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Effectiveness and safety of endoscopic submucosal dissection using the pocket creation method in the Japanese population: a systematic review and meta-analysis

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ABSTRACT

Background and study aims Endoscopic submucosal dissection (ESD) is a standard method for minimally invasive resection of superficial gastrointestinal tumors. The pocket creation method (PCM) facilitates ESD regardless of location in the gastrointestinal tract. The aim of this systematic review and meta-analysis is to evaluate the effectiveness and safety of ESD for superficial neoplasms in the upper and lower gastrointestinal tract comparing the PCM to the non-PCM.

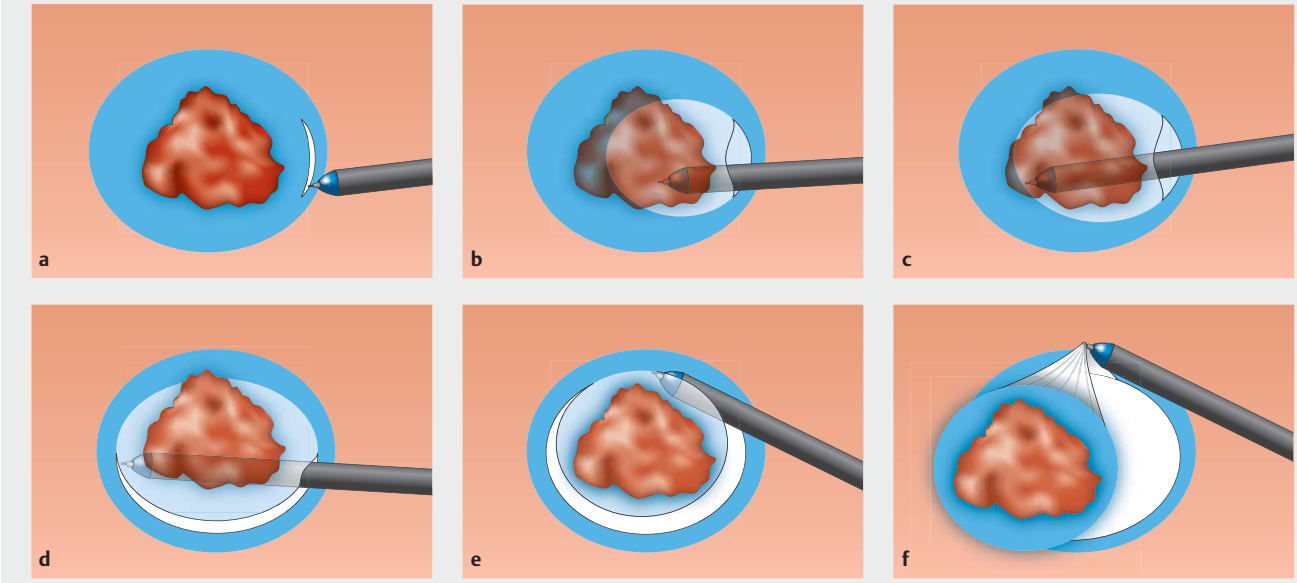
Methods Randomized controlled, prospective, and retrospective studies comparing the PCM with the non-PCM were included. Outcomes included en bloc resection, R0 resection, dissection speed, delayed bleeding and perforation. Pooled odds ratios (ORs) with 95 % confidence intervals (CIs) using the Mantel-Haenszel random effect model were documented.

Results Eight studies including gastric, duodenal, and colorectal ESD were included. The en bloc resection rate was significantly higher in the PCM group than the non-PCM group (OR 3.87, 95 %CI 1.24–12.10 $P=0.020$). The R0 resection rate was significantly higher in the PCM group than the non-PCM group (OR 2.46, 95 %CI 1.14–5.30, $P=0.020$). The dissection speed was significantly faster in the PCM group than the non-PCM group (mean difference 3.13, 95 % CI 1.35–4.91, $P<0.001$). The rate of delayed bleeding was similar in the two groups (OR 1.13, 95 %CI 0.60–2.15, $P=0.700$). The rate of perforation was significantly lower in the PCM group than the non-PCM group (OR 0.34, 95 %CI 0.15–0.76, $P=0.009$).

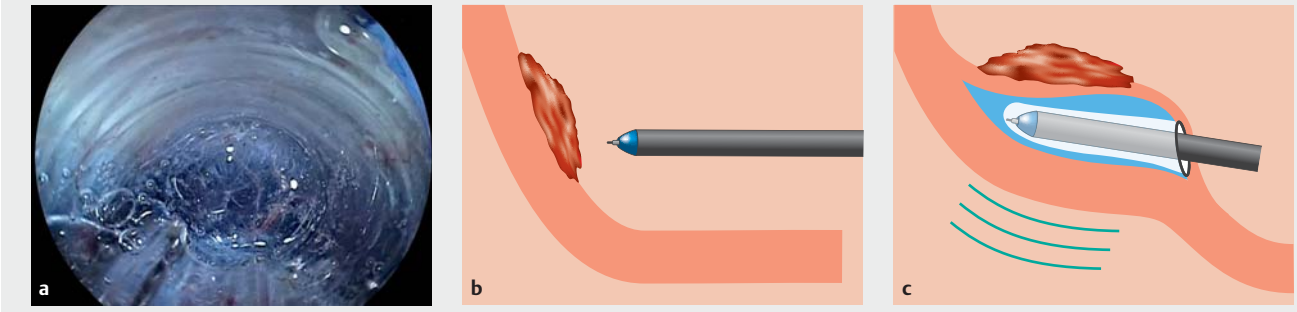
Conclusions The PCM facilitates high-quality, fast and safe colorectal ESD. Further studies are needed regarding the utility of PCM in ESD of the upper gastrointestinal tract.

Introduction

Endoscopic submucosal dissection (ESD) became the gold standard for the minimally invasive resection of superficial gastrointestinal tumors. The difficulty associated with this technique is largely influenced by the location of the tumor. An R0 resection, meaning an en bloc resection with negative margins, is mandatory for high-quality ESD regardless of the tissue resected. Positive vertical margins can severely limit the clinical significance of ESD. To achieve an R0 resection, stabilized endo-



▶ **Fig. 1** Procedure for the pocket creation method (PCM). **a** Minimal mucosal incision followed by submucosal dissection allowing the tip of a conical hood on the tip of the endoscope to enter the submucosa. **b** Extending the pocket by dissecting the submucosa. **c** Dissecting under the lesion without a circumferential incision. **d** Opening the pocket from the gravity side. **e** Opening the pocket on the non-gravity side. **f** Completion of en bloc resection.



▶ **Fig. 2** Advantages of the pocket creation method (PCM). **a** Endoscopic view showing the well-visualized submucosa in the pocket. The conical transparent hood naturally provides both traction and counter traction to stretch the submucosal tissue. **b** Vertical approach against the lesion. **c** The PCM changes a vertical to a tangential approach by creating the pocket. The fixed tip of the endoscope is less influenced by cardiopulmonary movement.

scopic maneuvering is important even in difficult locations. Endoscopic mucosal resection (EMR) is not useful for the resection of large superficial gastrointestinal tumors that sometimes have severe submucosal fibrosis, and EMR of such tumors is associated with an increased risk of perforation and positive vertical margins. ESD is a more sophisticated technique than EMR [1]. In difficult locations, vertical and/or distant approaches are sometimes inevitable, and ESD without clear visualization of the submucosa may result in damage to the muscularis or tumor.

We first reported the pocket creation method (PCM) to facilitate ESD [2]. The PCM is useful to achieve an en bloc resection regardless of location throughout most of the gastrointestinal tract. In summary, the PCM begins with a minimal mucosal incision at least 1 cm from the edge of a superficial lesion. Subsequently, several shallow dissecting passes enable the tip of the endoscope to enter the submucosa. Then, submucosal dissection is performed with clear visualization of the submucosa and muscularis without a circumferential mucosal incision. After complete dissection under the lesion, the pocket is opened from the gravity side and an en bloc resection is accomplished (▶ **Fig. 1**). There are five reasons that the PCM facilitates ESD: 1) prevention of dispersion of the injected solution due to a minimal mucosal incision without a circumferential incision; 2) traction and counter traction is provided in the pocket using a conical transparent hood (▶ **Fig. 2a**;) 3) a vertical approach

can be changed to a tangential approach regardless of location by entering the pocket (▶ **Fig. 2b**, ▶ **Fig. 2c**); 4) a specimen with a less-cauterized thick submucosa by selecting the dissection line just above the muscularis due to clear visualization of the submucosa stretched by the conical hood in the pocket (▶ **Fig. 2a**); and 5) the effect of cardiopulmonary movement is minimized by stabilizing the tip of the endoscope in the pocket (▶ **Fig. 2c**) [3]. In the non-PCM, submucosal dissection is performed after a partial or fully circumferential mucosal incision. The aim of this systematic review and meta-analysis is to evaluate effectiveness and safety of ESD for superficial neoplasms in the entire gastrointestinal tract using the PCM compared to the non-PCM.

Methods

This systematic review and meta-analysis were registered in the International Prospective Register of Systematic Review (PROSPERO, ID: CRD42020208735). We included randomized controlled trials (RCT), prospective and retrospective studies comparing the PCM with the non-PCM for ESD of superficial gastrointestinal tumors. Evaluated outcomes are the R0 resection rate, en bloc resection rate, dissection speed, and the occurrence of delayed bleeding and perforation.

Search strategy

Medline (PubMed), ISI the Web of Science, EMBASE and Cochrane Library were searched with following keywords: ("pocket creation method" or "conventional method") and "endoscopic submucosal dissection" on June 18, 2021. Language was limited to English. The search period was from 2014 to 2021.

Study selection

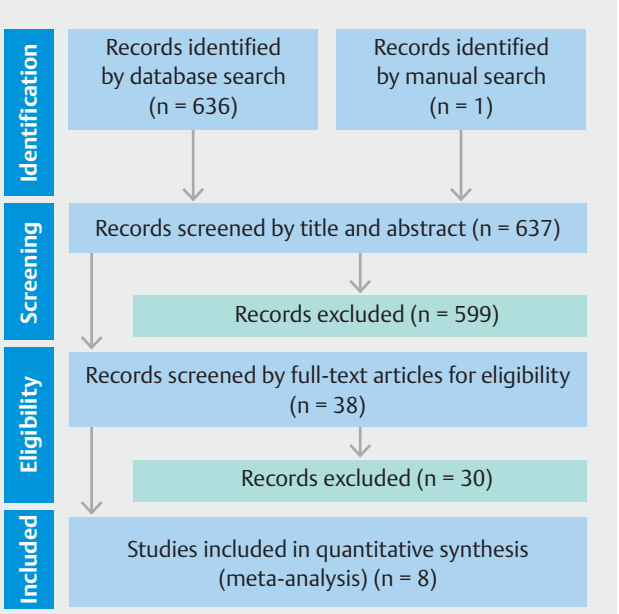
Abstracts and titles of screened articles were independently reviewed by the first and second authors (S.S. and Y.H.). Duplicate studies were excluded. Full text articles were also independently assessed by the two authors. In case of controversy, the first and second authors discussed the issue with another coauthor to reach a consensus.

Data extraction and quality assessment

We extracted the following data: first author, year of publication, study period, country, study design, treated organ, number of patients, age, gender, number of lesions, size of lesion, en bloc resection, R0 resection, dissection speed, delayed bleeding and perforation. After the first author extracted these data, the second author verified the data. In case of a lack of critical data, we requested further data from the corresponding authors by direct contact.

Risk of bias

The Cochrane criteria were used to estimate the risk of bias for RCTs [4]. The Risk of Bias Assessment tool for Non-randomized Studies was used to estimate risk of bias for non-RCTs [5].



▶ **Fig. 3** Study flowchart

Statistical analysis

To compare the PCM with the non-PCM, we used Review Manager (RevMan) Version 5.4, The Cochrane Collaboration, 2020. Pooled odds ratios (ORs) with 95% confidence intervals (CIs) were calculated with the Mantel-Haenszel random effect model, because great diversity among clinical studies was expected. Interstudy heterogeneity was evaluated by the chi-squared test with I^2 statistic [6]. The I^2 values were divided into low (0%–40%), moderate (41%–75%) and high (76%–100%) heterogeneity. For dissection speed, mean difference was calculated. $P<0.05$ was considered statistically significant.

Results

Study selection

The study flowchart for this review is shown in ▶ **Fig. 3**. The first search identified 636 studies, and finally eight studies were selected. Two studies from our own group [7, 8] were excluded due to many patients overlapping with subjects in another study [9]. The eight studies included five retrospective studies [3, 9–12], two RCTs [13, 14] and one prospective study [15]. Overall, eight studies including 1,585 ESDs were analyzed.

Characteristics of studies included

All studies were reported from Japan. The years of publication are from 2016 to 2021 (▶ **Table 1**). Treated organs include the stomach (n = 2), duodenum (n = 1) and colorectum (n = 5). One study regarding gastric ESD was limited to lesions involving the pyloric ring [12], and one study of lower gastrointestinal ESD excluded rectal lesions [9]. Two studies used the water immersion technique during the PCM [14, 15]. We extracted data for non-severe fibrosis in one study [10]. One study only included laterally spreading tumors of the colorectum [14]. Three pa-

▶ **Table 1** Characteristics of the eight studies evaluated.

First author	Year	Study period	Design	Organ	Method	Patients, n	Age, mean	Male, n	Lesion, n	Size of lesion, mm, mean
Kitamura [12]	2021	2006–2019	Retrospective	Stomach	PCM	20	72.1 ± 11.5	13	20	24.6 ± 11.6
					Non-PCM	46	72.7 ± 8.2	29	46	24.4 ± 13.2
Harada [15]	2018	2017	Prospective	Stomach	PCM	48	75.6 ± 6.8	42	48	16.0 ± 6.6
					Non-PCM	48	75.2 ± 7.1	44	48	17.6 ± 11.3
Miura [3]	2016	2006–2015	Retrospective	Duodenum	PCM	28	59.6 ± 10.9	16	28	30.5 ± 21.5
					Non-PCM	17	62.4 ± 12.7	12	17	21.0 ± 8.1
Kanamori [11]	2017	2014–2016	Retrospective	Colorectum	PCM	47	67.5 ± 11.1	32	47	29.1 ± 11.0
					Non-PCM	49	69.7 ± 9.2	33	49	31.1 ± 9.4
Yoshida [10]	2018	2006–2017	Retrospective	Colorectum	PCM	37	65.2 ± 13.5	18	37	31.1 ± 19.3
					Non-PCM	500	67.6 ± 10.6	282	500	37.3 ± 15.3
Takezawa [9]	2019	2010–2017	Retrospective	Colon	PCM	266	67.0 ± 9.9	153	278	35.3 ± 13.7
					Non-PCM	248	67.0 ± 10.0	143	262	35.7 ± 16.2
Harada [14]	2019	2017–2018	RCT	Colorectum	PCM	46	69.9 ± 10.4	29	46	26.4 ± 6.2
					Non-PCM	45	68.9 ± 14.1	26	45	26.8 ± 7.1
Yamashina [13]	2020	2016–2018	RCT	Colorectum	PCM	59	69.3 ± 9.9	34	59	33.4 ± 11.7
					Non-PCM	55	67.8 ± 9.4	33	55	31.7 ± 11.5

PCM, pocket-creation method; CM, conventional method; RCT, randomized-controlled trial.

tients in one study [9] were also included in a subsequent study [13], and these three patients were excluded from the initial study [9].

Risk of bias

Risk of bias assessments are shown in ▶ **Table 2** and ▶ **Table 3**. In retrospective studies, one study adopted propensity score matching to diminish the effects of confounding variables [15].

En bloc and R0 resection rates

The en bloc resection rate was significantly higher in the PCM group than the non-PCM group (OR 3.87, 95 %CI 1.24–12.10 P = 0.020) with low heterogeneity (I^2 = 13 %), although most studies did not show a significant difference independently except one (▶ **Fig. 4a**) [9]. The R0 resection rate was significantly higher in the PCM group than the non-PCM group (OR 2.46, 95%CI 1.14–5.30, P = 0.020) with low heterogeneity (I^2 = 40 %) (▶ **Fig. 4b**). Therefore, the PCM provides higher local curability compared to the non-PCM.

Dissection speed

Seven of the eight studies reported the dissection speed. The dissection speed was significantly faster in the PCM group than the non-PCM group (mean difference 3.13, 95 %CI 1.35–4.91, P < 0.001) with moderate heterogeneity (I^2 = 47 %) (▶ **Fig. 4c**). The PCM decreases the time needed for lengthy ESD procedures.

Safety

The rate of delayed bleeding was similar between the two groups (OR 1.13, 95 %CI 0.60–2.15, P = 0.700) (▶ **Fig. 4d**). The rate of perforation was significantly lower in the PCM group than the non-PCM group (OR 0.34, 95 %CI 0.15–0.76, P = 0.009) without heterogeneity (I^2 = 0 %) (▶ **Fig. 4e**). Use of the PCM results in safer ESD compared to the non-PCM. The PCM facilitates safe ESD.

Discussion

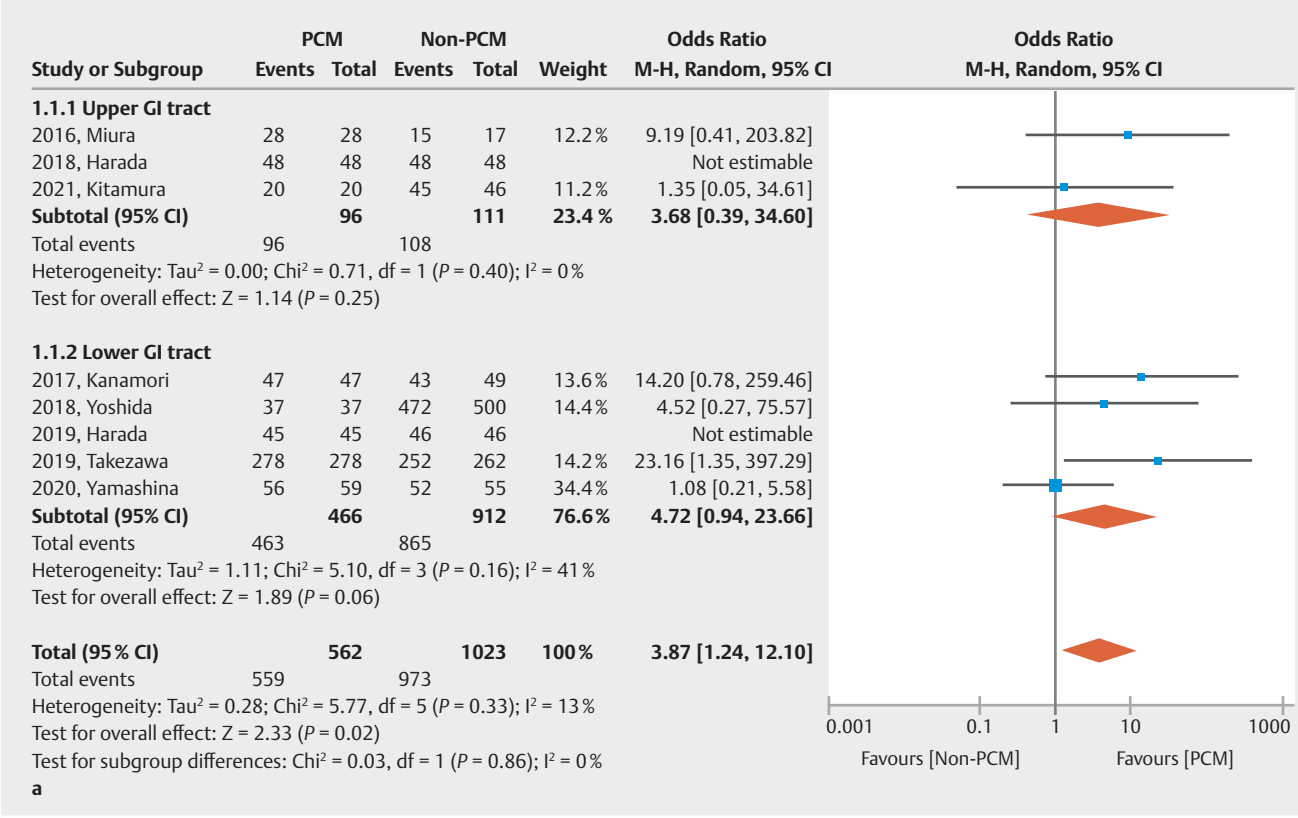
This quantitative review reveals significant superiority of the PCM over the non-PCM in ESD of lesions of the gastrointestinal tract regarding en bloc resection, R0 resection, dissection speed and perforation. The PCM improves curability and safety regardless of the organ where the lesion is located. En bloc resection is especially important because piecemeal resections make it impossible to confirm a negative margin and increases the rate of local recurrence (10–23.5 %) [16]. Since ESD is an advanced endoscopic technique compared with EMR, extensive training is necessary to attain competence to perform safe ESD. The location influences the difficulty of ESD due to factors such as a vertical approach, strong bending, presence of haustra and the pyloric ring. The PCM was developed and disseminated to conquer these difficult circumstances and provide a shortcut to learning ESD for beginner endoscopists. Past sys-

▶ **Table 2** Risk of bias assessment for randomized-controlled studies.

First author	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessments	Incomplete outcome data	Selective outcome reporting	Other bias
2019, Harada	Low	Low	High	Unclear	Low	Low	Unclear
2020, Yamashina	Low	Low	High	Unclear	Low	Low	Unclear

▶ **Table 3** Risk of Bias Assessment for Non-randomized Studies (RoBANS).

First author	Selection of participants	Confounding variables	Measurement of exposure	Blinding of outcome assessments	Incomplete outcome data	Selective outcome reporting
2021, Kitamura	High	High	Low	Unclear	Low	Low
2018, Harada	Low	Low	Low	Unclear	Low	Low
2016, Miura	High	High	Low	Unclear	Low	Low
2017, Kanamori	High	High	Low	Unclear	Low	Low
2018, Yoshida	High	High	Low	Unclear	Low	Low
2019, Takezawa	High	High	Low	Unclear	Low	Low



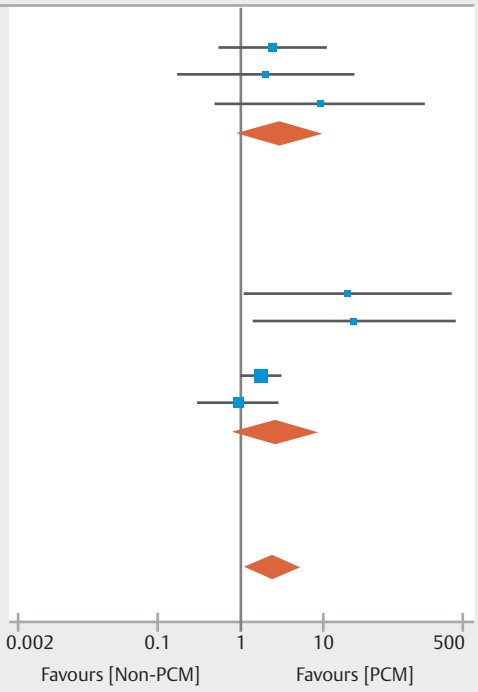
a

▶ **Fig. 4** A Forest plot comparing the pocket creation method (PCM) to the non-PCM. **a** En bloc resection rate.

tematic reviews and meta-analyses regarding the PCM were limited to colorectal ESD [17, 18]. This is the first quantitative review evaluating the effectiveness and safety of the PCM in both the upper and lower gastrointestinal tract.

This study demonstrates that the PCM facilitates R0 resection. Confirmation of a negative pathological margin and the presence/absence of lymphovascular invasion from resected specimens obtained by en bloc resection is important to determine future treatment strategies. Indications for additional sur-

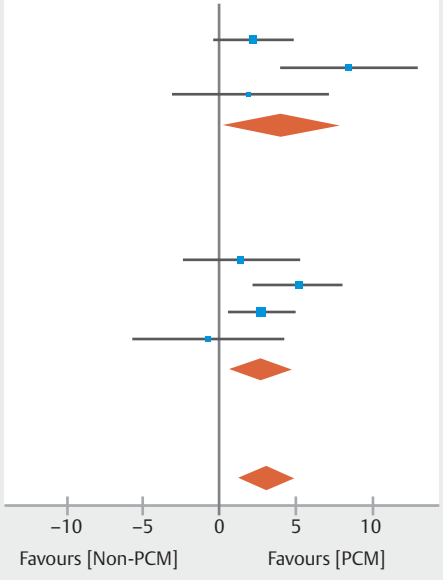
Study or Subgroup	PCM Events	PCM Total	Non-PCM Events	Non-PCM Total	Weight	Odds Ratio M-H, Random, 95% CI
1.2.1 Upper GI tract						
2016, Miura	24	28	12	17	16.2%	2.50 [0.57, 11.05]
2018, Harada	47	48	46	48	8.0%	2.04 [0.18, 23.32]
2021, Kitamura	20	20	38	46	6.0%	9.05 [0.50, 164.85]
Subtotal (95% CI)		**96**		**111**	**30.2%**	**2.94 [0.92, 9.38]**
Total events	91		96			
Heterogeneity: Tau² = 0.00; Chi² = 0.77, df = 2 (*P* = 0.68); I² = 0%						
Test for overall effect: Z = 1.82 (*P* = 0.07)						
1.2.2 Lower GI tract						
2017, Kanamori	47	47	41	49	6.0%	19.46 [1.09, 347.46]
2018, Yoshida	37	37	379	500	6.4%	24.01 [1.46, 393.96]
2019, Harada	45	45	46	46		Not estimable
2019, Takezawa	253	278	223	262	34.7%	1.77 [1.04, 3.02]
2020, Yamashina	51	59	48	55	22.7%	0.93 [0.31, 2.76]
Subtotal (95% CI)		**466**		**912**	**69.8%**	**2.73 [0.82, 9.14]**
Total events	433		737			
Heterogeneity: Tau² = 0.85; Chi² = 8.73, df = 3 (*P* = 0.03); I² = 66%						
Test for overall effect: Z = 1.63 (*P* = 0.10)						
Total (95% CI)		**562**		**1023**	**100%**	**2.46 [1.14, 5.30]**
Total events	524		833			
Heterogeneity: Tau² = 0.37; Chi² = 10.02, df = 6 (*P* = 0.12); I² = 40%						
Test for overall effect: Z = 2.30 (*P* = 0.02)						
Test for subgroup differences: Chi² = 0.01, df = 1 (*P* = 0.93); I² = 0%						



b

▶ **Fig. 4** A Forest plot comparing the pocket creation method (PCM) to the non-PCM. **b** R0 resection rate.

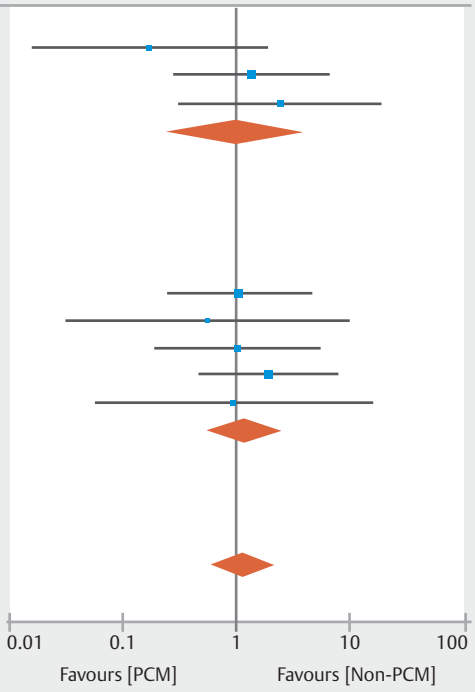
Study or Subgroup	PCM Mean	PCM SD	PCM Total	Non-PCM Mean	Non-PCM SD	Non-PCM Total	Weight	Mean difference IV, Random, 95% CI
1.5.1 Upper GI tract								
2016, Miura	9.5	3.6	28	7.3	4.6	17	19.2%	2.20 [−0.36, 4.76]
2018, Harada	26.7	13.2	48	18.2	8.7	48	10.6%	8.50 [4.03, 12.97]
2021, Kitamura	18	9	20	16	11	46	8.9%	2.00 [−3.07, 7.07]
Subtotal (95% CI)			**96**			**111**	**38.7%**	**4.08 [0.08, 8.09]**
Heterogeneity: Tau² = 8.36; Chi² = 6.13, df = 2 (*P* = 0.05); I² = 67%								
Test for overall effect: Z = 2.00 (*P* = 0.05)								
1.5.2 Lower GI tract								
2017, Kanamori	15.7	11.4	47	14.3	7.3	49	12.8%	1.40 [−2.45, 5.25]
2019, Harada	22	6.9	45	16.8	7.1	46	17.4%	5.20 [2.32, 8.08]
2019, Takezawa	23.5	11.6	278	20.7	13.7	262	21.8%	2.80 [0.65, 4.95]
2020, Yamashina	21	13.7	59	21.7	13.1	55	9.3%	−0.70 [−5.62, 4.22]
Subtotal (95% CI)			**429**			**412**	**61.3%**	**2.71 [0.62, 4.81]**
Heterogeneity: Tau² = 1.86; Chi² = 5.10, df = 3 (*P* = 0.16); I² = 41%								
Test for overall effect: Z = 2.54 (*P* = 0.01)								
Total (95% CI)			**525**			**523**	**100.0%**	**3.13 [1.35, 4.91]**
Heterogeneity: Tau² = 2.57; Chi² = 11.42, df = 6 (*P* = 0.08); I² = 47%								
Test for overall effect: Z = 3.45 (*P* = 0.0006)								
Test for subgroup differences: Chi² = 0.35, df = 1 (*P* = 0.55); I² = 0%								



c

▶ **Fig. 4** A Forest plot comparing the pocket creation method (PCM) to the non-PCM. **c** Dissection speed.

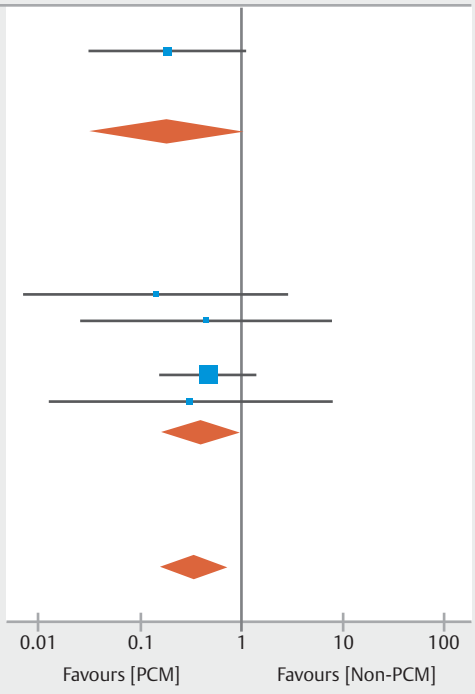
Study or Subgroup	PCM Events	PCM Total	Non-PCM Events	Non-PCM Total	Weight	Odds Ratio M-H, Random, 95% CI
1.3.1 Upper GI tract						
2016, Miura	1	28	3	17	7.4%	0.17 [0.02, 1.82]
2018, Harada	4	48	3	48	17.0%	1.36 [0.29, 6.45]
2021, Kitamura	2	20	2	46	9.9%	2.44 [0.32, 18.71]
Subtotal (95% CI)		**96**		**111**	**34.2 %**	**0.97 [0.24, 3.87]**
Total events	7		8			
Heterogeneity: Tau² = 0.52; Chi² = 3.05, df = 2 (*P* = 0.22); I² = 34%						
Test for overall effect: Z = 0.05 (*P* = 0.96)						
1.3.2 Lower GI tract						
2017, Kanamori	4	47	4	49	19.5%	1.05 [0.25, 4.45]
2018, Yoshida	0	37	11	500	5.0%	0.57 [0.03, 9.82]
2019, Harada	3	45	3	46	14.9%	1.02 [0.20, 5.36]
2019, Takezawa	6	278	3	262	21.0%	1.90 [0.47, 7.69]
2020, Yamashina	1	59	1	55	5.2%	0.93 [0.06, 15.26]
Subtotal (95% CI)		**466**		**912**	**65.8%**	**1.19 [0.54, 2.62]**
Total events	14		22			
Heterogeneity: Tau² = 0.00; Chi² = 0.79, df = 4 (*P* = 0.94); I² = 0%						
Test for overall effect: Z = 0.44 (*P* = 0.66)						
Total (95% CI)		**562**		**1023**	**100%**	**1.13 [0.60, 2.15]**
Total events	21		30			
Heterogeneity: Tau² = 0.00; Chi² = 3.87, df = 7 (*P* = 0.79); I² = 0%						
Test for overall effect: Z = 0.39 (*P* = 0.70)						
Test for subgroup differences: Chi² = 0.07, df = 1 (*P* = 0.80); I² = 0%						



d

▶ **Fig. 4** A Forest plot comparing the pocket creation method (PCM) to the non-PCM. **d** Rate of delayed bleeding.

Study or Subgroup	PCM Events	PCM Total	Non-PCM Events	Non-PCM Total	Weight	Odds Ratio M-H, Random, 95% CI
1.4.1 Upper GI tract						
2016, Miura	2	28	5	17	21.2%	0.18 [0.03, 1.09]
2018, Harada	0	48	0	48		Not estimable
2021, Kitamura	0	20	0	46		Not estimable
Subtotal (95% CI)		**96**		**111**	**21.2 %**	**0.18 [0.03, 1.09]**
Total events	2		5			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.86 (*P* = 0.06)						
1.4.2 Lower GI tract						
2017, Kanamori	0	47	3	49	7.5%	0.14 [0.01, 2.78]
2018, Yoshida	0	37	14	500	8.3%	0.45 [0.03, 7.65]
2019, Harada	0	45	0	46		Not estimable
2019, Takezawa	5	278	10	262	56.6%	0.46 [0.16, 1.37]
2020, Yamashina	0	59	1	55	6.4%	0.31 [0.01, 7.65]
Subtotal (95% CI)		**466**		**912**	**78.8%**	**0.40 [0.16, 1.00]**
Total events	5		28			
Heterogeneity: Tau² = 0.00; Chi² = 0.58, df = 3 (*P* = 0.90); I² = 0%						
Test for overall effect: Z = 1.96 (*P* = 0.05)						
Total (95% CI)		**562**		**1023**	**100%**	**0.34 [0.15, 0.76]**
Total events	7		33			
Heterogeneity: Tau² = 0.00; Chi² = 1.14, df = 4 (*P* = 0.89); I² = 0%						
Test for overall effect: Z = 2.60 (*P* = 0.009)						
Test for subgroup differences: Chi² = 0.56, df = 1 (*P* = 0.45); I² = 0%						



e

▶ **Fig. 4** A Forest plot comparing the pocket creation method (PCM) to the non-PCM.**e** Rate of perforation. CI, confidence interval; IV, inverse variance; M-H, Mantel-Haenszel; SD, standard deviation.

gical resection are discussed based on the depth of submucosal invasion, presence/absence of lympho-vascular invasion and budding grade [19]. Because these important factors are determined from examination of the submucosa, the resected specimen must have a thick less-cauterized submucosa to provide the information needed to decide on optimal treatment. The PCM provides clear submucosal visualization and stretching of submucosal tissue aided by the traction and countertraction provided by use of a small-caliber-tip transparent (ST) hood, which enables the operator to select the dissection level in the submucosa and divide submucosal tissue with minimum thermal damage. The ST hood facilitates entering the pocket and provides clear vision through its transparent wall enveloped in the pocket. The dissection level just above the muscularis (deep submucosa) is essential to keep a thick submucosa with the resected specimen which enables safe dissection by avoiding fat and branched vasculature generally located in the superficial submucosa. To assess local curability, a negative vertical margin is more important than a negative horizontal margin. Local recurrence at a positive horizontal margin is generally managed by additional endoscopic resection. A high R0 resection rate with a thick less-cauterized submucosa obtained by using the PCM provides important information to determine future treatment.

Greater dissection speed during ESD decreases the physical burden for the patient as well as the endoscopist. When using the non-PCM, the initial circumferential incision enhances dispersion of injected solution which decreases the traction in the submucosa. Dissection without a pocket in the stomach or duodenum is sometimes difficult due to cardiopulmonary movement. Dissection in a shallow submucosa increases bleeding which prolongs the procedure to achieve hemostasis. The PCM diminishes these time-consuming events and results in overall faster dissection.

This quantitative review shows a low rate of perforation in the PCM group. There are two reasons for this. First, the PCM can change a vertical approach to a tangential approach. As shown in ▶ **Fig. 2**, the PCM can avoid a vertical approach by entering the pocket and changing the direction. A tangential approach is essential to achieve safe ESD and provides stable maneuvering. Second, traction and countertraction when using the PCM provide clear visualization of the submucosa and muscularis. The PCM can complete ESD without the need for dedicated traction devices. The PCM surely makes difficult ESD easier, and it also makes standard ESD safer and faster. Therefore, the PCM is useful without the need for special devices and can be used as far as the endoscope reaches [20].

This study has acknowledged limitations. First, all studies originated from Japan. Data from western countries are necessary to generalize these results. Second, experience and skill levels of endoscopists vary. Third, seven of nine studies were non-RCTs. Since these retrospective studies used historical controls, this time-frame shift may influence the learning curve of endoscopists and the evolution of ESD devices. These factors may work to the advantage of the PCM group. Fourth, the resection method used was not blinded to the endoscopists. Fifth, heterogeneity exists among studies in the definition of R0 resection, delayed bleeding and procedure time. Sixth, only three studies regarding upper gastrointestinal ESD were included without esophageal ESD.

Conclusions

The PCM facilitates high-quality and safe colorectal ESD. Further studies are needed regarding the utility of PCM in ESD of the upper gastrointestinal tract.

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Competing interests

Drs. Hayashi, Miura, and Yano have received honoraria from the Fujifilm Corporation. Dr. Yamamoto has a consultant relationship with the Fujifilm Corporation and has received honoraria, grants, and royalties from the company.

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