ORIGINAL ARTICLE

Impact of endoscopic resection on the choice of surgical procedure in patients with additional laparoscopic gastrectomy

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Abstract

Background Additional surgery is recommended for patients with noncurative resection after endoscopic submucosal dissection (ESD) for early gastric cancer. Additional resection requires the excision of an area larger than that of the resected mucosa in ESD, which is larger than the lesion, with convergence of the gastric mucosa due to scarring. Thus, the selection of the surgical procedure for lesion removal in specific areas can be affected by ESD. This study therefore aimed to evaluate the impact of ESD on the selection of additional gastrectomy in patients with early gastric cancer in the boundary area between the upper third and middle third of the stomach (UM boundary region).

Methods Between January 2013 and June 2018, laparoscopic gastrectomy was performed in 89 patients with cT1N0M0 gastric cancer located only in the UM boundary region. The patients' backgrounds and surgical and pathological results were retrospectively investigated. The predictive factors for performing laparoscopic distal gastrectomy (LDG) were evaluated by multivariate analysis.

Results Among 89 patients, 23 patients underwent ESD before surgery. LDG was significantly less often performed in the ESD-surgery group than in the surgery-only group (34.8% vs. 72.7%; $p = 0.003$). Preoperative ESD was an independent negative predictor of LDG (odds ratio $= 0.266$; $p = 0.025$).

Conclusions Preoperative ESD has an impact on the selection of the type of additional gastrectomy, including reducing the conduct of LDG for early gastric cancer in the UM boundary region.

Keywords Early gastric cancer · Endoscopic submucosal dissection · Gastrectomy · Laparoscopy

Introduction

Recent advances in diagnostic technology have facilitated the early detection of gastric cancer, especially in Japan and Korea [1–3]. Patients with early gastric cancer (EGC) with a low risk of lymph node metastasis are generally treated by endoscopic submucosal dissection (ESD). ESD for EGC is used for treating absolute indications such as intramucosal differentiated-type adenocarcinoma and 2 cm or less in tumor size without ulceration [4] and has been expanded to cover other conditions as an investigational treatment [4–6]. In clinical practice, diagnostic ESD may be performed as a relative indication in patients at high risk for adverse surgical outcomes such as the elderly, even if submucosal invasion is clinically suspected. Patients who do not fulfill the pathological criteria for curative resection are considered for noncurative resection because of the potential risk of lymph node metastasis or a local residual tumor [4]. Therefore, additional surgical resection with lymph node dissection is recommended for these patients [4].

Acceptance has been growing for the use of laparoscopic gastrectomy as a standard procedure for the treatment of EGC due to its good safety profile and advantages over conventional open gastrectomy [7–10]. ESD causes

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the appearance of an artificial gastric ulcer, which induces local inflammation, edema, fibrosis, and intraabdominal adhesions. These ESD-induced effects might increase the level of technical difficulties seen during additional laparoscopic gastrectomy after ESD [11]. Previous studies have clarified the oncological safety profile and technical feasibility of performing additional laparoscopic gastrectomy [12, 13].

Generally, the surgical procedure is determined based on the location of the lesion. However, gastric cancer located in the upper gastric body (defined as the upper third of the region from the cardia to the angle) is resected with both distal gastrectomy (DG) and proximal gastrectomy [14]. The preservation of the fundus—that is, whether laparoscopic distal gastrectomy (LDG) can be performed—is one of the important points capable of affecting the patient's quality of life. This is because LDG has both surgical and nutritional benefits over laparoscopic proximal gastrectomy (LPG) or laparoscopic total gastrectomy (LTG) according to several studies [15, 16]. Overall, LDG is the most common type of laparoscopic gastrectomy, with a significant level of evidence accumulated supporting its use [17–19]. Especially given that LPG and LTG were more recently established [20], there are still some problems that must be overcome in terms of technical difficulties, standard procedures for reconstruction, and postoperative complications such as reflux esophagitis and anastomotic stenosis.

The portion to be excised during additional gastrectomy is larger than the original lesion. This is because the mucosa resected during ESD is larger than the lesion and there is contraction of the tissues at the site of resection during healing of the ESD ulcer. In contrast, the distance from the esophagogastric junction to the proximal margin of the lesion must be secured for performing LDG to ensure a passageway for meals and to avoid cutting into the lower esophageal sphincter, taking into account the width of approximately 1 cm of the device used to cut the stomach. According to previous studies, the proximal distance from the esophagogastric junction should be at least 2 cm for performing DG [21, 22]. In fact, Kawata et al. reported three cases in which DG as the estimated gastric resection had to be altered to total gastrectomy because of the contraction of the ESD ulcer [22]. Thus, we hypothesized that for lesions located near the expected cutline for LDG procedure, performing ESD can make it difficult to resect the lesion via LDG, thereby resulting in an increase in the frequency of LPG or LTG.

In this study, we considered the area potentially affected by ESD and any subsequent scarring as the boundary area between the upper third and middle third of the stomach (UM boundary region). Consequently, study participants were limited to those with lesions in the UM boundary region. We evaluated the effects of ESD on the selection of

an additional gastrectomy procedure among patients with EGC in the UM boundary region.

Patients and methods

Patients

We retrospectively reviewed the data of patients who had undergone gastrectomy for cT1N0M0 cStage I gastric cancer at Saitama Medical University International Medical Center, Saitama, Japan, between January 2013 and June 2018. Among the 487 consecutive patients identified, 426 patients who underwent R0 laparoscopic gastrectomy for single EGC were included after the exclusion of those with remnant gastric cancer, multiple lesions, open surgery, and R1 resection. Subsequently, after excluding patients with tumors that extended outside the distal one-half of the upper third of the stomach and the proximal one-half of the middle third of the stomach, we finally analyzed 89 patients who underwent laparoscopic gastrectomy for cT1N0M0 cStage I gastric cancer located only in the UM boundary region (Fig. 1). We defined the distal one-half of the upper third of the stomach and the proximal one-half of the middle third of the stomach collectively as the UM boundary region. The clinical staging and pathological examination of all tumors were performed according to the Japanese Classification of Gastric Cancer [4] as proposed by the Japanese Gastric Cancer Association (JGCA). An upper gastrointestinal multidisciplinary team comprising senior staff reviewed the endoscopic findings, computed tomography, and other pretreatment examination findings and selected the appropriate treatment strategies, including surgical and endoscopic resection, based on the guidelines of the JGCA [4]. In surgical resection cases, the tumor location was determined via endoscopy and gastrointestinal series. The proximal margins of the lesion or the ESD scar were marked using clips during endoscopy. Subsequently, an upper gastrointestinal series was performed before surgery in all cases. This study was conducted after obtaining approval from the institutional review board of Saitama Medical University.

Criteria for the noncurative resection of ESD

A diagnosis of noncurative resection of ESD was made when the pathological findings did not meet the criteria for curative resection as defined in the JGCA guidelines [4]. In other words, patients were diagnosed as having noncurative resection when at least one of the following conditions was met: (1) a differentiated tumor with a size of more than 30 mm that satisfied at least one of the conditions of sm1 invasion (<500 μm) or ulceration; (2) an undifferentiated tumor that satisfies one of the conditions of submucosal invasion, size

Fig. 1 Flowchart of patient enrollment. *ESD* endoscopic submucosal dissection
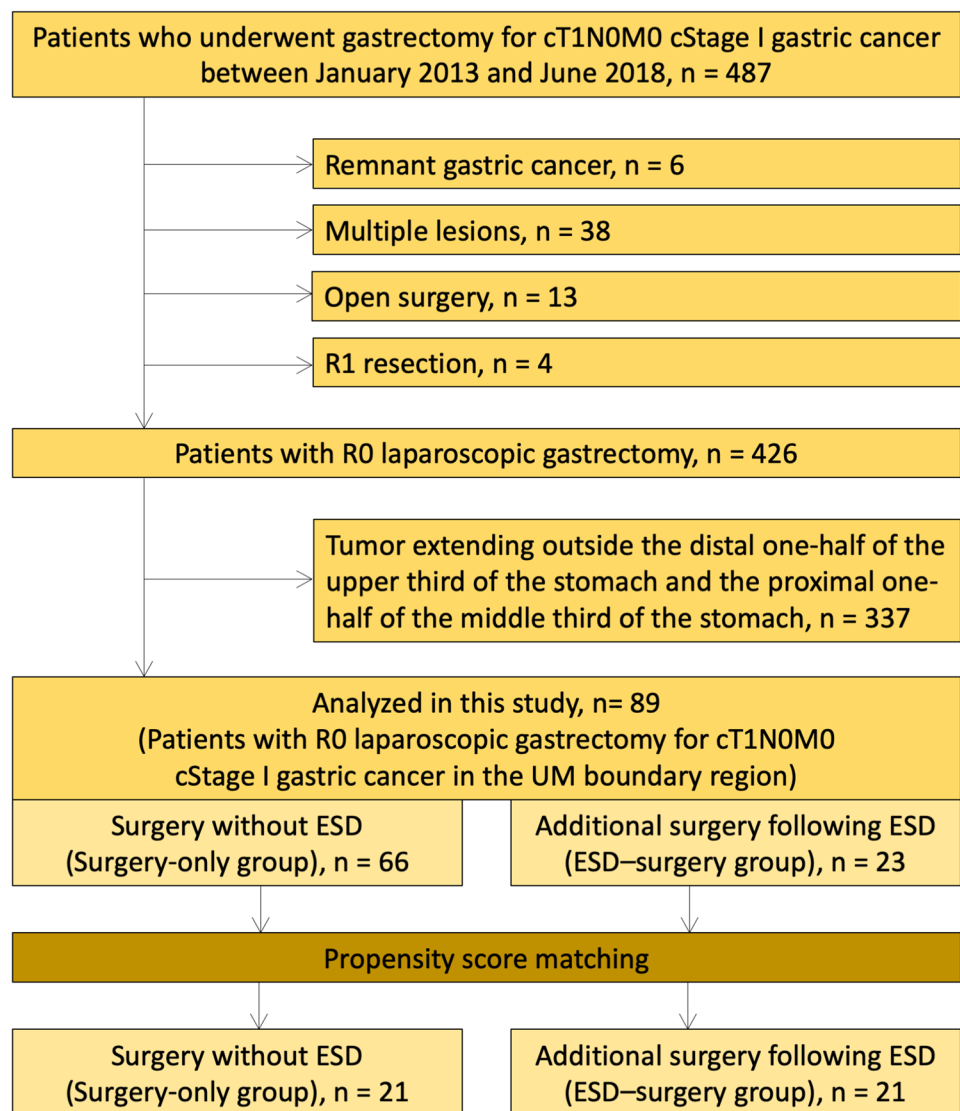
of greater than 20 mm, or ulceration; (3) the presence of lymphatic invasion; (4) the presence of vascular invasion; (5) sm2 or deeper invasion (≥ 500 µm); (6) positive horizontal margin or horizontal margin that could not be assessed; and (7) positive vertical margin or vertical margin that could not be assessed.

Surgical procedure

At our institution, LDG is the primary choice for the treatment of EGC in the UM boundary region. An upper gastrointestinal multidisciplinary team reviewed all preoperative findings and finally determined whether LDG can be performed based on the virtual cutting line of the stomach, which was determined using proximal marking clips. LPG or LTG was considered if LDG was deemed to be not feasible.

In LDG, a Billroth I reconstruction operation was essentially performed. If the Billroth I procedure was considered difficult to complete based on intraoperative findings including intraoperative endoscopy, then the Roux-en-Y procedure was performed. During LPG, an esophagogastric anastomosis or double-tract reconstruction was performed. During LTG, Roux-en-Y reconstruction via an antecolic route was completed. Finally, in any type of gastrectomy, D1+ lymphadenectomy was done.

Propensity score matching

A propensity score matching analysis was performed to align background factors between study participants who underwent additional gastrectomy after noncurative resection of ESD, labeled as the ESD-surgery group, and those who underwent gastrectomy without ESD, labeled as the surgery-only group. Propensity scores were estimated using a multivariable logistic regression model according to age, sex, preoperative body mass index (BMI), and American

Society of Anesthesiologists physical status (ASA-PS). One-to-one matching without replacement was performed using a 0.1 caliper width and the resulting matched pairs were used in subsequent analyses.

Statistical analysis

Differences in the qualitative data between the two groups were evaluated using the Chi squared test or Fisher's exact test and quantitative data were compared using the Student's *t* test. A multivariate logistic regression analysis was used to calculate odds ratios (ORs) and their 95% confidence intervals (CIs) for identifying factors that could influence the decision-making about the type of gastrectomy. A *p* value of less than 0.05 was considered to be statistically significant. The Statistical Package for the Social Sciences version 25 software program (IBM Corp., Armonk, NY, USA) was used to perform the statistical analyses.

Results

The clinical characteristics of the patients are summarized in Table 1. Of the 89 included patients, 23 underwent ESD before surgery. The patients in the ESD-surgery group tended to be significantly older, male, and have higher BMI values in comparison with those in the surgery-only group. In addition, the lesions were more likely to be distributed

in the lesser curvature in the surgery-only group and in the greater curvature in the ESD-surgery group.

As shown in Table 2, LDG was significantly less often performed in the ESD-surgery group than in the surgery-only group (34.8% vs. 72.7%; $p = 0.003$), while LPG was the most frequently performed operation in the ESD-surgery group (52.2%). There was no difference in the operation time, amount of blood loss, or frequency of postoperative complications between the groups, although the length of hospital stay was longer in the ESD-surgery group than in the surgery-only group (9 days vs. 8 days; $p = 0.041$).

The pathological characteristics of the patients are shown in Table 3. The proportion of cases of the differentiated dominant type was significantly higher in the ESD-surgery group than that in the surgery-only group. Further, the depth of tumor invasion included only pT1b or T2 in the ESD-surgery group, whereas it included pT1a and T3 as well in the surgery-only group, resulting in a significant difference in the distribution of tumor depth between the two groups. There was no significant difference in the frequency of lymph node metastasis, lymphatic invasion, and venous invasion between the two groups. In addition, the median length of the proximal margin of the tumors resected via LDG was 16 mm. Furthermore, the median proximal margin length of the tumors resected via LPG or LTG was 30 mm.

The median time interval between ESD and subsequent surgery in the ESD-surgery group was 12 weeks. Patients ($n = 23$) in the ESD-surgery group were divided into two

Table 1 Characteristics of the patients before and after propensity score matching

	All patients ($n=89$)			Matched patients ($n=42$)		
	Surgery-only group ($n=66$)	ESD-surgery group ($n=23$)	*p* value	Surgery-only group ($n=21$)	ESD-surgery group ($n=21$)	*p* value
Age (years), mean ± SD	64.3 ± 10.9	70.6 ± 10.1	0.017*	70.0 ± 8.2	69.9 ± 10.3	0.961
Sex: *n* (%)			0.003*			
Male	38	21		19	19	1.000
Female	28	2		2	2	
BMI (kg/m²), mean ± SD	22.6 ± 3.1	24.3 ± 1.9	0.012*	24.0 ± 2.7	24.1 ± 1.7	0.967
ASA-PS: *n* (%)			0.351			1.000
1	27	6		6	6	
2	38	17		15	15	
3	1	0		0	0	
Circumference: *n* (%)			0.014*			0.018*
Anterior wall	7	6		1	6	
Posterior wall	22	3		7	3	
Greater curvature	11	9		3	8	
Lesser curvature	26	5		10	4	
Tumor size (mm), mean ± SD	28.1 ± 13.1	27.8 ± 14.8	0.940	31.2 ± 13.2	27.1 ± 14.6	0.351

ESD endoscopic submucosal dissection, *SD* standard deviation, *BMI* body mass index, *ASA-PS* American Society of Anesthesiologist physical status

*$p < 0.05$

Table 2 Operative characteristics and perioperative outcomes of the patients before and after propensity score matching

	All patients ($n=89$)			Matched patients ($n=42$)		
	Surgery-only group ($n=66$)	ESD-surgery group ($n=23$)	p value	Surgery-only group ($n=21$)	ESD-surgery group ($n=21$)	p value
Type of gastrectomy, n (%)			0.003*			0.002*
Distal gastrectomy	48	8		17	6	
Total gastrectomy	6	3		2	3	
Proximal gastrectomy	12	12		2	12	
Operation time (min), median (range)	254 (157–421)	250 (187–389)	0.847	275 (194–368)	243 (187–350)	0.091
Blood loss (mL), median (range)	30 (0–200)	12 (0–130)	0.803	37 (0–200)	12 (0–130)	0.223
Postoperative complications C–D grade ≥ II, n (%)	4	3	0.256	2	2	1.000
Postoperative hospital stay (days), median (range)	8 (6–24)	9 (7–31)	0.041*	8 (6–17)	9 (7–31)	0.065

ESD endoscopic submucosal dissection, *SD* standard deviation, *C–D* Clavien–Dindo classification

*$p<0.05$

Table 3 Pathological characteristics of the patients before and after propensity score matching

	All patients ($n=89$)			Matched patients ($n=42$)		
	Surgery-only group ($n=66$)	ESD-surgery group ($n=23$)	p value	Surgery-only group ($n=21$)	ESD-surgery group ($n=21$)	p value
Dominant histological type, n (%)			<0.001*			0.004*
Differentiated	26	22		12	20	
Undifferentiated	40	1		9	1	
pT, n (%)			0.001*			0.006*
T1a	27	0		8	0	
T1b	29	21		12	19	
T2	8	2		0	2	
T3	2	0		1	0	
pN, n (%)			0.581			0.303
N0	58	20		20	18	
N1	8	3		1	3	
pStage, n (%)			0.222			0.835
IA	50	20		19	18	
IB	13	1		1	1	
IIA	2	2		1	2	
IIB	1	0		0	0	
Lymphatic invasion			0.554			0.500
Negative	56	20		18	19	
Positive	10	3		3	2	
Venous invasion			0.418			0.348
Negative	54	20		16	18	
Positive	12	3		5	3	

ESD endoscopic submucosal dissection, *SD* standard deviation

*$p<0.05$

groups based on the time interval between ESD and subsequent surgery, with a cutoff of 12 weeks. Surgical procedure and the ratio of the length of the ESD scar to that of the resected mucosa were compared between the two groups (Table 4). The results showed no significant difference in this respect. The mean diameter of the resected mucosa in patients who underwent ESD was 48.3 mm, and the mean tumor size in the ESD-surgery group was 27.8 mm. Of note, the size of the resected mucosa in patients who underwent ESD was significantly larger than the tumor size in

Table 4 Relationship between surgical procedure and duration after ESD

	ESD-surgery group (n = 23)	The duration between ESD and subsequent surgery		p value
		≤ 12 weeks (n = 12)	> 12 weeks (n = 11)	
Tumor size (mm), mean ± SD	27.8 ± 14.8	28.4 ± 16.5	27.2 ± 13.5	0.847
Resected mucosal size at ESD (mm), mean ± SD	48.3 ± 21.6	49.4 ± 22.2	47.0 ± 12.7	0.590
ESD scar in surgical specimen (mm), mean ± SD	21.6 ± 9.2	22.6 ± 9.8	20.5 ± 8.7	0.750
The scar/resected mucosal size ratio, mean ± SD	0.49 ± 0.24	0.52 ± 0.26	0.45 ± 0.22	0.476
Type of gastrectomy, n (%)				0.311
Distal gastrectomy	8	4	4	
Total gastrectomy	3	3	0	
Proximal gastrectomy	12	5	7	

ESD endoscopic submucosal dissection, *SD* standard deviation

*p < 0.05

Table 5 Noncurative factors in the ESD-surgery group

Factors for noncurative resection (with overlap)	n	%
(1) Differentiated tumor with size > 30 mm		
Sm1 invasion (< 500 μm)	2	(8.7)
Ulceration	0	(0.0)
(2) Undifferentiated tumor		
Submucosal invasion	1	(4.3)
Size > 20 mm	0	(0.0)
Ulceration	0	(0.0)
(3) Presence of lymphatic invasion	8	(34.8)
(4) Presence of vascular invasion	8	(34.8)
(5) Sm2 or deeper invasion (≥ 500 μm)	20	(87.0)
(6) Horizontal margin was positive or could not be assessed	0	(0.0)
(7) Vertical margin was positive or could not be assessed	7	(30.4)

the surgery-only group (*p* < 0.001). However, no significant difference was observed in terms of tumor size between the surgery-only and ESD-surgery groups. In addition, the mean size of the ESD scar was 21.6 mm, which was less than one-half of the diameter of the excised mucosa.

The pathological factors influencing the diagnoses of noncurative resection among 23 patients in the ESD-surgery group are shown in Table 5. The most frequent cause of additional laparoscopic gastrectomy after ESD was sm2 invasion (87.0%). Lymphatic invasion, venous invasion, and positive vertical margin were recognized in 34.8%, 34.8%, and 30.4% of the patients, respectively.

As indicated, propensity score matching was performed to create comparable groups. The analysis of 21 matched patient pairs showed almost equal distributions of age, sex, BMI, and ASA-PS between the study populations. Even after matching, the frequency of performing LDG was significantly less in the ESD-surgery group than in the

surgery-only group (28.6% vs. 81.0%; *p* = 0.002; Table 2). Regarding dominant histological type, pT stage, and circumference of the tumor, there were significant differences as before matching.

As part of this study, patients were divided into two groups, LDG and non-LDG, to detect factors related to the decision about the type of gastrectomy. Univariate and multivariate analyses were performed involving the LDG and non-LDG groups (Table 6). A univariate analysis verified that the choice of LDG was associated with the dominant histological type (*p* = 0.022) and preoperative ESD (*p* = 0.001). In addition, a multivariate analysis also revealed preoperative ESD (OR 0.266, 95%CI 0.084–0.846) to be the only independent negative predictive factor for performing LDG.

Discussion

The primary purpose of this study was to evaluate the influence of ESD on the decision regarding the type of additional gastrectomy to conduct. In this investigation, we analyzed only patients with EGC confined to the UM boundary region. Generally, the type of gastrectomy is determined by the location of the lesion. However, our results demonstrated that when considering cases limited to EGC in the UM boundary region, preoperative ESD was the only independent factor influencing the selection of gastrectomy procedure. To the best of our knowledge, this is the first report to clarify the relationship between preoperative ESD and the choice of the type of additional gastrectomy.

Our study revealed significant differences in patients' backgrounds between the surgery-only group and the ESD-surgery group. The percentages of pT1b tumor and the differentiated-type tumor were higher in the ESD-surgery group than in the surgery-only group. These results were consistent with a previous study [12]. The authors mentioned this

Table 6 Predictive factors for LDG in patients with gastric cancer in the UM boundary region

	Univariate analysis			Multivariate analysis		
	OR	95% CI	p value	OR	95% CI	p value
Age (years), < 75 vs. ≥ 75	0.960	0.353–2.609	0.936			
Sex, female vs. male	2.589	0.962–6.966	0.066	1.554	0.494–4.889	0.451
BMI (kg/m^2), ≤ 23 vs. > 23	1.200	0.507–2.843	0.679			
ASA-PS, 1 vs. 2, 3	1.294	0.526–3.186	0.574			
Circumference, lesser curvature vs. other	2.178	0.836–5.676	0.107			
Tumor size (mm), ≤ 30 vs. > 30	0.500	0.197–1.269	0.141			
Dominant histological type, differentiated vs. undifferentiated	0.351	0.141–0.871	0.022*	1.331	0.423–4.191	0.625
Procedure, preoperative ESD vs. surgery only	0.200	0.072–0.552	0.001*	0.266	0.084–0.846	0.025*
pT, T1a/1b vs T2/3/4a	0.522	0.131–2.085	0.276			
pN, N0 vs. N1	0.600	0.147–2.441	0.358			
pStage, IA/IB vs. IIA/IIB	0.406	0.043–3.797	0.384			
Lymphatic invasion, negative vs. positive	0.460	0.117–1.810	0.209			
Venous invasion, negative vs. positive	0.564	0.164–1.942	0.360			

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *ASA-PS* American Society of Anesthesiologist physical status, *ESD* endoscopic submucosal dissection

*$p < 0.05$

because ESD was mainly performed among patients with absolute indications, which include the intramucosal and differentiated tumor types, while most patients diagnosed with T1a by ESD did not undergo surgery. In addition, the higher average age observed in the ESD-surgery group was similar to that observed in a previous report [12], possibly because of the biased treatment choice for older patients that would prefer minimal invasive endoscopic resection. As described, there were significant differences in patients' backgrounds; thus, we adjusted their characteristics using propensity score matching for analysis. The analysis after matching also revealed a relationship existed between ESD and type of additional gastrectomy chosen for EGC in the UM boundary region.

For EGC located in the upper third of the stomach, there are several surgical options available at this time. Conventionally, this type of case has been managed either by total or proximal gastrectomy. Patients with EGC in the upper third of the stomach usually undergo LTG or LPG, although available reports on postoperative quality of life and long-term outcomes after LTG or LPG are not as numerous as those evaluating patients post-LDG [23, 24]. In addition, laparoscopy-assisted subtotal gastrectomy (LsTG) with a very small remnant stomach, defined as LDG conducted for tumors located in the upper third of the stomach or tumors invading into the area, has been recently proposed as a procedure that can preserve the fundus [21]. Preserving the fundus maintains the secretion of ghrelin, which is mainly produced in the gastric fundic gland [25], and may better maintain the patient's nutritional status after gastrectomy.

Several studies have reported that LsTG offers a nutrition-related advantage over other procedures for EGC in the upper third of the stomach [15, 16]. However, future long-term observations and the further accumulation of evidence are warranted to determine the superiority of the procedure for EGC in the proximal stomach. Considering oncological safety, any of the LDG procedures including LsTG, LPG, and LTG appear to be safe for EGC in the upper third of the stomach, although the range of lymph node dissection varies with each surgical procedure [14, 26, 27]. In this study, cases of EGC located in the proximal one-half of the middle third of the stomach were also included in the analysis because the conduct of ESD in these individuals could affect the upper third of the stomach given the size of the excised mucosa at the time of ESD and subsequent scarring after ESD.

Limited information is available regarding the excised mucosa diameter for the lesion in ESD and the size of the scar in surgical specimens. In our study, the resected mucosa in ESD was a mean of 20.5 mm larger than the lesion diameter. In addition, the diameter of the scar in surgical specimens was a mean of 26.7 mm smaller than the resected specimens in ESD, which was less than one-half of the resected mucosa size. Kakushima et al. [28] investigated the healing process of gastric artificial ulcers after ESD and reported that a remarkable size reduction was observed at 4 weeks, leading to the observation of less than one-half of the initial ulcer size, which was almost the same as was noted our results. Artificial ESD ulcers have less inflammation and fibrosis of the local area than ordinary peptic ulcers [29] such that the surrounding mucosa converges due to the

contraction of the stomach wall [30]. Because the resection of the mucosa is larger than the lesion and due to contraction of the resected area, designing a gastric resection line on the proximal side of the lesion as part of additional surgery becomes difficult. As a result, the choice of LDG could have been limited after ESD. Based on our results, the time interval between ESD and subsequent surgery did not affect the choice of surgical procedure. However, ulcer healing was affected by time; this phenomenon was likely attributable to the fact that surgery was performed on an average of 12 weeks after ESD, which was considered after complete ulcer healing. Our results suggested that LDG could have been selected if surgery was primarily performed without ESD. Although the superiority of procedures over each other is controversial, endoscopists and surgeons should recognize that the type of additional resection procedure could be affected by ESD prior to moving forward with performing ESD as a primary treatment among patients with EGC in the UM boundary region.

This study had several limitations. First, it was a retrospective single-institution study with a relatively small population. Second, various factors were involved in the decision of the procedure, and detailed indications for each gastrectomy option likely differ among facilities. Therefore, it lacked clear objective indicators for decision-making for additional gastrectomy procedures. The present study may only reflect the trend of treatment choices at a single hospital. For instance, LPG, which is more effective than LDG in dissecting lymph nodes in no. 4sb and 4sa areas, was preferred owing to the greater number of lesions observed in the greater curvature in the ESD-surgery group. Further, depending on the institution, the array of possible procedures is limited to different degrees. LPG and LsTG may not be performed without intraoperative upper gastrointestinal endoscopy or frozen section analysis. Conversely, the strength of this study is that the included patients underwent treatment with relatively uniform indication criteria and procedures because the key members involved in the surgery and treatment decisions did not change during the study period. However, this makes it difficult to generalize our results at other facilities.

In conclusion, we found that patients who underwent additional resection after ESD for EGC in the UM boundary region were more likely not to undergo LDG in comparison with those without ESD. Although the superiority of LDG or LPG/LTG is controversial, our results suggested that ESD used for EGC in the UM boundary region had an impact on the decision of procedure in the case of additional resection.

Compliance with ethical standards

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