Original article

Comparison on colonoscopic parameters according to length of adult-colonoscope

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Keywords: *colonoscopy; intubation time; intubation rate; colonoscope length*

Background High success rate of intubation and short intubation time have been needed to endoscopists for a complete and comfortable colonoscopy, if possible. The purpose of present study was to compare procedure efficiencies according to adult-colonoscope length.

Methods This was a prospective, randomized, single-blinded controlled trial. A total of 239 healthy Korean subjects were randomly assigned to two groups: one group receiving intermediate-length adult-colonoscope (n=119), and the other group receiving long-length adult-colonoscope (n=120). Cecal intubation time and rate, and terminal ileal intubation time and rate as well as other procedure-related outcomes (adenoma detection rate, withdrawal time, and total procedure time) were evaluated.

Results There were significant differences in cecal intubation time and terminal ileal intubation rate according to colonoscope length. The time of cecal intubation was shorter in the intermediate-scope group than that in the long-scope group ((222.13±101.67) s vs. (253.85±109.40) s, P=0.014). However, the rate of terminal ileal intubation was higher in the long-scope group than that in the intermediate-scope group (94.2% vs. 83.2%, P=0.007). In addition, terminal ileal intubation time was also shorter in the long-scope group than that in the intermediate-scope group ((35.21±38.89) s vs. (44.09±33.87) s, P <0.001). There were no significant differences in other procedure-related outcomes between the two groups.

Conclusions The intermediate-length adult-colonoscope had an advantage over the long-length adult-colonoscope regarding cecal intubation time, whereas the long-scope had an advantage over the intermediate-scope regarding the rate and time of terminal ileal intubation. These results suggest that it is rational to prepare and use these two types of colonoscope properly, instead of employing only one type of colonoscope.

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Colorectal neoplasm has been becoming a worldwide concern.[1] Colorectal cancer (CRC) is one of the most common malignancies in more developed regions, such as North America and Europe,[2,3] and the incidence of CRC appears to be increasing in East Asian countries including China and Korea due to changing dietary habit and lifestyle and increased obesity population.[4,5] In Korea, according to the statistics of the Korea Central Cancer Registry (KCCR) in 2010, CRC ranked second, fourth, and third among the most common malignancies in males, females, and both males and females), respectively.[6] Since its first introduction in 1969, colonoscopy has become as a potent screening method for the detection of early CRC.[7] It also plays an important role in the prevention of CRC through the diagnosis and removal of adenomatous polyps (premalignant lesions of CRC).[8] It has been estimated that 50% to 80% of CRC are preventable or effectively treated if caught early.[9] Therefore, the demand for colonoscopic examination is growing rapidly worldwide.

For achieving performing a complete colonoscopy without missing abnormal lesions including colorectal neoplasm, especially in areas such as the terminal ileum and proximal colon (cecum and ascending colon), it is essential to accomplish a high success rate of intubation of cecum and terminal ileum.[10] Moreover, it is also important to perform cecal and ileal intubation as quickly as possible. If intubation is delayed, the total procedure time (intubation time plus withdrawal time) may be prolonged as well. Prolonged procedural time may be associated with endoscopy-related complications (e.g. abdominal and anal discomfort, flatulence, hypoxia due to increased sedation doses, increased risk of iatrogenic perforation). According to previous studies, factors affecting cecal intubation time and rate have already been investigated.[11,12] However, most of these studies to date have dedicated on patient-related factors (e.g. age, sex, body mass index, waist circumference, previous history of operation, quality of bowel cleanliness) or endoscopist-related factors (e.g. experienced cases of colonoscopy (staff vs. fellow), specialty (gastroenterologist vs. non-gastroenterologist)).[13,14] A few studies have reported cecal intubation with regard to colonoscope-related factors, such as variable stiffness[15-17] and length (pediatric vs. adult; adult-intermediate vs. adult-long).[18-20] Additionally, to the best of our knowledge and through extensive review of

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literatures, no research so far has been reported on the effect of length of adult-colonoscope on terminal ileal intubation time and rate.

Thus, we have conducted a randomized controlled trial of colonoscopy between two groups, intermediate adult-colonosocpe (IAC) group versus long adult-colonoscope (LAC) group. The purpose of present study was to compare procedure efficiencies, including cecal intubation time and rate, terminal ileal intubation time and rate, and adenoma detection rate, according to the length of adult-colonoscope.

METHODS

This was a prospective, randomized, single-blinded controlled trial, which was approved by the Institutional Review Board at Ajou University Hospital (Suwon, Republic of Korea). Written informed consent was obtained from all subjects enrolled in the study.

Study subjects

From October 2012 to February 2013, 253 Korean adults over 20 years of age were recruited for the research. Among the initial 253 subjects, we excluded 14 subjects. Exclusion criteria were inability to provide informed consent (n=3), pregnancy (n=1), previous large bowel resection (n=1), medical history of malignancy or inflammatory bowel disease (IBD) (n=3), underlying diseases including chronic renal failure (n=2), heart failure (n=1), and asthma (n=1), and allergy to the drug used in the study (n=2). Finally, a total of 239 Korean adults were included and randomized into two groups on the basis of a computer-generated list: the IAC group (n=119) was assigned colonoscopic examination with an intermediate-length adult-colonoscope, whereas the LAC group (n=120) was assigned colonoscopic examination with a long-length adult-colonoscope. A flow diagram of enrollment was shown in Figure 1. All included subjects, but not colonoscopist, were blinded to the colonoscopes used.

Process of colonoscopy in the study

All colonoscopic examinations were performed by a single experienced colonoscopist, who had 5 or more years of experience and had performed more than 10 000 colonoscopies until now, because success rate and time of intubation may be affected by the endoscopist's skills and experience. Procedures were performed with either an Olympus CF-H260-I or CF-H260-L video colonoscope (Olympus Optical Co., Ltd., Japan). Both scopes had the same angulation ranges of bending section, insertion tube diameter of 12.9 mm, and distal end diameter of 13.2 mm. They differed only in the total and working lengths (CF-H260-I with 165 cm and 133 cm, respectively; CF-H260-L with 200 cm and 168 cm).

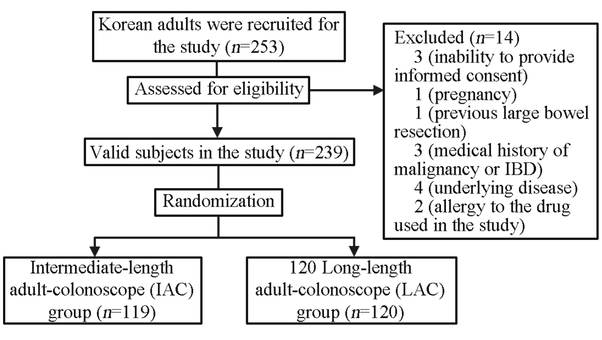

Figure 1. Flow chart of the study. IBD: inflammatory bowel disease.

All included subjects were prepared using 3 liters of polyethylene glycol (PEG) solution (Colonlyte, Taejun Pharmaceutical Co., Korea) the day before and 1 liter on the day of colonoscopy. All colonoscopic examinations were performed under conscious sedation with combinations of intravenous midazolam, propofol, and pethidine titrated as required. An antispasmodic agent, cimtropium bromide (Algiron, Greencross Pharmaceutical Co., Korea), was given intravenously immediately before the procedure to prevent colonic wall spasms. The procedure began with the subject in the left lateral position. When the colonoscope could not be advanced further, one of the assistant nurses applied external abdominal pressure or positional change of the subject (from the initial left lateral to the supine position) at the discretion of the colonoscopist, as needed.

Measurements

Lifestyle and anthrophometric data

All enrolled patients completed a structured, self-administered questionnaire on the following topics before the procedure: current smoking habit (smoked regularly during the previous 12 months); alcohol consumption ($\geq$ 70 g/week or $\geq$ 10 g/d); Exercise (at least once a week on a regular basis); Experience of previous colonoscopy; History of abdominopelvic surgery. On the day of the colonoscopic examination, height and weight of all included subjects were measured while they wore light clothing without shoes. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2).

Colonoscopic parameters

During and after the colonoscopic examination, we recorded data on all procedure-related outcomes, such as cecal intubation time (CIT), cecal intubation rate (CIR), terminal ileal intubation time (TIIT), terminal ileal intubation rate (TIIR), total procedure time (TPT), and detected polyps, i.e, adenoma detection rate (ADR). All procedure-related times were recorded by an assistant nurse using the stopwatch function in the endoscopy equipment (Figure 2). We defined success of cecal intubation as the visualization of a combination of colonoscopic landmarks, i.e., the ileocecal valve (ICV) and appendiceal orifice (AO), and the CIT as the time required to reach the base of the cecum (Figure 3A and 3B). After the cecum was identified and still photographs of cecal landmarks were taken, TIIT was defined as the time taken for the tip of the colonoscope to be maneuvered from the cecum to entering the terminal ileum.[21] As we confirmed cecal intubation using photographic documentation of cecal landmarks (ICV, AO), we confirmed complete intubation of terminal ileum

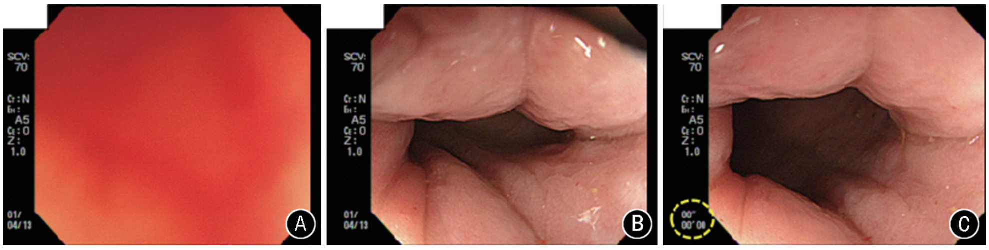

Figure 2. Serial series of colonoscopic view during insertion into the anus and the method of time-recording in this study. **A:** The initial red-out phenomenon is usually seen on the monitor immediately after colonoscope inserted into the anus. **B:** After aeration, the anal lumen is distended and identified. **C:** At this time, the stopwatch function of the endoscopic equipment was activated by an assistant nurse. Yellow dotted circle is time measured by the colonoscopic stopwatch.

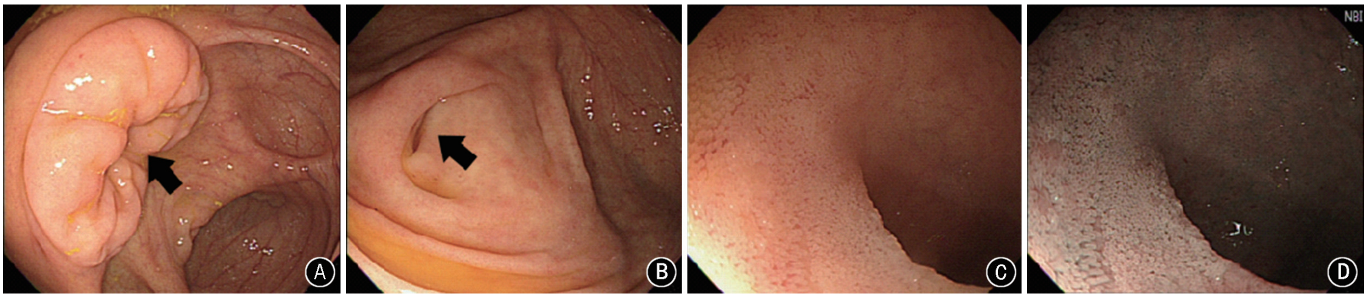

Figure 3. The colonoscopic landmarks using photographic documentation of complete cecal and terminal ileal intubation. **A:** Ileocecal valve (Arrow). **B:** Appendiceal orifice (Arrow). **C:** Terminal ileum. Villi were observed in the terminal ileum (Water-filling method). **D:** Terminal ileum. Villi were prominently observed in the terminal ileum (Narrow-band imaging (NBI) method).

using photographic documentation of apparent villi in the terminal ileum by water-filling or using the narrow-band imaging method (Figure 3C and 3D).[22] Subjects in whom the terminal ileum could not be reached were excluded from the analysis of TIITs, except for TIIR. Withdrawal time (WT) was calculated by subtracting the TIIT or CIT (unsuccessful cases of intubation of the terminal ileum) from the TPT.

Detailed examination was performed during the withdrawal phase of the colonoscope. During examination, all polyps found were removed by either cold biopsy or snare polypectomy, and then sent for pathology. In order to avoid the effect of intubation time, all biopies and polypectomies were performed during withdrawal. Adenoma was diagnosed by pathological evaluation of retrieved lesions. In addition, during the colonoscopic examination, the quality of bowel preparation was classified by the colonoscopist as: excellent (no or minimal solid stool and only small amounts of clear fluid requiring suctioning), good (no or minimal solid stool with large amounts of clear fluid requiring suctioning), fair (collections of semisolid debris that are cleared with difficulty), and poor (solid or semisolid debris that cannot be effectively cleared).[23]

Statistical analysis

All continuous variables were expressed as means ± standard deviation, whereas categorical variables were presented as numbers and percentages. Continuous variables were tested for normality and analyzed using the independent *t*-test or the Mann-Whitney *U*-test where appropriate. Categorical variables were analyzed using the Chi-squared test or the Fisher-Freeman-Halton extension of Fisher's probability test. A *P* value less than 0.05 was considered statistically significant. All statistical analyses were performed using SPSS for Windows version 13.0 (SPSS Inc., USA).

RESULTS

Baseline characteristics of all enrolled subjects and two groups according to colonoscope length

Between October 2012 and February 2013, 239 colonoscopies were performed by a single colonoscopist in our hospital. The baseline characteristics of all subjects (n=239) are shown in Table 1. Their mean age was (51.05±10.82) years (range 29–91 years), and 64.9% (n=155) of the subjects were men and 35.1% (n=84) were women. Current smokers, alcohol users, and those who were taking regular exercises constituted 25.1% (n=60), 55.6% (n=133), and 61.9% (n=148) of the study population, respectively. The mean BMI was (24.06±3.06) kg/m^2 (range 16.72–34.14 kg/m^2), and 48.1% (n=115) had an experience of previous colonoscopy. Of all included subjects, 18.0% (n=43) had undergone prior abdominopelvic surgery: simple appendectomy (n=28, 15 males and 13 females), laparoscopic cholecystectomy (n=10, 6 males and 4 females), and cesarean section without complications (n=5, all females). The colonoscopist-assessed quality of bowel preparation was excellent in 11.3% (n=27), good in 60.7% (n=145), fair in 24.3% (n=58), and poor in 3.8% (n=9). No significant differences between the two groups (IAC group (n=119) vs. LAC group (n=120)) were observed in baseline characteristics (Table 1).

Results and complications associated with colonoscopic examination

In the present study, 159 (66.5%) of all subjects showed normal colonoscopic findings, whereas 80 (33.5%) showed abnormal colonoscopic findings. Of those who

Table 1. Baseline characteristics of the two groups

Characteristics	All subjects (*n*=239)	IAC group (*n*=119)	LAC group (*n*=120)	*P* values
Age (year)	51.05±10.82	51.36±10.52	50.74±11.15	0.659*
≤ 40 (*n* (%))	45 (18.8)	21 (17.6)	24 (20.0)	
41–50 (*n* (%))	73 (30.5)	37 (31.1)	36 (30.0)	0.305†
51–60 (*n* (%))	79 (33.1)	35 (29.4)	44 (36.7)	
≥ 61 (*n* (%))	42 (17.6)	26 (21.8)	16 (13.3)	
Sex (*n* (%))				
Male	155 (64.9)	74 (62.2)	81 (67.5)	0.398†
Female	84 (35.1)	45 (37.8)	39 (32.5)	
BMI (kg/m^2)	24.06±3.06	23.92±3.04	24.19±3.09	0.490*
<19 (*n* (%))	10 (4.2)	7 (5.9)	3 (2.5)	
19–25 (*n* (%))	140 (58.6)	70 (58.8)	70 (58.3)	0.156‡
>25–30 (*n* (%))	81 (33.9)	39 (32.8)	42 (35.0)	
>30–40 (*n* (%))	8 (3.3)	3 (2.5)	5 (4.2)	
Current smoker (*n* (%))	60 (25.1)	31 (26.1)	29 (24.2)	0.737†
Alcohol user (*n* (%))	133 (55.6)	69 (58.0)	64 (53.3)	0.469†
Exercise (*n* (%))	148 (61.9)	77 (64.7)	71 (59.2)	0.378†
Experience of previous CE (*n* (%))				
Yes	115 (48.1)	64 (53.8)	51 (42.5)	0.081†
No	124 (51.9)	55 (46.2)	69 (57.5)	
Hx of abdominopelvic surgery (*n* (%))				
Yes	43 (18.0)	18 (15.1)	25 (20.8)	0.251†
No	196 (82.0)	101 (84.9)	95 (79.2)	
Quality of bowel preparation (*n* (%))				
Excellent	27 (11.3)	16 (13.4)	11 (9.2)	0.762‡
Good	145 (60.7)	71 (59.7)	74 (61.7)	
Fair	58 (24.3)	28 (23.5)	30 (25.0)	
Poor	9 (3.7)	4 (3.4)	5 (4.1)	

IAC: intermediate-length adult-colonoscope; LAC: long-length adult-colonoscope; BMI: body mass index; CE: colonoscopic examination; Hx: history. Data were expressed as mean ± standard deviation or number (percentage, %), as appropriate. **P* values were calculated using the independent *t*-test. †*P* values were calculated using the Chi-squared test. ‡*P* values were calculated using the Fisher-Freeman-Halton extension of Fisher's probability test.

had abnormal results, colorectal polyps were observed in 74 (31.0%) of them. On the basis of pathologic evaluation of retrieved polyps, subjects with polyps identified as follows: hyperplastic polyp (*n*=33, 13.8%), adenomatous polyp (*n*=46, 19.2%), inflammatory polyp (*n*=1, 0.4%), neuroendocrine tumor, i.e. carcinoid tumor, (*n*=1, 0.4%), and lymphoid aggregates (*n*=3, 1.3%). Among these, adenomatous polyp was considered as "true" polyp, i.e, adenoma, which was used to analyze of the ADR in the study. Other findings, except colorectal polyp lesion, were as follows: diverticulum or diverticuli (*n*=13, 5.4%; single diverticulum and diverticuli were 10 and 3, respectively), melanosis coli (*n*=5, 2.1%), internal hemorrhoid (*n*=5, 2.1%), anal skin tag (*n*=1, 0.4%), hypertrophied anal papilla (*n*=2, 0.8%), and colonic mucosa-associated lymphoid tissue lymphoma (*n*=1, 0.4%). No other serious complications, such as perforation or severe bleeding occured in our study patients during the procedure.

Comparison of procedure-related outcomes between the two groups according to length of adult-colonoscope

Table 2 summarizes the procedure-related outcomes for all subjects and the two groups (IAC group vs. LAC group). Overall, the CIR, CIT, TIIR, TIIT, TPT, WT and ADR in all included subjects were 100.0% (239/239), (238.05±106.59) seconds (range 80–822 seconds), 88.7% (212/239), (39.36±36.81) seconds (range 5–290 seconds), (582.82±221.44) seconds (range 246–1615 seconds), (310.40±185.06) seconds (range 113–1263 seconds), and 19.2% (46/239), respectively.

When the two groups were compared, as shown in Table 2, there were significant differences in CIT, TIIR, and TIIT: (1) The CIT was shorter in the IAC group than that in the LAC group ((222.13±101.67) seconds vs. (253.85±109.40) seconds, *P*=0.014); (2) The TIIR was higher in the LAC group than that in the IAC group (94.2% vs. 83.2%, *P*=0.007); (3) The TIIT was also shorter in the IAC group than that in the LAC group ((35.21±38.89) seconds vs. (44.09±33.87) seconds, *P* <0.001). No significant differences between the two groups were seen for CIR, TIIT, TPT, WT, and ADR.

Univariate analysis of the effect of subject-related factors on cecal and ileal intubation time and ileal intubation rate in all enrolled subjects

After the statistical analysis of procedure-related outcomes according to colonoscope length, we analyzed the association with intubation time (CIT, TIIT) and various subject-related factors, which were selected based on published reports and clinical experience. In addition, subject-related factors affecting TIIR were analyzed, but not CIR, because CIR was 100.0% in our study population. Age, BMI, and quality of bowel preparation were categorized as follows: (1) ≥51 years versus ≤50 years, (2) obese (BMI >25 kg/m^2) versus non-obese (BMI ≤25 kg/m^2), and (3) unclean (fair and poor in bowel preparation) versus clean (excellent and good in bowel preparation).

Table 3 shows that old age (*P*=0.001), female sex (*P*=0.012) and poor bowel preparation (*P* <0.001) were associated with longer CIT among all subject-related factors in this study. The CIT was also significantly shorter in subjects with high BMI (*P* <0.001) as well. However, in the present study, experience of previous colonoscopy and preexisting abdominopelvic surgery had no significant association with CIT. When analyzing subject-related factors affecting TIIT, only one factor, female sex (*P*=0.012), was associated

Table 2. Comparison of two groups with regard to procedure-related outcomes

Variables	All subjects (*n*=239)	IAC group (*n*=119)	LAC group (*n*=120)	*P* values
CIR (*n* (%))	239 (100.0)	119 (100.0)	120 (100.0)	1.000*
CIT (seconds)	238.05±106.59	222.13±101.67	253.85±109.40	0.014†
TIIR (*n* (%))	212/239 (88.7)	99/119 (83.2)	113/120 (94.2)	0.007*
TIIT (seconds)	39.36±36.81	44.09±33.87	35.21±38.89	<0.001†
TPT (seconds)	582.82±221.44	569.13±216.92	596.39±225.92	0.264†
WT (seconds)	310.40±185.06	310.33±185.40	310.48±185.50	0.538†
ADR (*n* (%))	46/239 (19.2)	23/119 (19.3)	23/120 (19.2)	0.975*

IAC: intermediate-length adult-colonoscope; LAC: long-length adult-colonoscope; CIR: cecal intubation rate; CIT: cecal intubation time; TIIR: terminal ileal intubation rate; TIIT: terminal ileal intubation time; TPT: total preocedure time; WT: withdrawal time; ADR: adenoma detection rate. Data were described as mean ± standard deviation or number (%), as appropriate. The WT was calculated by subtracting the TIIT or CIT (unsuccessful cases of terminal ileal intubation) from the TPT. **P* values were calculated using the Chi-squared test. †*P* values were calculated using the Mann-Whitney *U*-test.

with a longer TIIT. In our study, there were no statistically significant subject-related factors affecting TIIR (Table 3).

DISCUSSION

In the present study, we analyzed and compared procedure-related efficiencies between the IAC group and the LAC group. We found several interesting results according to adult-colonoscope length after statistical analysis.

First, the mean CIT was shorter in the IAC group than that in the LAC group with statistical significance, and there were no significant differences in CIR between the two groups. The results of our study correspond with earlier studies. Previous studies showed that the length of colonoscope may impact on CIT. Barthel et al[24] compared an intermediate-length adult-colonoscope with a long length-adult-colonoscope in their study. Although they did not compare CIT, the investigators found that the TPT was shorter with an intermediate-length adult-colonoscope, and CIR was similar between the two groups. In addition, in a large-scale study, Lee et al[20] demonstrated that an intermediate-scope appears to offer an advantage over a long-scope on the topic of CIT. Controversy exists concerning the benefits of intermediate-length adult-colonoscope in CIT. Dickey et al[25] demonstrated that there were no differences in the CIR and CIT between both groups in their study. However, although the difference was not statistically significant, there was a trend toward a shorter CIT with the intermediate-length adult-colonoscope (all patients; the mean CIT of the intermediate group =7.73 minutes vs. the mean CIT of the long group = 8.11 minutes; P=0.44). As mentioned above, our finding was similar to that of previous studies.[20,24,25] Some of the possible explanations for this result are as follows: (1) the intermediate-scope is more comfortable to handle than the long-scope because of its light weight and the relatively short length in the portion not inserted during the procedure; (2) the intermediate-scope does not tend to form loops in the sigmoid colon compared with the long-scope; (3) the long-scope allows the colonoscopist to push through loops without concern about so-called ‘‘running out of scope’’, whereas the intermediate-scope forces the colonoscopist to straighten the scope, reduce loops, and accordion the colon over the scope.

Second, the TIIR was higher than in the LAC group than that in the IAC group, with statistical significance. Furthermore, the TIIT was significantly shorter in the LAC group than that in the IAC group. Previously, De Silva et al[21] investigated the association between the patient’s position and the intubation of terminal ileum. They reported that the prone position significantly reduces TIIT during colonoscopy compared to the left lateral (standard) position (P <0.0001). Also, their study showed that the TIIR was higher in the prone position group than that in the left lateral position group (98.7% vs. 94.7%), although P value was not shown. However, there are few published data on how different lengths of adult-colonoscope affect time and success in reaching the terminal ileum. Our study focused on TIIR and TIIT according to the length of adult-colonoscope. According to the results of our study, we suggest that long-scopes may offer a potential advantage over intermediate-scopes in terms of terminal ileal intubation. Most colonoscopists recognize that the length of a colonoscope may influence the completion rate. Although there have been no direct studies regarding the association between the length of colonoscope and terminal ileal intubation, previous studies have already proved that long-scopes best guarantee insertion to the cecum.[19,20,24-26] In our study, the correlation between colonoscope length and intubation rate, that is, “the longer the colonoscope, the better the success of intubation”, seems to be applied in the terminal ileal intubation, even when performed by very-experienced colonoscopists with experience of more than 10 000 colonoscopies.

Table 3. Univariate analysis of the effect of subject-related factors on cecal and terminal ileal intubation time and terminal ileal intubation rate in all enrolled subjects

Variables	CIT (seconds)	*P* values	TIIT (seconds)	*P* values	TIIR (%)	*P* values
Age						
≤50	215.76 ± 85.13	0.001*	34.48 ± 28.75	0.101*	109/118 (92.4)	0.111†
≥51	259.79 ± 120.43		44.52 ± 43.31		104/121 (86.0)	
Sex						
Male	230.08 ± 113.34	0.012*	35.87 ± 36.25	0.012*	137/155 (88.4)	0.620†
Female	252.77 ± 91.69		45.73 ± 37.22		76/84 (90.5)	
BMI						
Non-obese	255.06 ± 118.95	0.003*	38.45 ± 36.39	0.779*	136/150 (90.7)	0.319†
Obese	209.39 ± 73.80		40.95 ± 37.73		77/89 (86.5)	
Experience of previous CE						
Present	241.33 ± 108.54	0.580*	41.52 ± 37.30	0.618*	104/115 (90.4)	0.530†
None	235.02 ± 105.11		37.28 ± 36.39		109/124 (87.9)	
Hx of abdominopelvic sugery						
Present	231.74 ± 99.23	0.737*	37.15 ± 30.64	0.959*	40/43 (93.0)	0.588‡
None	239.44 ± 108.33		39.87 ± 38.17		173/196 (88.3)	
Quality of bowel preparation						
Clean	218.15 ± 81.71	<0.001*	36.93 ± 31.25	0.172*	153/172 (89.0)	0.894†
Unclean	289.15 ± 141.39		45.64 ± 48.11		60/67 (89.6)	

CIT: cecal intubation time; TIIT: terminal ileal intubation time; TIIR: terminal ileal intubation rate; CE: colonoscopic examination; Hx: history. Data were expressed as mean ± standard deviation or number (%). “Obese”, and “Unclean” were defined as more than 25 kg/m^2, and fair and poor in quality of bowel preparation, respectively. *P values were calculated using the Mann-Whitney U-test. †P values were calculated using the chi-squared test. ‡P values were calculated using the Fisher-Freeman-Halton extension of Fisher’s probability test.

Finally, there was no significant difference in the ADR between the two groups. A possible explanation for this result is that both groups have similar WTs. The ADR is one of the most important indicator of the quality of colonoscopy.[23] Previous studies have revealed that the ADR is related to key outcome indicators, such as interval cancer.[27,28] Although various factors (e.g., age, sex, and bowel preparation) have been reported to influence the ADR, recent studies have found that the ADR is strongly related to WT,[27,29,30] especially to the colonoscopy procedure itself, because the majority of colonoscopists usually use the withdrawal to carefully examine the colonic mucosa. In addition, in our study, no differences were found between the two groups regarding baseline characteristics such as age, sex, and bowel preparation, which may be another explanation for this result.

Additionally, we evaluated subject-related factors predictive of longer CIT. Most studies to date have focused on subject-related factors concerning CIT. In accordance with previous studies, old age, female sex, low BMI, and poor bowel preparation were associated with longer CIT.[12,31,32] It is believed that previous pelvic surgery makes negotiating the sigmoid colon more difficult and that upper abdominal surgery makes negotiation of the transverse colon and hepatic flexure more difficult because the colon may be trapped in an adhesion. However, contrary to earlier studies, there was no association between the history of abdominopelvic surgery and CIT in our study. The likely reason is that low-risk operations of adhesion, such as simple appendectomy, laparoscopic appendectomy, and cesarean section without complications were most common among our study patients with a surgical history.

The value of intubation of terminal ileum during colonoscopy remains controversial.[22,33] Thus, termainal ileal intubation (ileoscopy) is not routinely performed during colonoscopic examination in clinical practice. However, ileoscopy has a few beneficial advantages with regard to colonoscopic examination.[34,35] Ileoscopy is particularly useful in patients with symptoms suggestive of IBD in order to exclude isolated ileal disease or to facilitate the differential diagnosis between Crohn's disease and ulcerative colitis.[36] Moreover, ileoscopy may also be useful to confirm the completeness of the colonoscopy, together with cecal landmarks (ICV and AO).[22] The unreliability of cecal landmarks to document the extent of colonic examination is corroborated by previous prospective studies.[37,38] Thus, we would like to recommend endoscopists to intubate the terminal ileum during colonoscopic examination, especially subjects with IBD symptoms, or in cases that unreliability of cecal intubation. In this aspect, it is of importance to know factors affecting TIIR and TIIT. In our study, TIIR was only associated with colonoscope length, but not with subject-related factors such as age, sex, BMI, experience of colonoscopy, surgical history, and quality of bowel preparation, which are known associated factors with CIR by previous studies.[11,31] For a further large-scale study, we also evaluated subject-related factors predictive of longer TIIT. In our study, TIIT was associated with age and colonoscope length (Table 3). The TIIT of female sex was significantly longer than those of male sex, and this trend was similarly seen with association between CIT and female sex.[10,31] Therefore, some possible explanations for this finding are as follows: (1) there is decreased colon support in females compared to males, because fat in females is predominantly distributed in the gluteal region and less distributed in the viscera compared to males; (2) females have also been shown to have longer colons than males, making females more predisposed to loop formation; (3) increased abdominal wall musculature in males, which may provide more external resistance and act as an external splint to the colonoscope, prevents loop formation. However, because of the small sample size in this study, no firm conclusions could be drawn from these results. Thus, a further large-scaled study is needed about factors affecting TIIR and TIIT.

There are some limitations associated with this study. It was impossible to apply the double-blinded method to this study. Although all enrolled subjects were blinded, the endoscopist performing the procedure was not blinded, because the clearly different shaft lengths prevented blinding of the examiner. Also, all colonoscopic examinations were performed by only one colonoscopist, so individual characteristics of colonoscopic procedures could have acted as a bias, i.e. operator bias. Therefore, it will be necessary to assess whether or not these findings would be seen across different colonoscopists, especially inexperienced colonoscopists. However, despite these limitations, our study has the strength of being the first study to evaluate the association between procedural outcomes and adult-colonoscope length assessed by the method of "true" randomization, not by the method of alternation of colonoscopes in previous studies.[20,25]

In conclusion, no one colonoscope is ideal for all patients. On the basis of our study, the intermediate-length adult-colonoscope had an andvantage over the long-length adult-colonoscope regarding CIT, whereas the long-length adult-colonoscope had an advantage over the intermediate-length adult-colonoscope regarding TIIR and TIIT. In addition, they showed similar ADRs. Thus, in clinical practice, instead of insisting on one type of colonoscope, it may be reasonable to prepare two types of colonoscope (intermediate and long), and use them as appropriate, depending on the situation.

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