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Endoscopic resection of colorectal circumferential and near-circumferential laterally spreading lesions: outcomes and risk of stenosis

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Abstract

Purpose Almost any colorectal superficial neoplastic lesion can be treated by endoscopic resection (ER) but very little is known about outcomes of ER leaving circumferential or near-circumferential mucosal defects. We report the outcomes of ER leaving $\geq$ 75% circumferential mucosal defects performed in a western expert centre.

Methods Five hundred eighty-seven ERs of large colorectal lesions $\geq$ 20 mm were grouped according to the extent of the mucosal defect and comparisons made between those with < 75% and $\geq$ 75% defects. Independent predictors of stenosis were identified.

Results Forty-seven patients had ER leaving $\geq$ 75% circumference defect, most located at or distal to the rectosigmoid, with $\geq$ 90% defects in 5 and 100% in 11. There were no significant colonic muscle injuries in patients with $\geq$ 75% defect and no differences in post-procedure bleeding (OR 1.6, 95% CI 0.2–13.7, $p = 0.64$) between patients with $\geq$ 75% and < 75% defects. Stenosis developed in 9 patients. $\geq$ 90% circumference defect was the only independent risk factor for stenosis (OR 286, $p < 0.001$). Three of 4 patients with asymptomatic stenosis had successful expectant management. The remainder were treated with dilatation. Recurrence was more likely in those with $\geq$ 75% defect (OR 7.9, 95% CI 3.8–16.4, $p < 0.001$) but was managed with further ER in all but 2 cases.

Conclusion ER of colorectal lesions resulting in defects $\geq$ 75% of the luminal circumference is challenging but safe and effective when performed in an expert centre. The only independent predictor of stenosis is $\geq$ 90% circumference defect but some patients improve with expectant management; therefore, pre-emptive intervention may not be warranted.

Keywords Colorectal endoscopic resection · Circumferential adenoma · Near-circumferential adenoma · Endoscopic submucosal dissection · Endoscopic mucosal resection

Introduction

Experience in endoscopic resection of large colorectal superficial neoplastic lesions has advanced to such an extent that almost any lesion without massive submucosal invasion can be treated by curative resection [1]. The safety and efficacy of expert colorectal endoscopic resection (ER) has been established for large lesions in general [2]. In recent years, ER for lesions with characteristics once considered contraindications for ER, such as near-circumferential adenomas, has been reported [3–6]. Although the true incidence is unclear, many patients with large colorectal adenomas without invasive cancer are still treated with radical surgery [7]. It is likely that extremely challenging lesions, such as circumferential or near-circumferential adenomas, form a high proportion of those treated surgically. It is therefore imperative to establish the safety and efficacy of ER of such lesions. However, even in tertiary referral centres, the overall incidence of circumferential or near-circumferential adenomas is small and there are very few published data on ER of these lesions. Almost all the available data is from Japanese expert centres and relates exclusively to the use of endoscopic submucosal dissection

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(ESD) [3–5]. Although ESD is increasingly used in western expert centres, due to the complexity of ER of near-circumferential lesions, it is likely that even these units would employ a combination of piecemeal endoscopic mucosal resection (pEMR) and ESD. Only one western unit has reported outcomes from ER of circumferential and near-circumferential colorectal adenomas, exclusively using pEMR for resection [6].

Establishing the short- and long-term outcomes of ER of circumferential or near-circumferential lesions will help define treatment goals, inform patient discussions about their expected course for recovery and the likelihood of further treatment of complications such as stenosis and recurrence, and inform general endoscopists to help guide referral to an expert centre for assessment for ER before surgery.

We aimed to report the outcomes of ER of large colorectal neoplastic lesions leaving circumferential or near-circumferential mucosal defects performed in a western expert centre.

Methods

Setting

Our interventional endoscopy unit is a regional tertiary referral service for endoscopic resection of colorectal lesions. We retrospectively analysed all patients identified from a prospectively maintained database of resections between January 2011 and June 2018. Only endoscopic resections of lesions 20 mm or larger were included. Standard polypectomy and basic EMR are widely performed in the region, but patients were referred to our service if the endoscopist performing the index procedure felt the lesion was beyond the capabilities of the referring institution as a result of large size, difficult location, challenging morphology or previous failed attempts at resection.

Procedures

Our approach to assessment and resection has been previously described [8, 9]. Procedures were generally performed using conscious sedation and analgesia with intravenous midazolam and fentanyl administered by the endoscopist and patients were discharged home on the day of the procedure.

All lesions were assessed prior to resection with chromoendoscopy using indigo carmine and magnification colonoscopy (colonoscopes: CF-H260AZL Olympus, Tokyo, Japan, and EC-600Z, Fujifilm, Düsseldorf, Germany) and classified according to Kudo pit pattern and vascular pattern (Showa classification) [10, 11]. Selected lesions were also evaluated with variable high-frequency miniprobe ultrasound (Fujifilm) to evaluate for submucosal

invasion. All lesions were considered for endoscopic resection except those with invasive cancer > T1 (Kudo type Vn pit pattern, sparse vascular pattern, at least muscularis propria invasion on high-frequency miniprobe colonoscopic ultrasound) for which surgery was advised. The techniques used for resection included ESD, hybrid ESD and EMR or piecemeal EMR (pEMR). The decision for resection technique was based on the patient and lesion characteristics specific to each, bearing in mind our general considerations when undertaking ER [12]. In brief, depending on technical feasibility, ESD or hybrid ESD is preferred where there is a suspicion of, or a high risk of, an area containing invasive cancer to either resect the lesion en bloc for accurate pathological staging, or at least resect the highest risk area, such as a dominant nodule in a laterally spreading tumour (LST) mixed-nodular type, in one piece. Hybrid ESD is also used to aid complete resection in cases with profound submucosal fibrosis as a result of prior heavy manipulation (failed attempt at resection or heavy biopsy sampling). pEMR is considered for LST granular homogeneous type as these have a low risk (< 1%) of harbouring covert invasive cancer.

EMR and pEMR were performed using a sequential injection and resection technique. The submucosal injection consisted of succinylated gelatine (Gelofusine; B. Braun, Crissier, Switzerland) with adrenaline diluted to 1:100,000 and dyed with methylene blue or indigo carmine. A variety of snare types as appropriate to the lesion were used. ESD was performed using an Olympus PCF Q260JL with ST distal hood (Fujifilm) and the FlushKnife (Fujifilm). In brief, a standard technique was usually employed consisting of a mucosal incision on the anal side of the lesion, trimming and flap creation followed by submucosal dissection under the lesion. The mucosal incision was then completed around the lesion. Hybrid ESD was used to aid resection of some previously heavy manipulated lesions and consisted of variable ESD dissection to aid resection or snare capture of areas of submucosal fibrosis. The ERBE VIO 300D electrosurgery device (Erbe Elektromedizin, Tübingen, Germany) was used for all procedures with appropriate settings depending on the resection technique. After resection, lesions were retrieved and submitted for histopathological analysis. The resection bed was routinely examined again using magnification chromoendoscopy for any residual polyp. For lesions with profound submucosal fibrosis, argon plasma coagulation (APC) was sometimes used as an adjunctive measure after resection of visible adenoma (not to ablate visible residual tissue), although this was dependent on the endoscopist's preference at the time of resection.

Patients underwent surveillance endoscopy at 3–6 months and 12 months, and thereafter were placed on a surveillance programme as per national guidelines for adenoma surveillance if appropriate [13].

Data collection and definitions

Data was collected on patient demographics, lesion characteristics, details of the resection procedure, histopathology findings, complications, recurrence and subsequent treatments.

Lesions are measured using the known size of an opened snare prior to resection or directly once pinned out after en bloc resection. The extent of the circumferential defect is estimated as a percentage of the full circumference and routinely recorded in our standard reporting for ER. Lesions were grouped for comparison according to the extent of the mucosal defect in the following categories: < 75%, 75–89%, 90–99% and 100%.

Stenosis at the site of resection was defined as narrowing of the lumen of sufficient severity to prevent passage of a 11.8-mm-diameter colonoscope (PCF Q260JL, Olympus), regardless of symptoms. Treatment of stenosis was decided on an individual basis.

Invasive cancer was defined as invasion through the muscularis mucosa. For invasive cancer, invasion ≥ 1000 μm from the muscularis mucosa was deemed *massive submucosal invasion*, generally considered an indication for radical surgery [14]. Recurrence or residual adenoma for this study was defined as any evidence of adenoma occurring at the scar from previous ER at any surveillance endoscopy (examined with magnification chromoendoscopy and narrow band imaging (NBI)). Post-procedure bleeding was defined as haematochezia resulting in any presentation to an emergency department or admission to hospital, regardless of re-intervention. Any muscle (muscularis propria) injury requiring additional non-routine management, including unplanned extended antibiotic treatment (routine antibiotic prophylaxis is not given), unplanned admission to hospital for observation and/or surgery, was considered a *significant muscle injury*.

Successful ER was defined as apparent complete clearance of adenoma by ER after examination of the resulting defect with magnification chromoendoscopy and NBI.

Statistical analysis

Results are reported using means and standard deviation for continuous variables and frequencies for categorical variables. Comparisons were made using t test to compare means and χ^2 test to compare categorical variables. Exploratory univariate analysis was used to identify factors associated with stenosis and significant factors were subjected to multiple logistic regression to identify independent associations.

Ethical approval for this study was granted by the National Research Ethics Committee.

Results

Initial ER was attempted for 587 large colorectal superficial neoplastic lesions ≥ 20 mm. At least massive submucosal invasive cancer was discovered in 30 and ER was initially successful in 552 of the remaining 557 (99.1%). The mean patient age was 71.3 ± 11.5 years and 333 (57%) patients were male. The mean lesion size was 53.4 mm (median 45 mm, range 20–160 mm). Forty-seven patients had ER leaving a mucosal defect ≥ 75% of the luminal circumference with a mucosal defect 75–89% in 31, 90–99% in 5 and 100% in 11. Table 1 shows a comparison of the patient and lesion characteristics of these patients compared to those with ER leaving a mucosal defect < 75%.

The mean size of lesions leaving a defect ≥ 75% of the luminal circumference was 109 mm versus 48.6 mm for those with lesser circumferential involvement ($p < 0.001$) and there were significant differences in lesion location with the vast majority of defects ≥ 75% circumference located at and below the rectosigmoid. Figure 1 shows examples of the challenges with ER of these lesions. All lesions ≥ 75% circumference were granular laterally spreading tumours and were significantly more likely to have been subjected to attempts at resection or extensive tissue sampling (≥ 6 biopsy samples) prior to referral (OR 2.4, 95% CI 1.3–4.4, $p = 0.006$). For those successfully resected, lesions leaving ≥ 75% circumference defects were more likely to require a two-stage resection (OR 11.6, 95% CI 3.0–45.2, $p < 0.001$), although only 4 patients required this, and overall, these lesions were less likely to have successful ER (OR 0.1, 95% CI 0.0–0.7, $p = 0.005$), although ER was successful in over 95%.

There were no significant differences between patients with mucosal defects ≥ 75% circumference and those with lesser defects in rates of intraprocedural (OR 1.8, 95% CI 0.9–3.7, $p = 0.08$) or post-procedure bleeding (OR 1.6, 95% CI 0.2–13.7, $p = 0.64$). Although muscle injury occurred more frequently during resection for those with defects ≥ 75% circumference, these were almost always of no clinical relevance. There were no significant muscle injuries in patients with ≥ 75% circumference defect and none required surgical intervention.

Stenosis at the area of ER occurred almost exclusively in patients with ≥ 90% circumference defects (OR 125.6, 95% CI 15.3–1033, $p < 0.001$) with only 1 patient with a defect < 75% circumference developing stenosis. In patients with ≥ 75% circumference defects who had completed at least the first surveillance endoscopy, both overall recurrence (OR 7.9, 95% CI 3.8–16.4, $p < 0.001$) and the requirement for surgery for recurrence (OR 12.8, 95% CI 1.7–93.9, $p = 0.001$) were more likely, although only 2 patients have required surgery for recurrent adenoma not amenable to further ER (both right hemicolectomies) after a mean follow-up of 17 months. No patients with rectal lesions leaving ≥ 75% circumference

Table 1 Comparison of the patient and lesion characteristics of those leaving mucosal defects after ER >=75% compared to those leaving a mucosal defect < 75% (statistically significant *p* values are italicized)

	Extent of mucosal defect		*p* value
	< 75%	≥ 75%	
Age, mean	71.0 years	74.6 years	*0.04*
Size, mean	48.6 mm	109.0 mm	*< 0.001*
Location			
Right colon	215 (39.8%)	5 (10.6%)	*< 0.001*
Left colon	131 (24.3%)	8 (17.0%)	
Rectosigmoid	48 (8.9%)	9 (19.2%)	
Rectum	129 (23.9%)	11 (23.4%)	
Anorectum	17 (3.2%)	14 (29.8%)	
Morphology			
Is/Isp	113 (20.9%)	0 (0%)	*< 0.001*
LST G homogeneous	263 (48.7%)	12 (25.5%)	
LST G mixed-nodular	140 (25.9%)	35 (74.5%)	
LST non-granular	24 (4.4%)	0 (0%)	
Kudo pit pattern*			
Types I–II	23 (4.3%)	0 (0%)	0.28
Types III–IV	486 (90.0%)	43 (91.5%)	
Type V	31 (5.7%)	4 (8.5%)	
Vascular pattern*			
Normal/faint	22 (4.1%)	0 (0%)	0.34
Adenoma	501 (92.8%)	46 (97.9%)	
Cancer	17 (3.2%)	1 (2.1%)	
Heavy manipulation[†]			
Yes	244 (45.2%)	31 (66.0%)	*0.006*
No	296 (54.8%)	16 (34.0%)	
Resection technique			
EMR/pEMR	395 (73.2%)	30 (63.8%)	0.17
ESD/hybrid ESD	145 (26.9%)	17 (36.2%)	
2-stage ER required[††]			
Yes	5 (1.0%)	4 (10.3%)	*< 0.001*
No	508 (99.0%)	35 (89.7%)	
Successful ER[††]	513 (99.4%)	39 (95.1%)	*0.005*
Adjunctive APC			
Yes	79 (14.6%)	13 (27.7%)	*0.02*
No	461 (85.4%)	34 (72.3%)	
Intraprocedural bleeding			
Yes	84 (15.6%)	12 (25.5%)	0.08
No	456 (84.4%)	35 (74.5%)	
Post-procedure bleeding			
Yes	7 (1.3%)	1 (2.1%)	0.64
No	533 (98.7%)	46 (97.9%)	
Muscle injury			
Yes	17 (3.2%)	6 (12.8%)	*0.001*
No	523 (96.9%)	41 (87.2%)	
Significant muscle injury			
Yes	7 (1.3%)	0 (0%)	0.43

Table 1 (continued)

	Extent of mucosal defect		*p* value
	< 75%	≥ 75%	
No	533 (98.7%)	47 (100%)	
Unplanned admission			
Yes	26 (4.8%)	5 (10.6%)	0.09
No	514 (95.2%)	42 (89.4%)	
Stenosis[†††]			
Yes	1 (0.2%)	8 (19.0%)	*< 0.001*
No	534 (99.8%)	34 (81.0%)	
Level of invasion			
Mucosal	497 (92.0%)	41 (87.2%)	*0.02*
Superficial submucosal	19 (3.5%)	0 (0.0%)	
Massive submucosal	24 (4.4%)	6 (12.8%)	
Recurrence			
Yes	50 (11.8%)	18 (51.4%)	*< 0.001*
No	375 (88.2%)	17 (48.6%)	
Surgery for recurrence			
Yes	2 (0.5%)	2 (5.7%)	*0.001*
No	423 (99.5%)	33 (94.3%)	

*Highest/most dysplastic area recorded

[†] Prior attempt at endoscopic resection or ≥ 6 biopsy samples

[††] Excluding massive submucosal invasive cancer

[†††] Excluding unsuccessful ER

defects without massive submucosal invasion have had radical surgery.

Covert massive submucosal (or deeper) invasive cancer was significantly more likely in lesions with ≥ 75% circumference defects (OR 3.1, 95% CI 1.2–8.1, $p < 0.01$).

Nine patients developed stenosis: 1 with a mucosal defect < 75% circumference and the remainder with ≥ 90% circumference defects. Four patients were asymptomatic, 1 had mild symptoms of frequency of defaecation and 4 had significant symptoms of discomfort, pain, frequency of defaecation or rectal bleeding, although none had obstructive symptoms. Dilatation under anaesthesia was performed for 3 patients who could not tolerate standard balloon dilatation (all symptomatic) and balloon dilation performed for 3 patients, 2 of whom were not symptomatic. Expectant management with laxatives was pursued for 3 patients (2 asymptomatic and 1 with mild symptoms), all of whom improved and were able to have a standard endoscopy passed at subsequent surveillance. One patient has subsequently undergone low anterior resection for invasive cancer, one is awaiting further dilatation and the rest have been successfully treated.

Table 2 shows a comparison of patients who developed stenosis compared to those who did not. Stenosis occurred significantly more frequently in patients with larger lesions, more extensive circumferential mucosal defects, in lesions
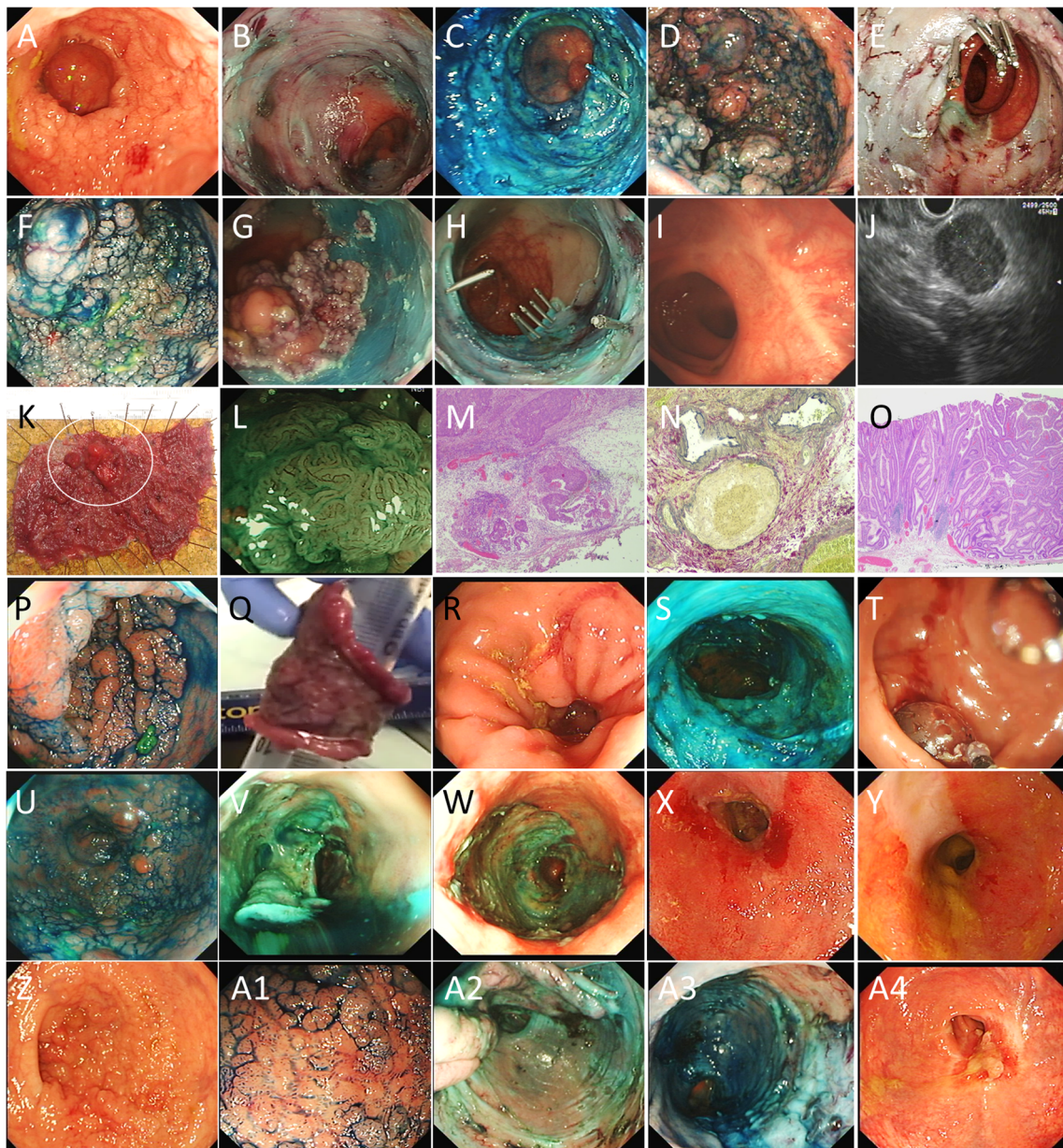
Fig. 1 Examples of the challenges associated with circumferential and near-circumferential laterally spreading tumours. A two-stage endoscopic resection is more likely required, although uncommon, in circumferential or near-circumferential LSTs, as it was in these two lesions, (A–C) and (D–E). (F–O) Covert invasive cancer is more commonly encountered in these lesions. The lesion in (F–J) was successfully resected by pEMR revealing a T1 invasive cancer with massive submucosal invasion. The patient refused surgery and was observed intensely with magnification, MRI and ultrasound. The luminal scar remained free from recurrence (I), but after more than 2 years follow-up, extraluminal recurrence in the mesorectum was diagnosed and confirmed with guided biopsy (J). En bloc resection or avoiding sectioning a dominant nodule (K, white circle) is important as, despite apparent benign surface characteristics on magnification, a poorly differentiated invasive cancer with massive invasion and lymphatic invasion is found under the nodule (M–N).

Large areas of the lesion contain low-grade dysplasia (O); therefore, biopsy sampling is misleading. Post-surgery the staging was T1 N1. (P–R) and (S–T) show ESD and pEMR of LSTs which developed stenosis. Stenosis occurs almost exclusively among lesions with > 90% mucosal defect and can be treated by balloon dilatation (T), although can be asymptomatic, as it was in this patient, and dilatation may not be necessary. (U–A4) A high proportion of circumferential or near-circumferential LSTs had been subjected to prior attempts at resection, resulting in profound fibrosis clearly visible in (U–V) and (A1–A2). Hybrid ESD is useful to achieve clearance in these challenging cases, but there is persistent stenosis after dilatation on successive surveillance endoscopies in (X–Y), and narrowing but not stenosis with no recurrence in (A4) after 12 months of surveillance (the polypoid tissue was granulation on magnification, confirmed with biopsy)

extending to the anal canal and where intraprocedural bleeding occurred. However, multiple logistic regression (Table 3)

revealed only circumferential extent of the mucosal detect ≥ 90% was an independent risk factor for stenosis (OR 286,

Table 2 Univariate analysis of factors associated with stenosis (statistically significant p values are italicized)

	Stenosis	No stenosis	p value
Age			
< 70 years	2 (0.8%)	242 (99.2%)	0.08
70–79 years	2 (1.0%)	192 (99.0%)	
≥ 80 years	5 (3.6%)	134 (96.4%)	
Sex			
Male	5 (1.5%)	323 (98.5%)	0.94
Female	4 (1.6%)	245 (98.4)	
Size			
20–100 mm	2 (0.4%)	542 (99.6%)	< 0.001
101–140 mm	4 (16.7%)	20 (83.3%)	
≥ 140 mm	3 (33.3%)	6 (66.7%)	
Extent of mucosal defect			
< 75%	1 (0.2%)	534 (99.8%)	< 0.001
75–89%	0 (0%)	29 (100%)	
90–99%	2 (40%)	3 (60%)	
100%	6 (75%)	2 (25%)	
Location			
Right colon	0 (0%)	219 (100%)	< 0.001
Left colon	1 (0.7%)	135 (99.3%)	
Rectosigmoid	2 (3.8%)	50 (96.2%)	
Rectum	1 (0.7%)	139 (99.3%)	
Anorectum	5 (16.7%)	25 (83.3%)	
Prior manipulation			
Heavy	7 (2.6%)	264 (97.4%)	0.06
Light	2 (0.7%)	304 (99.3%)	
Technique			
EMR/pEMR	4 (1.0%)	414 (99%)	0.06
ESD/hybrid ESD	5 (3.1%)	154 (96.9%)	
Adjunctive APC			
Yes	2 (2.2%)	89 (97.8%)	0.60
No	7 (1.4%)	479 (98.6%)	
2-stage ER			
Yes	0 (0%)	9 (100%)	0.70
No	9 (1.6%)	559 (98.4%)	
Intraprocedural bleeding			
Yes	5 (5.3%)	90 (94.7%)	0.001
No	4 (0.8%)	478 (99.2%)	
Post-procedure bleeding			
Yes	0 (0%)	8 (100%)	0.72
No	9 (1.6%)	560 (98.4%)	
Muscle injury			
Yes	1 (4.5%)	21 (95.5%)	0.25
No	8 (1.4%)	547 (98.6%)	

Table 3 Results of multivariate logistic regression of factors associated with stenosis (statistically significant p values are italicized)

	Odds ratio (95% CI)	p value
Size		
20–100 mm	ref	–
101–140 mm	21.6 (0.8–587)	0.07
≥ 140 mm	26.7 (0.4–2031)	0.14
Extent of mucosal defect		
< 90%	ref	–
90–100%	286 (16.6–4958)	< 0.001
Location		
Proximal to rectum	ref	–
Rectum	0.2 (0.0–22.3)	0.53
Anorectum	0.8 (0.0–17.5)	0.87
Intraprocedural bleeding	1.2 (0.1–21.5)	0.89

of the circumference. Asymptomatic stenosis was noted at the first surveillance but was managed expectantly and improved spontaneously allowing free passage of the colonoscope at subsequent surveillance with no recurrence of the adenoma or stenosis after 32 months of follow-up.

Discussion

The boundaries of colorectal ER have rapidly expanded to the extent that virtually all lesions without invasive cancer are considered for ER in expert centres [1]. However, there are very few reports on outcomes of lesions at the extremes of the spectrum of ER, such as those with extensive or complete circumferential involvement which in the past were routinely referred for surgery. Defining these outcomes is all the more important given that, even in the current era of advanced ER, patients with large colorectal lesions without invasive cancer are still subjected to radical surgery [7, 15].

Almost all reports on outcomes of ER resulting in near or total circumferential defects and the risk of stenosis originate from Japanese expert centres focusing solely on ESD, some focusing exclusively on rectal tumours [3–5]. Only one other western centre has reported on ER of near or total circumferential lesions [6].

We found that the vast majority of lesions resulting in ≥ 75% circumference defects after ER are located at or distal to the rectosigmoid, although they occur throughout the colon. Although rarely necessary, these lesions were more likely to require two-stage resections. However, the reason for this was almost always concern about patient tolerance on the part of the endoscopist and was not based on any objective measure. As such, the practice has become very infrequent as experience has increased. Of 4 patients with ≥ 75% circumference defects who required two-stage resection, only 1 was performed in the last 3 years in a patient with an extensive LST

95% CI 16.6–4958, $p < 0.001$). All except one patient who developed stenosis had ≥ 90% circumference defect. This patient had ESD of a 90-mm rectosigmoid LST occupying 50%

involving the ileocolic anastomosis after a right hemicolectomy. Technical success of ER is achieved less frequently for these extreme lesions, although it is still achieved in over 95% versus 99% of other lesions.

Importantly, no major morbidity resulted from these complex ERs. Although muscle injury occurred more frequently in ER resulting in ≥ 75% circumference defects, these were treated with endoscopic clips, a largely routine practice, and were of no clinical relevance. No patients required any additional treatment or suffered any adverse sequelae. Neither intraprocedural nor post-procedure bleeding was significantly more frequent in these ERs compared to those with less extensive mucosal defects.

Stenosis occurred in 9 patients, all with lesions located at or distal to the rectosigmoid. In keeping with other studies, 8 of 9 patients had ≥ 90% circumference mucosal defects which was the only independent predictor of stenosis in our study [3, 4]. However, 1 patient with only 50% circumference defect at the rectosigmoid developed an asymptomatic stenosis. The patient had diverticulosis and Tutticci et al. have postulated diverticular disease with luminal narrowing may play a role in the development of stenosis [6]. The patient had also received radiotherapy for prostate cancer in the past which may have contributed to the development of stenosis with a less extensive defect. Also, in keeping with other studies, we found that several patients with stenosis were asymptomatic [3–6]. Interestingly, we found that stenosis in such patients generally improves spontaneously with evident improvement at subsequent surveillance endoscopy and none progressed to develop symptoms. This may be due to an "auto-dilatation" effect with the regular passage of faeces and maturation of the scar. Hayashi et al. noted that the incidence of stenosis could be influenced by the length of the first surveillance period explaining some of the variation between studies in centres with differing surveillance protocols [3, 4]. It is possible that some patients may develop asymptomatic stenosis which resolves or improves by the time of the first surveillance if this is not performed too soon after ER. Our findings would support this and indicate that pre-emptive dilatation need not be performed unless the patient is symptomatic. Most stenoses in our series, whether symptomatic or not, were detected within 3 months of ER.

Recurrence of adenoma after ER resulting in ≥ 75% circumference defect occurred frequently, in keeping with Tutticci et al.'s results [6]. The vast majority of these cases were successfully treated with further ER. Given that 68% of these patients had already been subjected to prior heavy manipulation in the form of attempts at resection or extensive injudicious biopsy sampling, these are already very challenging resections and this is a satisfactory outcome. However, 2 patients required a right hemicolectomy for recurrence: 1 with a profoundly scarred recurrence embedded in the ileocaecal valve and the other with a large recurrence at the hepatic flexure with an unstable and difficult scope position to achieve

ER. It is important to note that the majority of these extensive circumferential lesions occur at or distal to the rectosigmoid and that no patients without invasive cancer required rectal resection which is associated with significant morbidity [16].

In contrast to Tutticci et al. who did not encounter any invasive cancer, we found that covert massive submucosal invasion was more likely to be encountered in these lesions (OR 3.1, $p < 0.01$). This is unlikely to be a result of inadequate interrogation of the lesions as we routinely use magnification chromoendoscopy for lesion assessment and our findings are in keeping with studies from Japanese experts who found massive submucosal invasion in 4 of 22 (18%) lesions involving ≥ 90% of the circumference and 9 of 69 patients with rectal tumours with ≥ 75% circumference defect [3, 4].

We recognise several limitations to the current study. This is a retrospective study subject to selection bias. However, all ER over the study period were included and there were no patients with lesions ≥ 75% of the luminal circumference over the study period without obvious endoscopic features of invasive cancer who were denied an attempt at ER. All ER were performed at a tertiary referral unit and the results are not generalizable, but we believe that all such complex lesions should be referred to expert centres without injudicious prior attempts at ER or biopsy sampling, as is so often the case in our experience. We used several techniques to achieve ER including pEMR, ESD and hybrid ESD. However, we believe this reflects modern western expert practice where increased adoption of ESD is taking place. Few, if any, centres outside of Japan would exclusively use ESD to resect circumferential or near-circumferential LSTs. Some would argue against the use of ESD techniques but we believe they are invaluable in certain situations, such as hybrid ESD for profound fibrosis to help achieve complete clearance or ESD to achieve en bloc resection or resection in one piece of high-risk areas which may contain invasive cancer, especially in rectal lesions. This is highlighted in many of the examples in Fig. 1. Finally, this study involves relatively few patients with such extensive lesions. However, these lesions are not frequently encountered which underscores the importance of reporting the outcomes of ER, particularly in western practice, in the few centres performing these procedures.

We have previously reported outcomes from this cohort of ER of massive adenomas (≥ 80 mm) [17]. Although many circumferential or near-circumferential lesions will be ≥ 80 mm, we believe the technical challenges and considerations in these two groups are different, and therefore outcomes should be reported separately. This is evidenced by other groups with considerable experience in ER of large adenomas reporting outcomes for near-circumferential resections separately [3, 4, 6]. The vast majority of massive adenomas are not circumferential or near-circumferential but the level of technical difficulty in performing ER of near-circumferential lesions is considerable (many experts once considered circumferential extent a contraindication to ER),

and therefore the risk of complications is higher. Furthermore, risks such as stenosis appear to be unique to these lesions; therefore, a comparison of outcomes is warranted.

Conclusion

ER of extensive colorectal superficial neoplastic lesions resulting in defects ≥ 75% of the luminal circumference is safe and effective when performed in an expert centre. Stenosis occurs almost exclusively after ER leaving defects ≥ 90% of the circumference and extent of the circumferential defect is the only independent predictor of stenosis. However, some patients who develop stenosis remain asymptomatic and improve with expectant management; therefore, pre-emptive intervention may not be warranted. Recurrence occurs frequently but successful further ER is almost always achieved.

Compliance with ethical standards

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