.92 | 0.89-0.96 | 1 | < 0.001 |
| Withdrawal time | 1.13 | 1.11-1.15 | 1 | < 0.001 |

1No, mild, and severe looping were scored 0, 1, and 2, respectively.

*P* value was calculated using binomial logistic regression model. DOF: Degree of freedom.



Published by **Baishideng Publishing Group Inc**

7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

**Telephone:** +1-925-3991568

**E-mail:** bpgoffice@wjgnet.com

**Help Desk:** https://www.f6publishing.com/helpdesk

https://www.wjgnet.com



**© 2022 Baishideng Publishing Group Inc. All rights reserved.**