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Prevalence of Proximal Serrated Polyps and Conventional Adenomas in an Asymptomatic Average-Risk Screening Population

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Background/Aims: Detection of proximal serrated polyps (PSPs) is increasingly recognized as a new qualitative target for colonoscopy. The aims of this study were to assess the detected prevalence of PSPs and synchronous adenomas in an asymptomatic average-risk screening cohort and to evaluate potential factors associated with detection of PSPs. **Methods:** The study included 1,375 asymptomatic average-risk Korean patients (aged 50 years or older) who underwent screening colonoscopy. In total, 1,710 polyps were evaluated pathologically. **Results:** The overall PSP detection rate (PSPDR) was low at 3.1%, despite high polyp (54.0%) and adenoma detection rates (ADRs, 43.5%). ADR did not correlate with PSPDR, but it was strongly correlated with PDR (r=0.810; p<0.001). Patients with PSPs were more likely to have longer withdrawal time and more proximal colon adenomas than patients without PSPs (adjusted odds ratio [OR], 1.19; 95% confidence interval [CI], 1.09 to 1.31; p<0.001) (adjusted OR, 2.03; 95% CI, 1.06 to 3.88; p=0.031, respectively). **Conclusions:** The detected prevalence of PSPs was low (<5%) in an asymptomatic average-risk screening Korean population, despite the high prevalence of conventional adenomas. A longer mucosal inspection of the proximal colon may serve as a practical method to enhance detection of PSPs. **(Gut Liver 2013;7:524-531)**

Key Words: Colonoscopy; Colorectal neoplasms; Colonic polyps; Prevalence

INTRODUCTION

Colonoscopy is the most efficient method for detection and removal of colorectal adenomas, thereby preventing colorectal cancer. Consequently, the adenoma detection rate (ADR) has been accepted as an independent predictor of interval cancer risk after a screening colonoscopy.[1,2] However, recent studies have demonstrated that proximal colon cancers are not efficiently prevented by colonoscopy screening.[3,4] This may result from failed cecal intubation, inadequate bowel preparation, and/or insufficient detection and removal of subtle lesions such as serrated polyps and nonpolypoid colorectal neoplasms.[5] Of these, serrated polyps in the proximal colon (proximal serrated polyps, PSPs) are particularly important since their genetic and molecular profiles are similar to those of proximal colon interval cancers, of which they may account for a considerable portion.[6] Therefore, PSPs are increasingly recognized as a new qualitative detection target in colonoscopy.[7,8] However, there are few studies reporting the prevalence of PSP in an asymptomatic average-risk screening population. There are also large variations in PSP detection both among studies and within individual studies, ranging from 1% to 18%.[9-12] In this context, more evidence is needed to clarify the rate of PSP detection in conjunction with synchronous adenomas. This will provide clinically relevant data for establishment of benchmark PSP detection rate (PSPDR) and ADR ranges as qualitative indicators of colonoscopy.

Thus, the aims of the present study were to define the detection prevalence of PSPs and synchronous conventional adenomas in an asymptomatic average-risk screening population and to assess potential relationship between PSPDR and ADR. Second, we evaluated potential factors associated with detection of PSPs in this population.

MATERIALS AND METHODS

1. Study design and patients

We conducted a retrospective analysis of a prospectively collected database of endoscopic results using high-definition (HD)

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colonoscopy for a 1-year period at a tertiary teaching hospital. The database is updated daily using a standardized reporting system. It includes patient demographic data, procedure-related characteristics (indication, timing of the colonoscopy, quality of bowel cleansing, procedure times, and procedure-related complications), polyp-related characteristics (as described below), and other multiple colonoscopy quality indicators, such as cecal intubation rate and ADRs of individual endoscopists.

From April 2011 to March 2012, all consecutive asymptomatic average-risk individuals aged 50 years or older, who were referred for a screening colonoscopy, were enrolled in the study. Exclusion criteria included high-risk colonoscopy (defined as a family history of colorectal cancers or polyposis syndrome), positive fecal occult blood test, a history of colorectal surgery, inflammatory bowel disease, and non-Korean patients. Patients were also excluded for failed cecal intubation and inadequate withdrawal time (<6 minutes). This study was approved by the Institutional Review Board of Kyung Hee University Hospital (KMC-IRB 1212-05).

2. Performance of colonoscopy and evaluation of colon polyps

All procedures were performed by one of six attending gastroenterologists in our center, all with experience in more than 10,000 colonoscopies. A commercially available HD endoscope and video system (CF-H260AL, EVIS Lucera spectrum system, OEV-191H HDTV monitor; Olympus, Tokyo, Japan) was used for all procedures. We measured insertion time, total procedure time (including colonoscope insertion, irrigation and suctioning of fluid, and polypectomy), and withdrawal time (the total time for the procedure minus the time taken for colonoscope insertion and polypectomy during withdrawal phase; the time for mucosal inspection) using a stopwatch. The quality of bowel preparation was assessed as excellent, good, fair, or poor. The colon was divided into four segments (cecum/ascending colon, transverse colon, descending and sigmoid colon, and rectum); the proximal colon was defined as the portion of the colon proximal to the splenic flexure. Each colonic segment was evaluated carefully during withdrawal.

All detected polyps were digitally photographed, and their characteristics were documented prospectively, including size (measured with open biopsy forceps or a snare), anatomical location, and shape according to the Paris classification of superficial gastrointestinal (GI) lesions.[13] Thereafter, each polyp was immediately biopsied or resected and sent for histopathological assessment. In cases of multiple diminutive hyperplastic polyps in the left colon and rectum, one or two representative biopsies were obtained. Histopathological diagnoses of all polyps, including serrated polyps, were based on the recently updated World Health Organization (WHO) classification.[14]

3. Histopathological evaluation of serrated polyps

One central pathologist with GI expertise prospectively re-reviewed all specimens of serrated polyps to exclude interobserver variation bias among pathologists. Serrated polyps were classified as hyperplastic polyp, sessile serrated adenoma/polyp (SSA/P) with or without dysplasia, and traditional serrated adenoma (TSA) using the WHO diagnostic criteria.[14] High-risk PSP was defined as PSP with cytological dysplasia (including SSA/P with dysplasia and TSA) or PSP of ≥10 mm in diameter.

4. Outcome measurements and statistical analysis

We evaluated the overall detection rates of colonic polyps and neoplastic lesions, including PSPDR (proportion of patients with ≥1 histologically proven PSP) and ADR (proportion of patients with ≥1 histologically proven adenoma). The means (standard error, SE) of all detected polyps and neoplastic lesions per colonoscopy were also calculated and separated by subject's gender. The Pearson correlation coefficient (r) was used to evaluate linear correlations between detection rates of polyps and neoplastic lesions. Multivariate logistic regression analysis was performed to evaluate factors associated with PSP detection. We also compared the detection rates of colonic polyps and neoplastic lesions between individual endoscopists. A high-level adenoma detector was defined as an endoscopist with an ADR of >40%.

Data are presented as means (standard deviation, SD) or means (SE). Student t-test was used to evaluate the significance of continuous data. Categorical data were tested using the chi-squared test or Fisher exact test for small expected frequencies. All data were analyzed using the SPSS software package version 18.0 for Windows (IBM Co., Armonk, NY, USA). A $p<0.05$ was indicative of statistical significance.

RESULTS

1. Baseline characteristics of study population

A total of 5,152 consecutive patients were referred for routine colonoscopy (2,469 surveillance or diagnostic examinations and 2,683 screening examinations) during the study period (Fig. 1). Of the eligible 2,683 screening examinations, 1,308 patients were excluded for various reasons, including age <50 years (n=1,220), a family history of colorectal cancer (n=16), non-Korean ethnicity (n=45), failed cecal intubation (n=8), withdrawal time <6 minutes (n=12), incomplete or duplicated data (n=6), and inflammatory bowel disease (n=1). After these exclusions, 1,375 subjects were evaluated in this study. The patient baseline characteristics were as follows: 52.4% of patients were male; the mean age was 59.4 years. The proportion of patients with adequate bowel preparation, rated as excellent or good, was 86.3% (1,186/1,375 patients). Mean total procedure and withdrawal times were 17.7 and 9.3 minutes, respectively.

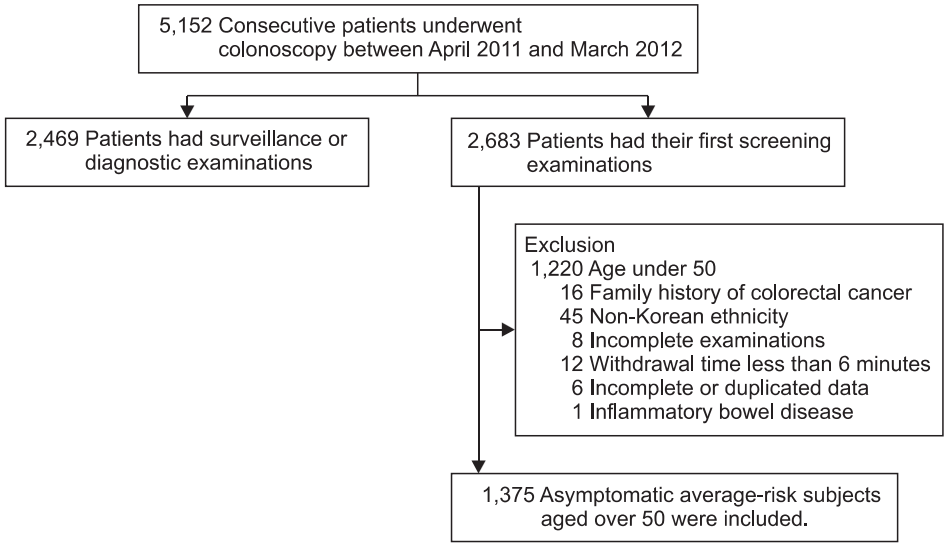

Fig. 1. Overall flow of study enrollment and case identification.

Table 1. Detection Rates and Numbers of Polyps and Neoplastic Lesions per Colonoscopy

	Polyps/Patients	Detection rates (% patients with ≥1)				No. of lesions detected per colonoscopy, mean (SE)			
		Overall	Male	Female	p-value	Overall	Male	Female	p-value
Polyps	1,710/742	54.0	63.3	43.7	<0.001	1.24 (0.05)	1.63 (0.08)	0.82 (0.05)	<0.001
Adenomas	1,184/598	43.5	53.3	32.7	<0.001	0.86 (0.04)	1.14 (0.06)	0.55 (0.04)	<0.001
Proximal colon adenomas	685/414	30.1	38.2	21.2	<0.001	0.50 (0.03)	0.66 (0.04)	0.32 (0.03)	<0.001
Advanced adenomas*	88/77	5.6	7.2	3.8	<0.001	0.06 (0.01)	0.09 (0.01)	0.04 (0.00)	<0.001
Serrated polyps	188/156	11.3	15.0	7.3	<0.001	0.14 (0.01)	0.18 (0.02)	0.08 (0.01)	<0.001
PSPs	47/42	3.1	3.5	2.6	0.35	0.03 (0.00)	0.04 (0.00)	0.03 (0.00)	0.52
High-risk PSPs†	9/7	0.5	0.4	0.6	0.72				
Others‡	338								

PSP, proximal serrated polyp; SE, standard error.
*Size ≥10 mm, villous histology, or high-grade dysplasia; †PSP with cytological dysplasia (including sessile serrated adenoma/polyp with dysplasia and traditional serrated adenoma) or PSP ≥10 mm in diameter; ‡Includes three leiomyomas, two carcinoid tumors, one lymphocele, two lipomas, 330 inflamed polypoid mucosa samples (overall positive biopsy rate, 80.7%).

2. Detection rates and numbers of polyps and neoplastic lesions per colonoscopy

In this study, 1,710 polyps were detected in 742 patients, giving an overall polyp detection rate (PDR) of 54.0%. The proportion of adenomas of all detected polyps was 69.2% (1,184/1,710 polyps). Of these, 57.9% (685/1,184 polyps) were located in the proximal colon and 7.4% (88/1,184 polyps) were diagnosed as an advanced neoplasm. The overall detection rates of adenomas, proximal colon adenomas, and advanced adenomas were 43.5%, 30.1%, and 5.6%, respectively (Table 1). Overall, 188 histologically verified serrated polyps were detected in 156 patients, resulting in a serrated polyp detection rate (SPDR) of 11.3%. The overall PSPDR was 3.1% (42/1,375 patients) and the detection rate of high-risk PSPs was only 0.5% (7/1,375 patients). The detection rates of polyps and neoplastic lesions and the mean numbers per colonoscopy were significantly higher in males than in females (all p<0.001). However, the numbers of PSPs did not differ between males and females (mean number of PSPs/colonoscopy, 0.04 males vs 0.03 females, p=0.52; PSDPR, 3.5% vs 2.6%, p=0.35).

There was a strong positive correlation between the overall ADR and PDR (r=0.810; 95% confidence interval [CI], 0.78 to 0.83; p<0.001) (Table 2). In contrast, the ADR weakly correlated with the SPDR, but not with the PSPDR (r=0.163; 95% CI, 0.11 to 0.21; p<0.001) and (r=0.04; 95% CI, -0.01 to 0.09; p=0.135, respectively).

3. Characteristics of detected PSPs and factors associated with PSP detection

In total, 47 PSPs were detected in 42 patients in this study. Most were located in the transverse colon (55.3%, 26/47 lesions). The mean (SD) size of PSPs was 6.0 (4.6) mm (range, 2.0 to 23.0 mm). Twenty-seven cases (57.4%) were diminutive pol-

Table 2. Correlation between Detection Rates of Polyps and Neoplastic Lesions according to Histopathology and Anatomical Location

		Overall			Male			Female		
		r*	95% CI	p-value	r*	95% CI	p-value	r*	95% CI	p-value
ADR	PDR	0.810	0.78-0.83	<0.001	0.813	0.77-0.85	<0.001	0.791	0.75-0.83	<0.001
	SPDR	0.163	0.11-0.21	<0.001	0.175	0.10-0.24	<0.001	0.091	0.01-0.17	0.019
	PSPDR	0.040	-0.01-0.09	0.135	0.041	-0.03-0.10	0.277	0.030	-0.05-0.11	0.449
Proximal colon ADR	PDR	0.606	0.57-0.63	<0.001	0.598	0.55-0.63	<0.001	0.590	0.54-0.64	<0.001
	SPDR	0.185	0.12-0.24	<0.001	0.182	0.10-0.25	<0.001	0.141	0.05-0.24	<0.001
	PSPDR	0.068	0.01-0.12	0.012	0.070	-0.00-0.14	0.062	0.056	-0.03-0.15	0.151
Advanced ADR†	PDR	0.225	0.19-0.25	<0.001	0.212	0.18-0.24	<0.001	0.226	0.18-0.27	<0.001
	SPDR	0.362	0.27-0.44	<0.001	0.394	0.28-0.49	<0.001	0.280	0.14-0.42	<0.001
	PSPDR	0.049	-0.01-0.12	0.071	0.006	-0.05-0.09	0.879	0.118	-0.03-0.27	0.003

CI, confidence interval; ADR, adenoma detection rate; PDR, polyp detection rate; SPDR, serrated polyp detection rate; PSPDR, proximal serrated polyp detection rate.
*Pearson correlation coefficient, two-sided test; †Size ≥10 mm, villous histology, or high-grade dysplasia.

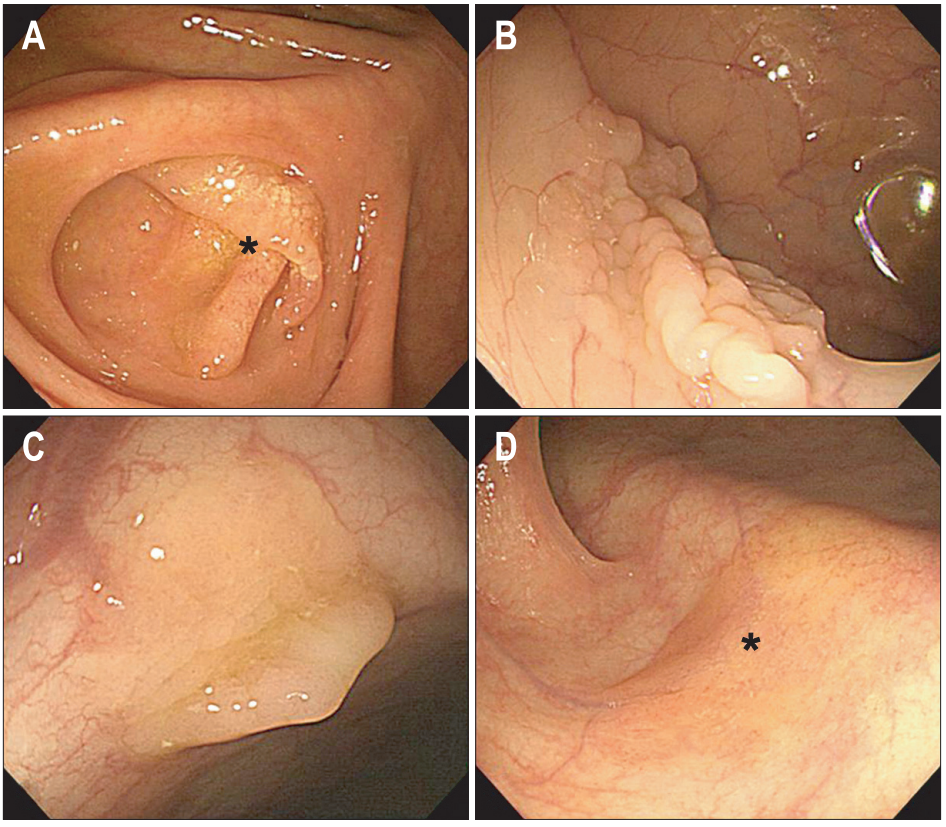

Fig. 2. Examples of high-risk (cytological dysplasia or ≥10 mm diameter) proximal serrated polyps detected in the study population. (A) Hyperplastic polyp located in the appendiceal orifice, 12 mm, Paris classification 0-IIb (*). (B) Sessile serrated adenoma/polyp (SSA/P) with dysplasia in the hepatic flexure, 30 mm, Paris classification 0-IIa. (C) SSA/P without dysplasia in the transverse colon, 17 mm, Paris classification 0-IIa. (D) SSA/P without dysplasia in the transverse colon, 20 mm, Paris classification IIb (*).

yp ≤5 mm in size. Nonpolypoid neoplasms (0-IIa or 0-IIb) were detected most frequently (91.4%, 43/47 lesions). There were four cases of SSA/P (one with low-grade dysplasia and three without dysplasia). In total, nine high-risk PSPs were detected in seven patients, including two dysplastic lesions and seven greater than 10 mm in size (Fig. 2).

Multivariate logistic regression analysis indicated no significant differences between subjects with PSPs and without PSPs, with regard to patient and procedure characteristics such as age, sex, quality of bowel preparation, timing of colonoscopy, and endoscopist. However, subjects with PSPs had a significantly longer withdrawal time than subjects without PSPs (12.3 minutes vs 9.2 minutes, p<0.001) (adjusted odds ratio [OR], 1.19; 95% CI, 1.09 to 1.31; p<0.001). Additionally, subjects with PSPs were more likely to have proximal colon adenoma than were subjects without PSPs (47.6% vs 29.6%, p=0.012) (adjusted OR, 2.03; 95% CI, 1.06 to 3.88; p=0.031), but not overall adenoma, multiple (≥3) or large (≥10 mm) adenoma, or all advanced ad-

enoma (Table 3).

4. Detection rates of polyps and neoplastic lesions by individual endoscopists

Table 4 shows the colonic polyp and neoplastic lesion detection rates of six endoscopists. All endoscopists performed more than 100 study colonoscopies (range, 136 to 396 study colonoscopies). Four endoscopists (designated A, B, E, and F) were classified as high-level adenoma detectors by the predefined criteria, and their mean ADR was 45.9% (range, 40.4% to 50.8%). The corresponding mean PSPDR in the high-level adenoma detectors was 3.4% (range, 1.9% to 4.8%). The ORs (95% CI) of

Table 3. Detection of Synchronous Conventional Adenomas in Subjects with or without Proximal Serrated Polyps

Synchronous conventional adenoma	With PSP	Without PSP	OR (95% CI)	p-value
Adenoma (overall)	23 (54.8)	575 (43.1)	1.435 (0.752-2.740)	0.274
Proximal colon adenoma	20 (47.6)	394 (29.6)	2.034 (1.066-3.882)	0.031
Multiple (≥3) adenoma	5 (11.9)	135 (10.1)	1.009 (0.379-2.686)	0.986
Large (≥10 mm) adenoma	3 (7.1)	69 (5.2)	1.301 (0.386-4.391)	0.671
Advanced adenoma*	5 (11.9)	72 (5.4)	2.247 (0.843-5.991)	0.106

Data are presented as number (%).
PSP, proximal serrated polyp; OR, odds ratio; CI, confidence interval.
*Size ≥10 mm, villous histology, or high-grade dysplasia.

Table 4. Detection Rates of Polyps and Neoplastic Lesions for Individual Endoscopists

Endoscopist	No. of study colonoscopies	PDR	ADR	Proximal colon ADR	Advanced ADR*	SPDR	PSPDR	High-risk PSPDR†
A	250	62.4 (156)	50.8 (127)	36.4 (91)	7.2 (18)	14.4 (36)	4.8 (12)	0.8 (2)
B	136	51.5 (70)	40.4 (55)	23.5 (32)	5.9 (8)	12.5 (17)	3.6 (5)	0.0 (0)
C	396	52.0 (206)	39.9 (158)	28.5 (113)	5.3 (21)	10.4 (41)	2.0 (8)	0.8 (3)
D	187	47.6 (89)	38.0 (71)	26.7 (50)	4.8 (9)	12.8 (24)	3.7 (7)	0 (0)
E	208	53.8 (112)	42.8 (89)	28.4 (59)	6.7 (14)	10.6 (22)	1.9 (4)	0.5 (1)
F	198	55.1 (109)	49.5 (98)	34.8 (69)	3.5 (7)	8.1 (16)	3.0 (6)	0.5 (1)
Combined	1,375	54.0 (742)	43.5 (598)	30.1 (414)	5.6 (77)	11.3 (156)	3.1 (42)	0.5 (7)

Unless indicated otherwise, data are expressed as the % of patients with ≥1 lesion (numbers of patients with ≥1 lesion).
PDR, polyp detection rate; ADR, adenoma detection rate; SPDR, serrated polyp detection rate; PSPDR, proximal serrated polyp detection rate.
*Size ≥10 mm, villous histology, or high-grade dysplasia; †PSP with cytological dysplasia (including sessile serrated adenoma/polyp with dysplasia and traditional serrated adenoma) or PSP with ≥10 mm diameter.

Table 5. Odds Ratios for Detection Rates of Polyps and Neoplastic Lesions among Endoscopists

Endoscopist	PDR		ADR		Proximal colon ADR		Advanced ADR*		SPDR		PSPDR	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
A	1 (NA)		1 (NA)		1 (NA)		1 (NA)		1 (NA)		1 (NA)	
B	0.58 (0.37-0.90)	0.016	0.58 (0.37-0.91)	0.018	0.47 (0.28-0.77)	0.003	0.75 (0.31-1.79)	0.519	0.81 (0.43-1.54)	0.534	0.76 (0.26-2.25)	0.630
C	0.60 (0.42-0.86)	0.005	0.56 (0.39-0.80)	0.002	0.60 (0.41-0.87)	0.007	0.65 (0.32-1.31)	0.234	0.70 (0.42-1.17)	0.177	0.45 (0.17-1.20)	0.113
D	0.50 (0.33-0.75)	0.001	0.54 (0.36-0.82)	0.004	0.59 (0.38-0.92)	0.020	0.63 (0.27-1.45)	0.281	0.81 (0.46-1.43)	0.480	0.71 (0.27-1.86)	0.489
E	0.59 (0.40-0.88)	0.011	0.61 (0.41-0.90)	0.013	0.57 (0.38-0.87)	0.009	0.81 (0.38-1.69)	0.575	0.63 (0.35-1.14)	0.129	0.39 (0.12-1.25)	0.116
F	0.66 (0.44-0.98)	0.043	0.86 (0.58-1.27)	0.461	0.84 (0.56-1.27)	0.434	0.43 (0.17-1.07)	0.071	0.47 (0.25-0.90)	0.022	0.65 (0.23-1.81)	0.421

PDR, polyp detection rate; ADR, adenoma detection rate; SPDR, serrated polyp detection rate; PSPDR, proximal serrated polyp detection rate; OR, odds ratio; CI, confidence interval; NA, not applicable.
*Size ≥10 mm, villous histology, or high-grade dysplasia.

colonic polyp and neoplastic lesion detection rates are shown in Table 5. When compared with the highest-level detector, the odds ratios for the PSPDR in the five other endoscopists ranged from 0.45 to 0.76; the differences were statistically insignificant (all p>0.05).

DISCUSSION

The primary aim of the present study was to determine the detection prevalence of PSPs and synchronous conventional adenomas in an asymptomatic average-risk screening population. The results demonstrated that the prevalence of PSPs was low in both genders (3.5% in males, 2.6% in females; overall 3.1%), despite a high corresponding ADR (53.3% in males, 32.7% in females; overall 43.5%). The overall detection rate of clinically significant high-risk PSPs was 0.5% (7/1,375 patients). The ADR in this study was significantly higher than the current recommended target for both genders (at least 25% in males and 15% in females),[15] but not unexpectedly so when compared with those of other recent randomized studies using HD colonoscopy, including our previous report, which ranged from 43.2% to 57% of screening examinations.[16-18] The number of adenomas per colonoscopy reported here was also similar to previous studies.[16-18]

We determined the proportions of detected polyps and neoplastic lesions according to their anatomical location and histologic characteristics. Of 1,184 conventional adenomas, 57.9% (685/1,184) were located in the proximal colon. The proportion of subjects with ≥1 proximal colon conventional adenoma in all subjects with ≥1 conventional adenoma was 69.2% (414/598 patients) (Table 1). In addition, subjects with PSPs showed a higher prevalence of synchronous proximal colon conventional adenoma than did subjects without PSPs (47.6% vs 29.6%, p=0.012) (adjusted OR, 2.034; 95% CI, 1.06 to 3.88; p=0.031) (Table 3). The results suggest that proximal colon is the preferential anatomic location of both serrated lesions and synchronous conventional adenomas. Therefore, these data reinforce the importance of careful inspection of the proximal colon for better protection from proximal colon cancers by colonoscopy.

Until now, there is little available data describing the prevalence of PSPs in an asymptomatic average-risk screening population. Two studies by different groups reported similar prevalences of PSPs. Schreiner *et al*.[9] reported that of 3,121 patients, 7.9% had ≥1 "nondysplastic serrated polyps" including hyperplastic polyps and SSAs in the proximal colon. However, the histological criteria and the definition of the proximal colon for reporting serrated lesions in that study was different from that used by other authors, including this report. Hetzel *et al*.[10] reported that the prevalence of PSPs among 7,192 screening colonoscopies ranged from 1.1% to 7.6%. More recently, Kahi *et al*.[11,12] reported the highest PSP prevalence to be 18% to 20% of 6,681 screening examinations, given the detection rate of the highest-level detector in their study. They suggested that a minimum 4.5% as a detection target of PSPs corresponded to the ADRs set by the current guidelines for both genders (25% in men and 15% in women undergoing screening colonoscopy).[12] However, the prevalence rates of PSPs reported by Kahi *et al*. was remarkably higher than those of other reports, including this report.[11,12]

In the present study, PSP detection rates ranged from 1.9% to 4.8% among six highly qualified endoscopists with ADRs of 38.0% to 50.8%. Interestingly, the mean PSPDR of four high-level adenoma detectors with an ADR of >40% was only 3.4%. The maximal prevalence of PSPs found by the highest-level adenoma detector (ADR of 50.8%), who is dedicated to performance of colonoscopies, was 4.8% with a corresponding proximal colon ADR of 36.4% (Table 4). Therefore, despite similar ADRs, there exists an approximately fourfold difference between the maximum PSP prevalences of the highest-level adenoma detectors in the report by Kahi *et al*.[11,12] and the current study. Our study suggests racial and ethnic disparities to be one of potential explanations for the huge variations in the population prevalence of PSPs. Previous studies have reported that serrated polyps are more common in Caucasians than in African-Americans and Hispanics.[6,19,20] However, the population prevalence of PSP in Asian countries has not been well-described. In one retrospective study of an average-risk Korean population, the overall prevalence of PSPs was 5.3% (49/926 patients) and prevalence of serrated polyps was 11.9% (110/926 patients).[21] The prevalence of PSPs and serrated polyps in that study is similar to those we report here, which targeted the same racial and ethnic group. Further studies should compare both the prevalence and epidemiologic risk factors of PSPs in various racial and/or ethnic groups.

Another interesting finding in this study was that subjects with PSPs had significantly longer mean withdrawal time than subjects without PSPs (12.3 minutes vs 9.2 minutes, p<0.001) (adjusted OR, 1.19; 95% CI, 1.09 to 1.31; p<0.001). It is well-known that a longer mean withdrawal time is associated with improved detection of adenomas.[22-24] However, there have until now been no available data regarding withdrawal time and PSP detection. Recently, Liang *et al*.[25] reported a significant relationship between withdrawal time and SPDR during screening colonoscopy (r=0.908; p=0.012), but did not evaluate the prevalence of serrated polyps according to anatomical location. Our study uniquely suggests that a longer inspection time increases the rate of detection of PSPs.

In the present study, there was a strong correlation between overall PDR and ADR in both genders (r=0.813 in males, r=0.791 in females; all p<0.001). Recently, Williams *et al*.[26,27] reported that endoscopists' PDR correlated well with their ADRs for both genders in two large retrospective studies. Our results are in line with those of Williams *et al*.[26,27] and support the idea that endoscopists' PDR can be a reliable surrogate of ADR.

However, we found no significant correlation between the ADR and PSPDR (r=0.041 in male, r=0.030 in female; all p>0.05), suggesting that the ADR alone is not a reliable surrogate for PSP detection during a screening colonoscopy. However, this finding may not be generalizable due to the limitations of this study; i.e., the lack of endoscopists who detected at a low level, and the relatively small number of participating endoscopists. Three studies involving more endoscopists with various ADRs indicate a correlation between the endoscopists' ADRs and their PSPDRs during screening colonoscopy.[10-12] A larger study is needed to draw a relationship between the ADR and PSPDR in subjects with a low PSP prevalence.

Our study has other potential limitations. The first is the lack of provision of additional educational programs to participating endoscopists about endoscopic appearance and their clinical relevance to PSPs. Serrated lesions are undoubtedly one of the most difficult types to detect and remove during colonoscopy. Therefore, knowledge of the characteristic endoscopic features of serrated lesions may improve the detection of PSPs.[28] The second limitation was that this was a single-center study conducted in an academic teaching hospital. Further studies using endoscopists in both academic and community practices are needed. Nevertheless, we believe that our study has strengths that overcome several measurement biases. For example, we used a standardized reporting system based on the current quality guidelines and structured endoscopic classification.[1,13,15] Additionally, all procedures were performed using HD colonoscopy, which might enhance the detection of subtle endoscopic lesions. However, we did not focus on the potential role of HD colonoscopy for detection of PSPs; thus, future prospective studies are required. We also classified all serrated lesions using the recently updated classification and all serrated lesion specimens were prospectively re-reviewed by a central expert GI pathologist to minimize interobserver variation.[14] We believe that prospective validation in the histologic diagnosis of serrated lesions is one of the most important factors for acquisition of reliable PSP prevalence data from a colonoscopy study.

In conclusion, the detection prevalence of PSPs is quite low (<5%) in an asymptomatic average-risk screening Korean population, despite the high prevalence of conventional adenomas. These data have a clinical relevance to develop targets and benchmark for detection of PSPs and adenomas. Detection of PSPs is associated with an increased risk for synchronous proximal colon adenomas. In addition, longer withdrawal time is associated with increased detection of PSPs. Therefore, a more thorough and longer mucosal inspection of the proximal colon may serve as a practical method for better protection from proximal colon cancers by colonoscopy screening.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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