Risk factors associated with clinical outcomes of endoscopic mucosal resection for colorectal laterally spreading tumors: A Honam Association for the Study of Intestinal Diseases (HASID) multicenter study

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ABSTRACT

Background/Aims: Colorectal laterally spreading tumors (LSTs) are large and superficial neoplasms. Most are adenomatous lesions. Endoscopic mucosal resection (EMR) is a standard technique of removing precursor colorectal lesions. The aim of the present study was to assess the factors associated with the clinical outcomes of EMR for LSTs.

Materials and Methods: A total of 275 patients with LSTs who underwent EMR were enrolled in the study. The clinical outcomes of the patients were analyzed by retrospectively reviewing their medical records.

Results: The en bloc resection and R0 resection rates were 86.9% and 80.4%, respectively. The bleeding and perforation rates were 7.6% and 0.4%, respectively. The frequency of high-grade dysplasia and adenocarcinoma histology was significantly higher, and the procedure time was significantly longer in LSTs >20 mm than in those ≤20 mm. The R0 resection rate was significantly higher in LSTs ≤20 mm than in those >20 mm. The frequency of piecemeal resection was significantly higher in LSTs with an adenomatous and cancerous pit pattern than in those with a non-neoplastic pit pattern. The frequency of piecemeal resection was significantly higher in LSTs with adenocarcinoma than in those with low-grade dysplasia. Multivariate analysis revealed that adenomatous pit pattern, high-grade dysplasia, or adenocarcinoma was a significant independent risk factor of LSTs for piecemeal resection after EMR.

Conclusion: EMR is useful for treating ≤20 mm LSTs with regard to curative resection and procedure time. LSTs with an adenomatous pit pattern, high-grade dysplasia, or adenocarcinoma are significant independent risk factors for piecemeal resection after EMR.

Keywords: Laterally spreading tumor, endoscopic mucosal resection, outcome

INTRODUCTION

Colorectal laterally spreading tumors (LSTs) are superficial and flat neoplasms with a diameter ≥10 mm. They extend laterally and circumferentially along the colorectal luminal wall. They are classified as either granular (LST-G) or non-granular (LST-NG) type according to their endoscopic macroscopic morphology. Kudo et al. proposed a subclassification of the LST-G and LST-NG types; LST-Gs are subclassified as homogeneous (HG) and nodular mixed (NM) subtypes, and LST-NGs are subclassified into flat elevated (FE) and pseudo-depressed (PD) subtypes (1-4). Invasive carcinomas are more frequent in the LST-NG type than in the LST-G type. The PD and NM subtypes have higher malignant potentials (5-9). However, most LSTs are of the LST-G type and are adenomatous lesions. Therefore, LSTs are usually removed using endoscopic resection techniques (10-18).

Endoscopic mucosal resection (EMR) is a safe and effective technique for the treatment of precursor colorectal lesions. This technique involves the injection of a mixture of normal saline, contrast dye, and diluted epinephrine into the submucosal layer of the lesion to lift the lesion off the muscle layer and create a dye-stained "submucosal cushion" between the mucosal layer and the proper muscle layer of the lesion. The lifted lesion is then excised through constriction with an electrical current using a snare wire. Colorectal neoplasms up to 20 mm can

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be removed en bloc using an EMR and >20 mm can be removed using a piecemeal EMR. However, it is difficult to obtain an accurate histopathological diagnosis in a piecemeal EMR, and the approach tends to lead to incomplete resection and local recurrence (19-22).

Endoscopic submucosal dissection (ESD) is a recently introduced advanced technique for treating large colorectal neoplasms that allows complete en bloc resection for an accurate histopathological evaluation, regardless of lesion size, shape, and location. However, it is a more complex, expensive, and time-consuming technique with higher rates of perforation and a longer learning curve (19-24). Therefore, it has not been extensively used for the treatment of large colorectal lesions, such as LSTs. EMR of lesions ≤20 mm and piecemeal EMR of colorectal lesions >20 mm are the standard techniques worldwide (19-22).

The aim of the present study was to investigate the factors associated with the clinical outcomes of EMR for colorectal LSTs.

MATERIALS AND METHODS

Patients

A total of 275 patients with LSTs that were resected using an EMR from January 2012 to December 2013 at five university hospitals in Honam Province, South Korea were enrolled in the study. Patient's medical records were collected and analyzed retrospectively. EMR was performed after explaining the procedure and its related complications, including bleeding and perforation. Informed consent was obtained from the patients after explaining the possibility of potential complications and additional surgery according to complications or pathological diagnosis of resected specimens. The institutional review board of each participating hospital approved the study protocol.

Definition and classification of colorectal LSTs

Laterally spreading tumor is defined as a lesion ≥10 mm in size that extends laterally along the interior luminal wall with a short vertical axis. Endoscopic macroscopic morphology was classified in accordance with a prior endoscopic classification using chromoendoscopy with a 0.5% indigo carmine with or without magnified examination (4). LSTs were then classified into the LST-G or LST-NG type based on endoscopic macroscopic morphology. The LST-G type was further subclassified into the HG and NM subtypes, and the LST-NG type was further subclassified into the FE and PD subtypes (4). The pit pattern of lesions was evaluated retrospectively by analyzing the results of conventional colonoscopy and chromoendoscopy with or without examination at higher magnification. The pit pattern was divided into six types as I, II, III_S, III_L, IV, and V (25). The location of the LST was either the distal colon (rectosigmoid colon and descending colon) or the proximal colon (transverse colon, ascending colon, and cecum). Two endoscopists blinded to the study reviewed all cases and subclassified them as described above. In cases of classification discrepancies, they discussed the results to reach a consensus and a single diagnosis.

EMR procedure

Endoscopic mucosal resection was performed using a CF-Q260AI endoscope model (Olympus, Tokyo, Japan) at all participating institutions. Chromoendoscopy with a 0.4% indigo carmine dye or narrow band imaging was performed to delineate the margins of the lesions and to evaluate their pit patterns. A mixture of normal saline and indigo carmine with diluted epinephrine (1:5000-1:10,000) was injected into the submucosal layer below the lesion using an NM-4U-1 23-gauge needle (Olympus) until the mucosa lifted. The lifted lesion was excised through constriction with electrical current using an SD-12L/U-1 snare wire model (Olympus) and an electrocautery device (ERBE Elektromedizin, Tübingen, Germany). The resected specimens were fixed in 10% buffered formalin, embedded in paraffin, sliced in 2 mm sections, stained with hematoxylin and eosin, and, finally, assessed microscopically. The histopathological diagnosis was based on the World Health Organization classifications of gastrointestinal epithelial neoplasia (26).

Definition of en bloc, piecemeal, R0 resection, and procedure time

En bloc and piecemeal resections were defined as resection with a single piece and resection with multiple pieces, respectively. R0 resection was defined as the removal of the specimen with tumor-free lateral and basal margins. Procedure time was counted from the start of local injection to the end of lesion removal.

Definition of adverse events

Procedure-related bleeding after EMR was defined as bleeding that required transfusion or surgical intervention or bleeding that decreased the hemoglobin level to >2 g/dL. Perforation was defined as the endoscopic finding of a full-thickness defect formed all the way through the colon wall or the presence of free air on abdominal plain radiography or computed tomography images.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences, version 22.0 software (IBM Corp.; Armonk, NY, USA). Continuous variables with normal distribution are expressed as mean ± standard deviation, and categorical variables are expressed as frequency and percentage (%). Differences were analyzed using the chi-square test, Student's *t*-test, or analysis of variance, as appropriate. Risk factors associated with piecemeal resection after EMR were determined using a logistic regression model. All risk factors were analyzed using univariate logistic regression analysis, and factors with a p-value of <0.05 were included in the multivariate logistic regression model. A P-value of <0.05 was considered statistically significant.

Table 1. Clinicopathological characteristics of colorectal laterally spreading tumors treated by endoscopic mucosal resection

Factors		n=275 (%)
Age (years)	Mean±SD (range)	65.9±9.7 (42.0-90.0)
Sex	Male/female	171/104 (62.2/37.8)
Comorbidity	No/yes	131/144 (47.6/52.4)
Smoking status	Non-/current smoker or ex-smoker	210/65 (76.4/23.6)
Alcohol drinking	No/yes	195/80 (70.9/29.1)
BMI (kg/m2)	Mean±SD (range)	24.1±3.5 (16.0-39.0)
Aspirin or NSAIDs	No/yes	245/30 (89.1/10.9)
Location	Proximal colon	147 (53.5)
	Distal colon	128 (46.5)
Size (mm)	Mean±SD (range)	18.0±7.9 (10.0-85.0)
	≤20 mm	215 (78.2)
	>20 mm	60 (21.8)
Macroscopic type	Granular	184 (66.9)
	Homogeneous	91 (33.1)
	Nodular mixed	93 (33.8)
	Non-granular	91 (33.1)
	Flat elevated	83 (30.2)
	Pseudo-depressed	8 (2.9)
Pit pattern (n=179)	Non-neoplastic (type I/II)	69 (38.5)
	Adenomatous (type IIIS/IIIL/IV)	103 (57.6)
	Cancerous (type VI/VN)	7 (3.9)
Histology	Low-grade dysplasia	207 (75.3)
	High-grade dysplasia	39 (14.2)
	Adenocarcinoma	29 (10.5)
Resection type	En bloc resection	239 (86.9)
	Piecemeal resection	36 (13.1)
Procedure time (min)	Mean±SD (range)	12.2±16.7 (1.0-110.0)
Complete r esection (R0)	Margin (−)	221 (80.4)
	Margin (+)	21 (7.6)
	Undetermined	33 (12.0)
Bleeding	No/yes	254/21 (92.4/7.6)
Perforation	No/yes	274/1 (99.6/0.4)

SD, standard deviation; BMI, body mass index; NSAIDs, nonsteroidal anti-inflammatory drugs.

RESULTS

Clinicopathological characteristics of the study population

Table 1 shows the clinicopathological characteristics of the study populationhttps://link.springer.com/article/10.1007%2Fs00384-012-1543-2 - Tab1. The mean age of the patients was 65.9±9.7 (42.0-90.0) years. There were 171 (62.2%) male and 104 (37.8%) female patients in the study group. The mean tumor size was 18.0±7.9 (10.0-85.0) mm. Of the tumors, there were 147 (53.5%) localized in the proximal colon and 128 (46.5%) localized in the distal colon. Among the 275 LSTs treated with EMR, there were 184 (66.9%) LST-Gs and 91 (33.1%) LST-NGs. According to the classification by Kudo et al., 69 (38.5%) lesions had a non-neoplastic pit pattern (type I/II), 103 (57.6%) had an adenomatous pit pattern (type III_S/III_L/IV), and 7 (3.9%) had a cancerous pit pattern (type V_I/V_N) in terms of pit pattern (4). Histological grading revealed 207 (75.3%) low-grade dysplasias, 39 (14.2%) high-grade dysplasias, and 29 (10.5%) adenocarcinomas. In 239 out of 275 LSTs, the en bloc resection rate was 86.9%. In 221 out of 275, the R0 resection rate was 80.4%. The bleeding and perforation rates after EMR were 7.6% (21 out of 275) and 0.4% (1 out of 275), respectively.

Clinical outcome and safety of EMR for colorectal LSTs according to endoscopic macroscopic morphology and size of the lesion

Tables 2 and 3 summarize the clinical outcomes and safety of EMR for colorectal LSTs according to the endoscopic macroscopic morphology and size of the lesions. LST-NGs were more commonly found in the distal colon, and LST-Gs were more commonly found in the proximal colon (p=0.013). The mean size of LST-Gs tended to be larger than that of LST-NGs (p=0.052). The bleeding rate tended to be higher in LST-NGs than in LST-Gs (p=0.079). There were no statistically significant differ-

ences in pit pattern, histological grade, resection method, mean procedure time, R0 resection, and perforation between the LST-G and LST-NG types. The frequency of LST-G type and cancerous pit pattern tended to be higher in LSTs >20 mm than in those ≤20 mm (p=0.052 and p=0.067, respectively). The frequency of high-grade dysplasia and adenocarcinoma histology was significantly higher in LSTs >20 mm than in those ≤20 mm (p=0.001). The en bloc resection rate tended to be higher in LSTs ≤20 mm than in those >20 mm (p=0.073). The mean procedure time was significantly longer in LSTs >20 mm than in those ≤20 mm (p=0.004). The R0 resection rate was significantly higher in LSTs ≤20 mm than in those >20 mm (p=0.013). There were no statistically significant differences in location, bleeding, and perforation rates between LSTs ≤20 and >20 mm.

Table 2. Clinical outcome and safety of colorectal laterally spreading tumors treated by endoscopic mucosal resection according to endoscopic macroscopic morphology

Factors	Macroscopic type		
	Granular type n=184 (%)	Non-granular type n=91 (%)	p
Location			0.013
—Proximal colon	108 (58.7)	39 (42.9)	
—Distal colon	76 (41.3)	52 (57.1)	
Size (mm) (mean±SD)	18.8±8.6	16.5±6.0	
—≤20 mm	139 (75.5)	78 (85.7)	0.052
—>20 mm	45 (24.5)	13 (14.3)	
Pit pattern (n=175)			0.511
—Non-neoplastic (type I/II)	52 (40.6)	17 (33.3)	
—Adenomatous (type IIIS/IIIL/IV)	72 (56.3)	31 (60.8)	
—Cancerous (type VI/VN)	4 (3.1)	3 (5.9)	
Histological grade			0.167
—Low-grade dysplasia	138 (75.0)	69 (75.8)	
—High-grade dysplasia	30 (16.3)	9 (9.9)	
—Adenocarcinoma	16 (8.7)	13 (14.3)	
Resection type			0.467
—En bloc resection	158 (85.9)	81 (89.0)	
—Piecemeal resection	26 (14.1)	10 (11.0)	
Procedure time (min) (mean±SD)	12.3±16.6	11.8±17.1	0.801
R0 resection (n=242)	154 (89.5)	67 (95.7)	0.122
Bleeding	11 (6.0)	11 (12.1)	0.079
Perforation	1 (0.5)	0 (0.0)	

SD, standard deviation.

Univariate analysis of risk factors associated with piecemeal resection after EMR for colorectal LSTs

Table 4 shows the clinicopathological factors associated with en bloc or piecemeal resection after EMR for colorectal LSTs. There was no significant difference between en bloc and piecemeal resection in terms of age, sex, comorbidity, smoking, alcohol drinking, body mass index, use of aspirin and nonsteroidal anti-inflammatory drugs, tumor location, and endoscopic macroscopic morphology. The rate of piecemeal resection tended to be higher in LSTs >20 mm than in those ≤20 mm (odds ratio (OR) 1.990, 95% confidence interval (CI) 0.929-4.262, p=0.077). The frequency of piecemeal resection was significantly higher in LSTs with an adenomatous and cancerous pit pattern than in those with a non-neoplastic pit pattern (OR 10.177, 95% CI 2.320-44.653, p=0.002 and OR 13.400, 95% CI 1.545-116.233, p=0.019, respectively). The frequency of piecemeal resection was significantly higher in LSTs with adenocarcinoma histology than in those with

Table 3. Clinical outcome and safety of endoscopic mucosal resection according to the size of the lesion

Factors	Size		
	≤20 mm n=217 (%)	>20 mm n=58 (%)	p
Location			0.554
—Proximal colon	114 (52.5)	33 (56.9)	
—Distal colon	103 (47.5)	25 (43.1)	
Macroscopic type			0.052
—Granular	139 (64.1)	45 (77.6)	
—Non-granular	78 (35.9)	13 (22.4)	
Pit pattern (n=179)			0.067
—Non-neoplastic (type I/II)	59 (42.8)	10 (24.4)	
—Adenomatous (type IIIS/IIIL/IV)	75 (54.3)	28 (68.3)	
—Cancerous (type VI/VN)	4 (2.9)	3 (7.3)	
Histology			0.001
—Low-grade dysplasia	174 (80.2)	33 (56.9)	
—High-grade dysplasia	23 (10.6)	16 (27.6)	
—Adenocarcinoma	20 (9.2)	9 (15.5)	
Resection type			0.073
—En bloc resection	192 (88.5)	47 (81.0)	
—Piecemeal resection	25 (11.5)	11 (19.0)	
Procedure time (min) (mean±SD)	10.2±14.3	19.1±22.2	0.004
R0 resection (n=242)	174 (94.1)	47 (82.5)	0.013
Bleeding	20 (9.2)	2 (3.4)	0.182
Perforation	1 (0.5)	0 (0.0)	

SD, standard deviation.

Table 4. Univariate analysis of risk factors associated with piecemeal resection after endoscopic mucosal resection for colorectal laterally spreading tumors

			Univariate analysis	
	En bloc resection n=239 (%)	Piecemeal resection n=36 (%)	OR (95% CI)	p
Age (years) (mean±SD)	66.0±9.5	65.5±10.7	0.995 (0.960-1.032)	0.782
Male sex	146 (85.4)	25 (14.6)	1.448 (0.680-3.081)	0.337
Comorbidity (+)	126 (87.5)	18 (12.5)	0.897 (0.445-1.808)	0.761
Current or ex-smoker	52 (80.0)	13 (20.0)	2.033 (0.964-4.287)	0.062
Alcohol drinking	68 (85.0)	12 (15.0)	1.257 (0.595-2.656)	0.548
BMI (kg/m^2) (mean±SD)	24.3±3.5	11.5±3.3	0.915 (0.810-1.032)	0.148
Use of aspirin or NSAIDs	20 (83.3)	5 (16.7)	1.381 (0.492-3.873)	0.540
Size (mean±SD)	17.8±8.1	19.9±6.2		
—Size ≤20 mm	191 (88.5)	24 (11.5)	1.000 (ref)	
—Size >20 mm	48 (81.0)	12 (19.0)	1.990 (0.929-4.262)	0.077
Location				
—Proximal colon	127 (86.4)	20 (13.6)	1.000 (ref)	
—Distal colon	112 (87.5)	16 (12.5)	0.907 (0.448-1.836)	0.786
Macroscopic type				
—Granular	158 (85.9)	26 (14.1)	1.000 (ref)	
—Non-granular	81 (89.0)	10 (11.0)	0.750 (0.345-1.632)	0.468
Pit pattern (n=179)				
—Non-neoplastic (type I/II)	67 (97.1)	2 (2.9)	1.000 (ref)	
—Adenomatous (type IIIS/IIIL/IV)	79 (76.7)	24 (23.3)	10.177 (2.320-44.653)	0.002
—Cancerous (type VI/VN)	5 (71.4)	2 (28.6)	13.400 (1.545-116.233)	0.019
P-value for trend				0.001
Histological grade				
—Low-grade dysplasia	185 (89.4)	22 (10.6)	1.000 (ref)	
—High-grade dysplasia	32 (82.1)	7 (17.9)	1.839 (0.726-4.660)	0.199
—Adenocarcinoma	22 (75.9)	7 (24.1)	2.676 (1.026-6.978)	0.044
P-value for trend				0.029

OR, odds ratio; SD, standard deviation; CI, confidence interval; BMI, body mass index; NSAIDs, nonsteroidal anti-inflammatory drugs.

Table 5. Multivariate analysis of risk factors associated with piecemeal resection after endoscopic mucosal resection for colorectal laterally spreading tumors

	Multivariate analysis	
Factors	aOR (95% CI)	p
Pit pattern		
—Non-neoplastic (type I/II)	1.000 (ref)	
—Adenomatous (type IIIS/IIIL/IV)	14.036 (2.882-68.360)	0.001
—Cancerous (type VI/VN)	4.293 (0.418-44.121)	0.220
Histological grade		
—Low-grade dysplasia	1.000 (ref)	
—High-grade dysplasia	3.418 (1.129-10.346)	0.030
—Adenocarcinoma	12.979 (2.377-70.855)	0.003

aOR, adjusted odds ratio; CI, confidence interval.

low-grade dysplasia histology (OR 2.676, 95% CI 1.026-6.978, p=0.044). There was no significant difference between en bloc and piecemeal resection in terms of procedure time.

Multivariate analysis of risk factors associated with piecemeal resection after EMR for colorectal LSTs

Table 5 summarizes the results of multivariate analysis of risk factors associated with piecemeal resection after EMR for colorectal LSTs. For regression analysis, LSTs with an adenomatous pit pattern, high-grade dysplasia histology, or adenocarcinoma histology were significant independent risk factors for piecemeal resection after EMR (OR 14.036, 95% CI 2.882-68.360, p=0.001; OR 3.418, 95% CI 1.129-10.346, p=0.030; and OR 12.979, 95% CI 2.377-70.855, p=0.003, respectively).

DISCUSSION

Colorectal LSTs are increasingly being reported in the literature owing to increased awareness of these lesions and the introduction of chromoscopic and magnifying colonoscopy (1-4). These lesions are usually adenomatous and are removed by endoscopic resection (5-9). However, the rate of colorectal LSTs with advanced histology varies according to endoscopic morphology and lesion size (5-9). Therefore, the appropriate therapeutic strategy for each colorectal LST must be selected with caution (10-18).

Endoscopic mucosal resection is an easy-to-learn, safe, and effective therapeutic technique for superficial colorectal neoplasms. However, if the lesion size is >20 mm, this technique is not feasible and safe for an en bloc resection owing to the size limitation of the snare (19-22). ESD is a recently developed technique with therapeutic advantages over EMR in terms of allowing a complete en bloc resection of a lesion irrespective of its size. However, it is a difficult technique with a high risk of perforation and a long learning curve (19-24). Therefore, it is not currently widely used as the standard method for treating large superficial colorectal neoplasms, such as LSTs, and EMR remains to be used for treating large superficial colorectal neoplasms, such as LSTs, in the clinical research setting.

Currently, we evaluated the efficacy and safety of EMR for colorectal LSTs. The en bloc and R0 resection rates were 86.9% and 80.4%, respectively. Generally, the en bloc and R0 resection rates were 88.5% and 94.1%, respectively, in LSTs ≤20 mm. However, the en bloc and R0 resection rates were 81.0% and 82.5%, respectively, in LSTs >20 mm. Furthermore, the mean procedure time in the larger LSTs was significantly longer than that in LSTs ≤20 mm. Our results are comparable to previous studies (19-22) and indicate that EMR remains an acceptable method for treating ≤20 mm colorectal LSTs with regard to mean procedure time, en bloc resection rate, and complete resection rate.

The main complications of colorectal EMR are bleeding and perforation (19-22). Currently, the bleeding and perforation rates after EMR were 7.6% and 0.4%, respectively. Previous studies reported that the factors affecting the risk of bleeding after colorectal EMR include the type and size of the lesion, the lesion location, and the patient's coagulation status (19-22). The bleeding rate after colorectal EMR was 1.0%-18.0% (19-22). In the present study, the bleeding rate tended to be higher in LST-NGs than in LST-Gs. There were no statistically significant differences in bleeding rate according to lesion size. Reported risk factors of perforation after colorectal EMR include the size and location of the lesion and the presence of fibrosis (19-22). The perforation rate after colorectal EMR was 0.31%-1.7% of the cases (19-22). Only one case of perforation was observed in the present study. This case was managed using a clip application. These results indicate that EMR for colorectal LSTs is a safe procedure with a low incidence of main complications, such as bleeding and perforation.

En bloc resection is a prerequisite for obtaining a precise histological diagnosis and for deciding complete curative resection after endoscopic resection of colorectal neoplasms (19-24). Then, we evaluated the clinicopathological factors associated with en bloc or piecemeal resection after EMR for colorectal LSTs. Most LSTs can be resected en bloc and completely with EMR (11-13). However, the present frequency of piecemeal resection was significantly higher in LSTs with an adenomatous and cancerous pit pattern or with adenocarcinoma histology. The frequency of piecemeal resection tended to be higher in LSTs >20 mm than in those ≤20 mm, but no statistical significance was found. However, EMR is difficult to perform en bloc resection of a colorectal neoplasm >20 mm owing to snare size limitation (19-22). Therefore, a larger size can still be a risk factor for piecemeal resection. There could be a significant difference if many colorectal neoplasms with a size >20 mm are enrolled in the study. For multivariate analysis, LSTs with an adenomatous pit pattern, high-grade dysplasia histology, or adenocarcinoma histology were significant independent risk factors for piecemeal resection after EMR. In previous studies, the frequency of piecemeal resection was reported to be increased in superficial colorectal neoplasms, including LSTs with a larger size, LST-NG type, and advanced histology (11-13, 19-24), similar to our results. Generally, since these lesions have a higher malignant potential, careful consideration is needed in selecting the endoscopic treatment modality for the en bloc and curative resection of these tumors. ESD may be considered as an alternative to EMR for en bloc and curative resection.

The present study has some limitations. The study was retrospectively and nonrandomly designed. Cases with colorectal LSTs treated only by EMR were enrolled in the study. LSTs with risk factors, such as large size and type V pit pattern, were usually resected by ESD (10-18). Therefore, LSTs with risk factors were excluded. For this reason, there could be selection biases in size and pit patterns of colorectal LSTs.

In conclusion, EMR is useful for treating ≤20 mm colorectal LSTs with regard to curative resection and procedure time, and LSTs with an adenomatous pit pattern, high-grade dysplasia histology, or adenocarcinoma histology are significant independent risk factors for piecemeal resection after EMR for colorectal LSTs. If EMR is considered as the endoscopic treatment for these lesions, the lesions should be removed en bloc with great caution to ensure an accurate histopathological diagnosis.

Ethics Committee Approval: The institutional review board of each participating hospital approved the study protocol.

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

Peer-review: Externally peer-reviewed.

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