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# Role of baseline adenoma characteristics for adenoma recurrence in patients with high-risk adenoma

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**Background/aim:** The present observational study aimed to determine the predictive value of 3-year recurrence adenoma characteristics at baseline conventional colonoscopy in patients with high-risk adenoma.

**Materials and methods:** A total of 47 patients with high-risk adenoma at baseline colonoscopy were followed up and underwent a surveillance colonoscopy at 3 years. Correlations between adenoma recurrence and baseline adenoma characteristics (size, number, histological features, and location) were analyzed.

**Results:** Among 135 patients with high-risk adenoma, 47 patients (35%) who underwent surveillance colonoscopy at 3 years following baseline colonoscopy were included in the study. In these 47 patients, at least one new adenoma was detected in 19 (40.4%) patients, and new advanced adenomas were detected in 5 (10.6%) patients during the surveillance colonoscopy. No significant difference was found in patients who had adenoma recurrence versus those who did not in terms of size of adenomas (P = 0.143), number of adenomas (P = 0.562), histological properties of adenomas (P = 0.658), or locations of adenomas (P = 0.567).

**Conclusion:** Baseline adenoma characteristics were not associated with the recurrence of adenomas or advanced adenomas in patients with high-risk adenoma.

**Key words:** Colonoscopy, adenoma characteristics, high-risk adenoma, surveillance

## 1. Introduction

Colorectal cancer (CRC), which is still associated with very high incidence and mortality rates, is the second most commonly diagnosed cancer in males and the third in females around the world (1–3). However, survival from CRC has seen an improvement over the past 30 years (4). Screening for CRC is recommended after 50 years of age for individuals at average risk (5–7). It is recognized that more than 95% of all CRCs develop from adenomas and it is accepted that the majority of CRC arise from the adenoma–carcinoma sequence (8–11). The risk of an adenoma becoming malignant is greatest for advanced adenoma (AA) (adenoma with size ≥1 cm, villous elements, or high-grade dysplasia) (8,12). In the CRC screening guidelines patients with adenomas were stratified at their baseline colonoscopy into those at lower risk or increased risk for a subsequent advanced neoplasia (2,6,8). The low-risk group refers to patients with 1–2 tubular adenomas <10 mm in diameter, while the high-risk group refers to patients with tubular adenoma ≥10 mm, 3 or more adenomas, adenoma with villous elements, or high-grade dysplasia (6). The guideline for colonoscopy surveillance after screening and polypectomy recommends a 3-year surveillance interval for patients in the high-risk group and a 5-year surveillance interval for those in the low-risk group (6).

According to a recent meta-analysis, it was hypothesized that the size of an adenoma is a more important determinant of adenoma recurrence (AR) than the villous component or high-grade dysplastic content (12). Although Martinez et al. (13) suggested that the size and number of removal adenomas were two important predictors of AR at follow-up colonoscopy, it is still not known exactly which adenoma feature is more important than the others for AR.

The aim of the present study was to determine the baseline patient and colorectal adenoma characteristics that are risk factors for AR at 3-year surveillance colonoscopy in patients with high-risk adenoma.

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## 2. Materials and methods

### 2.1. Patient selection

This was a prospective study of patients undergoing surveillance colonoscopy after removal of colorectal adenomatous polyps. Data of 3954 patients who underwent total colonoscopy for various indications between January 2007 and December 2009 were reviewed. Patients with a personal history of CRC, colorectal polyps, inflammatory bowel diseases, family history of CRC, hereditary nonpolyposis CRC, familial adenomatous polyposis, malignant polyps, or incomplete colonoscopies were excluded. The initial enrollment criteria included patients with a first-time diagnosis of at least one histologically confirmed adenoma, which was removed during the diagnostic complete colonoscopy, and over 20 years of age. From the database we identified 398 patients who had 1 or more adenomas removed at complete colonoscopy. Of the 398 patients, 135 who were in the high-risk group (high-risk patients) were included in the study. High-risk patients were defined as having tubular adenomas ≥10 mm, 3 or more adenomas, adenomas with at least 20% villous elements, or high-grade dysplasia. Then we contacted those patients by telephone to invite them for CRC screening with colonoscopy; surveillance colonoscopies after the removal of colorectal adenomas were performed from 2010 to 2012. Some patients declined to have follow-up colonoscopy at 3 years, some patients' contact details could not be obtained, and some patients died. Clinical follow-up colonoscopy at 3 years was performed for 47 of the 135 patients. At both baseline and 3-year examinations, the characteristics of adenomas and patients were noted. We considered a recurrence as 1 or more adenomas detected in follow-up colonoscopy. The patient selection schema is provided in Figure 1. The

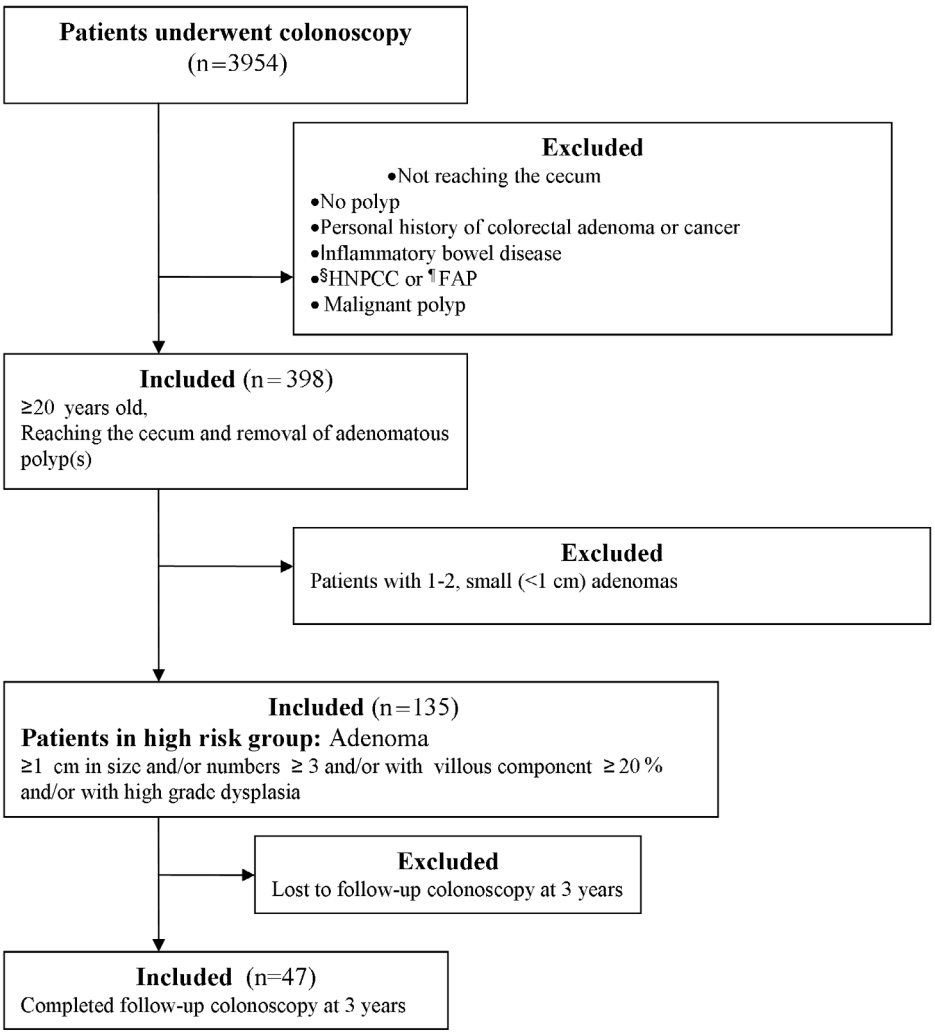


**Figure 1.** Patient selection §HNPCC: Hereditary nonpolyposis colorectal cancer, §FAP: Familial adenomatous polyposis.

study was approved by the Ethics Committee. The study protocol was carried out in accordance with the Helsinki Declaration as revised in 1989. All subjects were informed about the study protocol and written consent was obtained from each one.

**2.2. Endoscopic and pathological evaluation of adenomas**

The goal was to reach the cecum, achieve sufficient bowel preparation for the colonoscopic procedure, and ensure endoscopic removal of all detected polyps in all patients. When the patient had insufficient bowel preparation for the colonoscopic procedure or had at least 5 adenomas or adenomas that were at least 2 cm in size, the colonoscopic procedure was performed more than once.

We analyzed the number, size, location, and morphology of adenomas at baseline colonoscopy and the existence of villous elements and degree of dysplasia on pathology. Dysplasia was divided into two types: low-grade dysplasia (including moderate) and high-grade dysplasia.

Adenomas were separated into the following categories according to the World Health Organization criteria (14). AA was defined as an adenoma of diameter ≥10 mm or a villous component or high-grade dysplasia. The adenoma location was classified as the left side (splenic flexure, descending colon, sigmoid colon, and rectum), right side (cecum, ascending, and transverse colon), or both (for patients with more than 1 adenoma located in both sides).

**2.3. Statistical analysis**

Standard procedures in SPSS, version 11.5, were used for statistical analysis. The Shapiro–Wilk test was used to see whether or not the distribution of discrete numeric variables was close to normal. The Levene test was used to assess the homogeneity of variances. Descriptive statistics were expressed as means ± standard deviation for discrete numeric variables, and as a number or percentage of cases for categorical variables.

The significance of differences of average values between groups was assessed by Student's t test when there were two independent groups and by one-way ANOVA when there were more than two independent groups. Wilcoxon's signed rank test was used to investigate the significance of intragroup differences in the median number of adenomas found at baseline colonoscopy and at 3-year follow-up colonoscopy.

Pearson's chi-square test, Fisher's exact test or likelihood ratio test was used to assess categorical variables. P values of 0.05 were considered significant.

## 3. Results

The rate of high-risk adenomas was 3.75% in a total of 3594 colonoscopies (n = 135). Out of the 135 high-risk patients, 47 patients (35%) who had a 3-year follow-up colonoscopy were included in the study. Among a total of 47 patients, 72.3% were male and 27.7% were female (2.6/1; n = 34/13, respectively). The mean age of the patients was 55.81 ± 10.84 (mean ± standard error of the mean; range 28–77) at the baseline colonoscopy. The patients' descriptive characteristics are provided in Table 1. When the patients were divided into age groups, the frequency of adenomas was highest in the age group of 50–59 (34%, n = 16) (Figure 2).

At the baseline colonoscopy, a total of 136 adenomas were removed from 47 patients. The number of adenomas per patient was 2.7. The characteristics of adenomas detected at the baseline colonoscopy and the 3-year follow-up colonoscopy are provided in Table 2.

**Table 1.** Patient clinical characteristics at baseline (n = 47).

| Characteristics | No. of patients (%) |
|---|---|
| Age (years) | |
| <50 | 13 (27.7) |
| 50–59 | 16 (34.0) |
| 60–69 | 13 (27.7) |
| ≥70 | 5 (10.6) |
| Sex | |
| Male | 34 (72.3) |
| Female | 13 (27.7) |
| Location | |
| ‡Left site | 35 (74.5) |
| §Right site | 1 (2.1) |
| ¶Both | 11 (23.4) |
| No. of adenomas | |
| 1 | 17 (36.2) |
| 2 | 11 (23.4) |
| ≥ 3 | 19 (40.4) |
| Indications for colonoscopy | |
| Constipation | 21 (44.7) |
| Rectal bleeding | 9 (19.1) |
| Abdominal pain | 12 (25.5) |
| Anemia | 2 (4.3) |
| Chronic diarrhea | 3 (6.4) |

‡: Adenomas in the splenic flexure, descending colon, sigmoid colon, and rectum.
§: Adenomas in the cecum, ascending, and transverse colon.
¶: Adenomas in both left and right side of colon and rectum.

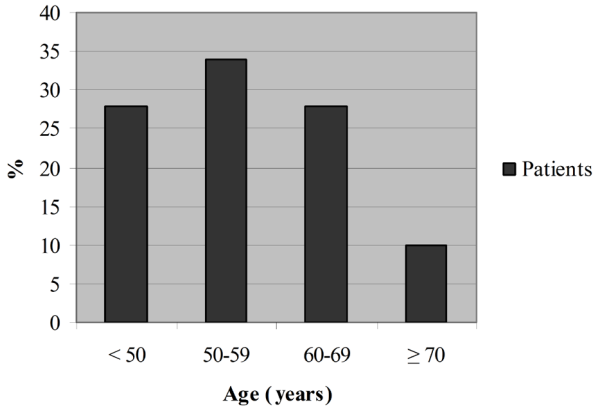


**Figure 2.** Patients according to age groups.

**Table 2.** Adenoma characteristics at baseline and endpoint colonoscopy.

| Characteristics | Baseline adenomas (n = 136) (%) | All recurrences (n = 63) (%) | Advanced recurrences* (n = 12 ) (%) |
|---|---|---|---|
| No. of adenomas | | | |
| 1 | 17 (12.5) | 6 (28.6) | 5 (62.5) |
| 2 | 22 (16.2) | 2 ( 9.5) | 1 (12.5) |
| ≥3 | 97 (71.3) | 13 (61.9) | 2 (25.0) |
| Size | | | |
| < 5 mm | 68 (50.0) | 41 (65.1) | 1 ( 8.3) |
| 5–9 mm | 23 (16.9) | 9 (14.3) | 2 (16.7) |
| 10–19 mm | 36 (26.5) | 9 (14.3) | 5 (41.7) |
| ≥ 20 mm | 9 ( 6.6) | 4 ( 6.3) | 4 (33.3) |
| Histological type of adenomas | | | |
| Tubular | 106 (77.9) | 56 (88.9) | 5 (41.7) |
| Tubulovillous | 22 (16.2) | 5 ( 7.9) | 5 (41.7) |
| Villous | 8 ( 5.9) | 2 ( 3.2) | 2 (16.6) |
| [a]HGD | 3 | 2 | 2 |
| [b]LGD | 0 | 1 | 0 |
| Location | | | |
| [‡]Left site | 84 (61.8) | 13 (20.6) | 2 (16.7) |
| [§]Right site | 1 ( 0.7) | 7 (11.1) | 2 (16.7) |
| [¶]Both | 51 (37.5) | 43 (68.3) | 8 (66.6) |

*: Advanced recurrences include adenomas ≥1 cm in size or with tubulovillous/villous histology.
[‡]: Adenomas in the splenic flexure, descending colon, sigmoid colon, and rectum.
[§]: Adenomas in the cecum, ascending, and transverse colon.
[¶]: Adenomas in both left and right side of colon and rectum.
[a]: High-grade dysplasia.
[b]: Low-grade dysplasia.

At the 3-year follow-up colonoscopy, at least one new adenoma was found in 40.4% of the patients (n = 19) and at least one recurrent AA was detected in 10.6% (n = 5). Following the removal of 136 adenomas by polypectomy, it was found that 63 new adenomas [12 of which were AAs (19%)] developed within 3 years and tubular adenoma was found to be the most common type of recurrent adenomas. The most frequent location of AR was on both sides of the colorectum simultaneously. The most common type of new adenomas detected in the 3-year follow-up was diminutive adenomas (<5 mm) (Figure 3).

The baseline colonoscopy findings and the characteristics of adenomas of patients with or without AR in the 3-year follow-up colonoscopy are shown in Table 3.

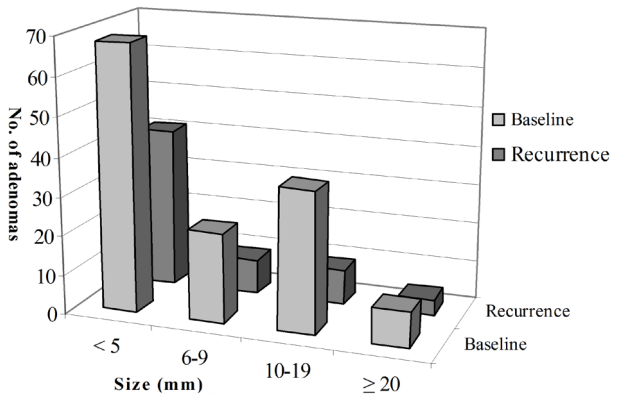


**Figure 3.**Size of adenomas at baseline and follow-up colonoscopy.

**Table 3.** Baseline characteristics of adenomas and patients according to adenoma recurrence.

| | Adenoma recurrence | | *P value |
|---|---|---|---|
| Characteristics | Yes; n = 19 (40%) | No; n = 28 (60%) | |
| Age (years) | 55.4 ± 9.0 | 56.1 ± 12.1 | 0.843 |
| Sex | | | |
| Male | 15 (78.9) | 19 (68) | 0.404 |
| Female | 4 (21.1) | 9 (32) | 0.409 |
| No. of adenomas | | | |
| 1 | 7 (36.8) | 10 (35.7) | 0.457 |
| 2 | 5 (26.3) | 6 (21.4) | 0.232 |
| ≥ 3 | 7 (36.8) | 12 (42.9) | 0.232 |
| Histology | | | |
| §High risk | 10 (52.6) | 11 (39.3) | 0.658 |
| ‡Low risk | 9 (47.4) | 17 (60.7) | 0.662 |
| Size of adenomas | | | |
| <1 cm | 16 (84.2) | 20 (71.4) | 0.142 |
| ≥1 cm | 3 (15.8) | 8 (28.9) | 0.140 |
| Location | | | |
| [a] Left side | 14 (73.7) | 21 (75.0) | 0.919 |
| [b] Right side | 1 ( 5.3) | 0 (0.0) | |
| [c] Both | 4 (21) | 7 (25.0) | 0.754 |

§: Adenoma with villous component and/or high-grade dysplasia.
‡: Tubular adenoma ± low-grade dysplasia.
[a]: Adenomas in the splenic flexure, descending colon, sigmoid colon, and rectum.
[b]: Adenomas in the cecum, ascending, and transverse colon.
[c]: Adenomas in both left and right side of colon and rectum.
* P value of 0.05 was considered significant.

There were no significant age or sex differences between the groups (P = 0.843 and P = 0.616, respectively). Sixty-three new adenomas were detected in a total of 19 patients (40.4%) and 12 AAs were detected in 5 patients (10.6%) in the third year. Comparisons were made between the patients with and without recurrent adenomas and no significant difference was found in size (≥1 cm) (P = 0.143), number (≥3) (P = 0.562), histological high-risk properties (villous component and/or dysplasia) (P = 0.658), or location (P = 0.567) of adenomas. Regression analysis was performed separately for each risk factor and it was found that size, number, histological properties, and location of adenomas were not determinants of new adenoma development (Table 4). Then the correlation between AAs detected at baseline colonoscopy and recurrent adenomas/AAs was explored and it was found that baseline AAs were also not a determinant of adenoma/AA recurrence (OR: 2.318/2.314; 95% CI: 0.415/0.435, 2.162/2.435; P = 0.817/0.912, respectively). In addition, size (≥1cm) and histological high-risk properties of adenomas were evaluated together and they did not have any predictive value for adenoma/AA recurrence (OR: 3.346/4.402; 95% CI: 0.498/0.326, 1.483/2.465; P = 0.687/0.423, respectively). However, it was found that the coexistence of two features, namely size (≥1 cm) and histological high-risk properties (villous component and/or high-grade dysplasia), was more common in patients with AR (42.1%) versus those without AA (28.6%), but this difference was not significant (P = 0.720).

When the role of baseline adenoma characteristics (size, number, location, and histology) as potential predictors of AA recurrence was investigated, none of the features were shown to be useful in determining the risk of AA recurrence (Table 5).

## 4. Discussion

The data of the National Polyp Study (15–17), a large longitudinal study on the surveillance of adenoma patients, showed that there was a reduction by 76%–90% in the development of CRC following colonoscopic polypectomy. Strock et al. (18) reported a very low incidence of CRC in patients who were taken into a follow-up program due to adenoma detection in basal colonoscopy (0.40/1000 years). In a recent study, Zauber et al. (19) suggested that removal of colorectal adenomas by polypectomy prevents death from CRC. Kolligs et al. (20) found an association between male sex and AA based on findings obtained from screening colonoscopy. In our study no association was found between sex or age and AR. This result must have been influenced by the small sample size of our study.

Recently, van Heijningen et al. (21) reported that the rate of AA recurrence was 7% and the rate of AR was 32% among their patients at the follow-up colonoscopy. In the Funen Adenoma Follow-up Study, Jørgensen et al. (22) determined that the rate of AR was 35% in patients who had follow-up colonoscopy 2 years after the initial colonoscopy and 35.5% in those who had follow-up colonoscopy 4 years after the initial colonoscopy. In the

**Table 4.** Association of baseline characteristics with adenoma recurrence at 3 years.

| Baseline variable | Adenoma recurrence | | |
|---|---|---|---|
| | OR | 95% CI | *P value |
| Age (per 10-year increase) | 0.994 | 0.942, 1.050 | 0.838 |
| Sex (male vs. female) | 1.776 | 0.457, 6.910 | 0.407 |
| Number (per 1 increase) | 1.881 | 0.807, 4.384 | 0.143 |
| Size (≥1cm vs. <1 cm) | 1.500 | 0.380, 5.928 | 0.737 |
| Histology (tubular adenomas vs. high risk) | 1.309 | 0.396, 4.323 | 0.658 |
| Location | | | |
| ‡Left side | 0.933 | 0.246, 3.536 | 0.919 |
| ¶Right side | | | |
| §Both | 0.800 | 0.198, 3.230 | 0.754 |

‡: Adenomas in the splenic flexure, descending colon, sigmoid colon, and rectum.
¶: Adenomas in the cecum, ascending, and transverse colon.
§: Adenomas in both left and right side of colon and rectum.
*: P value of 0.05 was considered significant.

**Table 5.** Association of baseline characteristics with advanced adenoma recurrence at 3 years.

| | Advanced adenoma recurrence | | |
|---|---|---|---|
| Baseline variable | OR | 95% CI | *P value |
| Age (per 10-year increase) | 1.984 | 0.845, 1.150 | 1.000 |
| Sex (male vs. female) | 0.625 | 0.063, 6.180 | 0.517 |
| Number (per 1 increase) | 2.318 | 0.415, 0.384 | 0.445 |
| Size (≥1 cm vs. <1 cm) | 1.330 | 0.818, 2.162 | 0.667 |
| Histology (tubular adenomas vs. high risk) | 2.700 | 0.405, 18.002 | 0.990 |
| Location | | | |
| ‡Left side | 1.419 | 0.143, 3.536 | 1.000 |
| ¶Right side | | | |
| §Both | 0.800 | 0.080, 8.007 | 0.567 |

‡: Adenomas in the splenic flexure, descending colon, sigmoid colon, and rectum.
¶: Adenomas in the cecum, ascending, and transverse colon.
§: Adenomas in both left and right side of colon and rectum.
*: P value of 0.05 was considered significant.

present study, the rate of AR and AA recurrence was 40% and 10.6% respectively. This result was in agreement with the literature.

Studies that investigate baseline adenoma characteristics affecting the development of colorectal adenomas identified the following features as risk factors: villous component, high-grade dysplasia, and size, number, and location of adenomas (17,22–30). Noshirwani et al. (29) studied 697 patients who underwent colonoscopic polypectomy and found that 63 patients (9%) had AR at 3-year follow-up. They reported that the mean follow-up duration was 18 months. In addition, they showed by multiple regression analyses that the number (≥3) and size of adenomas (≥1 cm) were associated with AR. Bonithon-Kopp et al. (31) suggested that the number of adenomas and their proximal location at baseline were the main predictors of recurrence. In another study, Laiyemo et al. (26) divided the patients with adenomas at initial colonoscopy into two groups: high-risk patients and low-risk patients. They performed follow-up colonoscopy on their patients 4 years after the initial colonoscopy and suggested that AA recurrence was associated with size (≥1 cm), high-grade dysplasia, and villous histology, and was not associated with the number of adenomas. Martinez et al. (32) suggested that adenomas of larger sizes or those located proximal to the colon affected AA recurrence and the number of adenomas had significant association with AR, but villous histology did not play a significant role in the recurrence. In another study from Korea, the authors reported that number (≥3) and size (>1 cm) of adenomas increased the risk of AA recurrence; however, histological properties did not play a role in the increased risk (33). Contrary to the results of these studies, in our study it was found that the number (≥3), size (≥1 cm), location, and histological properties of adenomas (villous component and/or high-grade dysplasia) that were identified as initial adenoma characteristics did not play a role in the increased risk for recurrence. This might have been caused by the limited number of patients, short follow-up duration, inclusion of exclusively high-risk patients in the study, and the absence of comparisons with low-risk patients. Moreover, the quality of preliminary preparation for initial colonoscopy was not assessed in this study. Since colorectal carcinogenesis is a slow process, long follow-up duration increases the possibility of accurately identifying the determinants of AR. There is no consensus among the studies on the determining roles of initial adenoma features in recurrence. Recently, Rosa et al. (34) have published the results of their study of 156 patients who were followed up by colonoscopy for 48 to 232 months. In agreement with the results of our study, the authors of that study found no significant correlations between the number, the presence of villous component, or the size of adenomas at index colonoscopy and the presence of adenomas at subsequent colonoscopies. In another study, colonoscopic data of 44 patients who were screened 24–26 months after initial colonoscopy were published and it was reported that histological properties, size, and location of

adenomas were not associated with AR (35). Recently, it has been suggested that studies investigating AR have various limitations. Van Stolk et al. (25) reported that number (≥3) and type of baseline adenomas predicted recurrent adenomas and they pointed out that this was caused by polyps that were missed at the initial colonoscopy. The same opinion was also suggested by Lorenzo-Zúñiga et al. (36). In many studies, the number of adenomas was reported to be a significant risk factor in AR. The main reason behind these results may be polyps that are missed at the initial colonoscopy. This may also affect the results that are related to the other adenoma features, which is also true for our study.

There are various limitations to be addressed in the present study. Firstly, the sample size was relatively small, which may have affected the statistical data. Secondly, the quality of preliminary preparation for initial colonoscopy was not assessed in this study. Thirdly, follow-up duration was relatively short. Colorectal carcinogenesis is a long process and development of new adenomas may take a while.

In conclusion, the most common type of recurrent adenoma in the present study was tubular and diminutive adenoma (<5 mm), and AR most frequently occurred in both segments of the colon simultaneously. There was no association between AR and age or sex in patients with high-risk adenoma. In addition, initial adenoma features (size: ≥1cm, number: ≥3, location and villous component, and/or high-grade dysplasia) were not associated with and did not play a determining role in adenoma/AA recurrence at the 3-year follow-up colonoscopy in patients with high-risk adenoma. AA detected at the initial colonoscopy was also not a determinant of AR. AA should be monitored in shorter intervals independently for the component that makes an adenoma an AA.

## References


1. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D. Global cancer statistics. CA-Cancer J Clin 2011; 61: 69-90.
2. Qaseem A, Denberg TD, Hopkins RH Jr, Humphrey LL, Levine J, Sweet DE, Shekelle P. Screening for colorectal cancer: a guidance statement from the American College of Physicians. Ann Intern Med 2012; 156: 378-386.
3. Pendergrass CJ, Edelstein DL, Hylind LM, Phillips BT, Iacobuzio-Donahue C, Romans K, Griffin CA, Cruz-Correa M, Tersmette AC, Offerhaus GJ et al. Occurrence of colorectal adenomas in younger adults: an epidemiologic necropsy study. Clin Gastroenterol H 2008; 6: 1011-1015.
4. Lee CS, Ronan L, O'Morain C, McNamara D. Screening for colorectal cancer: what fits best? Expert Rev Gastroenterol Hepatol 2012; 6: 301-312.
5. Centers for Disease Control and Prevention. Vital signs: colorectal cancer screening, incidence, and mortality-United States, 2002-2010. MMWR Morb Mortal Wkly Rep 2011; 60: 884-889.
6. Lieberman DA, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. Gastroenterology 2012; 143: 844-857.
7. Imperiale TF, Wagner DR, Lin CY, Larkin GN, Rogge JD, Ransohoff DF. Results of screening colonoscopy among persons 40 to 49 years of age. New Engl J Med 2002; 346: 1781-1785.
8. Bond JH. Polyp guideline: diagnosis, treatment, and surveillance for patients with colorectal polyps; Practice Parameters Committee of the American College of Gastroenterology. Am J Gastroenterol 2000; 95: 3053-3063.
9. Fearnhead NS, Wilding JL, Bodmer WF. Genetics of colorectal cancer: hereditary aspects and overview of colorectal tumorigenesis. Brit Med Bull 2002; 64: 27-43.
10. Cummings OW. Pathology of the adenoma-carcinoma sequence: from aberrant crypt focus to invasive carcinoma. Semin Gastrointest Dis 2000; 11: 229-237.
11. Risio M. Reprint of: the natural history of adenomas. Best Pract Res Clin Gastroenterol 2010; 24: 397-406.
12. de Jonge V, Sint Nicolaas J, van Leerdam ME, Kuipers EJ, Veldhuyzen van Zanten SJ. Systematic literature review and pooled analyses of risk factors for finding adenomas at surveillance colonoscopy. Endoscopy 2011; 43: 560-572.
13. Martínez ME, Baron JA, Lieberman DA, Schatzkin A, Lanza E, Winawer SJ, Zauber AG, Jiang R, Ahnen DJ, Bond JH et al. A pooled analysis of advanced colorectal neoplasia diagnoses after colonoscopic polypectomy. Gastroenterology 2009; 136: 832-841.
14. Hamilton SR, Aaltonen LA. WHO Classification of Tumours: Pathology and Genetics of Tumours of the Digestive System. Lyon, France: IARC Press; 2000.
15. Winawer SJ. The achievements, impact, and future of the National Polyp Study. Gastrointest Endosc 2006; 64: 975-978.
16. Winawer SJ, Zauber AG, Ho MN, O'Brien MJ, Gottlieb LS, Sternberg SS, Waye JD, Schapiro M, Bond JH, Panish JF et al. Prevention of colorectal cancer by colonoscopic polypectomy. New Engl J Med 1993; 329: 1977-1981.
17. Winawer SJ, Zauber AG, O'Brien MJ, Ho MN, Gottlieb L, Sternberg SS, Waye JD, Bond J, Schapiro M, Stewart ET et al. Randomized comparison of surveillance intervals after colonoscopic removal of newly diagnosed adenomatous polyps. New Engl J Med 1993; 328: 901-906.

18. Strock P, Mossong J, Scheiden R. Colorectal cancer incidence is low in patients following a colonoscopy. Dig Liver Dis 2011; 43: 899-904.

19. Zauber AG, Winawer SJ, O'Brien MJ, Lansdorp-Vogelaar I, van Ballegooijen M, Hankey BF, Shi W, Bond JH, Schapiro M, Panish JF et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. New Engl J Med 2012; 366: 687-696.

20. Kolligs FT, Crispin A, Munte A, Wagner A, Mansmann U, Göke B. Risk of advanced colorectal neoplasia according to age and gender. PLoS One 2011; 6: e20076.

21. van Heijningen EM, Lansdorp-Vogelaar I, Kuipers EJ, Dekker E, Lesterhuis W, Ter Borg F, Vecht J, De Jonge V, Spoelstra P, Engels L et al. Features of adenoma and colonoscopy associated with recurrent colorectal neoplasia based on a large community-based study. Gastroenterology 2013; 144: 1410-1418.

22. Jørgensen OD, Kronborg O, Fenger C. A randomized surveillance study of patients with pedunculated and small sessile tubular and tubulovillous adenomas: The Funen Adenoma Follow-up Study. Scand J Gastroenterol 1995; 30: 686-692.

23. Bertario L, Russo A, Sala P, Pizzetti P, Ballardini G, Andreola S, Spinelli P. Predictors of metachronous colorectal neoplasms in sporadic adenoma patients. Int J Cancer 2003; 105: 82-87.

24. Ji JS, Choi KY, Lee WC, Lee BI, Park SH, Choi H, Kim BW, Chae HS, Park YM, Park YJ. Endoscopic and histopathologic predictors of recurrence of colorectal adenoma on lowering the miss rate. Korean J Intern Med 2009; 24: 196-202.

25. Van Stolk RU, Beck GJ, Baron JA, Haile R, Summers R. Adenoma characteristics at first colonoscopy as predictors of adenoma recurrence and characteristics at follow-up. Gastroenterology 1998; 115: 13-18.

26. Laiyemo AO, Murphy G, Albert PS, Sansbury LB, Wang Z, Cross AJ, Marcus PM, Caan B, Marshall JR, Lance P et al. Postpolypectomy colonoscopy surveillance guidelines: predictive accuracy for advanced adenoma at 4 years. Ann Intern Med 2008; 148: 419-426.

27. Lieberman DA, Weiss DG, Harford WV, Ahnen DJ, Provenzale D, Sontag SJ, Schnell TG, Chejfec G, Campbell DR, Kidao J et al. Five-year colon surveillance after screening colonoscopy. Gastroenterology 2007; 133: 1077-1085.

28. Nusko G, Hahn EG, Mansmann U. Risk of advanced metachronous colorectal adenoma during long-term follow-up. Int J Colorectal Dis 2008; 23: 1065-1071.

29. Noshirwani KC, van Stolk RU, Rybicki LA, Beck GJ. Adenoma size and number are predictive of adenoma recurrence: implications for surveillance colonoscopy. Gastrointest Endosc 2000; 51: 433-437.

30. Imperiale TF, Glowinski EA, Lin-Cooper C, Larkin GN, Rogge JD, Ransohoff DF. Five-year risk of colorectal neoplasia after negative screening colonoscopy. New Engl J Med 2008; 359: 1218-1224.

31. Bonithon-Kopp C, Piard F, Fenger C, Cabeza E, O'Morain C, Kronborg O, Faivre J. Colorectal adenoma characteristics as predictors of recurrence. Dis Colon Rectum 2004; 47: 323-333.

32. Martínez ME, Sampliner R, Marshall JR, Bhattacharyya AK, Reid ME, Alberts DS. Adenoma characteristics as risk factors for recurrence of advanced adenomas. Gastroenterology 2001; 120: 1077-1083.

33. Chung SJ, Kim YS, Yang SY, Song JH, Kim D, Park MJ, Kim SG, Song IS, Kim JS. Five-year risk for advanced colorectal neoplasia after initial colonoscopy according to the baseline risk stratification: a prospective study in 2452 asymptomatic Koreans. Gut 2011; 60: 1537-1543.

34. Rosa I, Fidalgo P, Soares J, Vinga S, Oliveira C, Silva JP, Ferro SM, Chaves P, Oliveira AG, Leitão CN. Adenoma incidence decreases under the effect of polypectomy. World J Gastroenterol 2012; 18: 1243-1248.

35. Triantafyllou K, Papatheodoridis GV, Paspatis GA, Vasilakaki TH, Elemenoglou I, Karamanolis DG. Predictors of the early development of advanced metachronous colon adenomas. Hepatogastroenterology 1997; 44: 533-538.

36. Lorenzo-Zúñiga V, Moreno de Vega V, Domènech E, Mañosa M, Cabré E, Planas R, Boix J. High-definition colonoscopy and risk factors for recurrence of advanced adenomas in patients with a personal history of polyps. Eur J Gastroenterol Hepatol 2011; 23: 425-430.