Underwater versus conventional endoscopic submucosal dissection for colorectal lesions: systematic review and meta-analysis

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Background and Aims: Effect of underwater endoscopic submucosal dissection (UESD) on clinical outcomes as compared with conventional ESD (CESD) remains unclear. We conducted a meta-analysis of the available data.

Methods: Online databases were searched for studies comparing UESD with CESD for colorectal lesions. The outcomes of interest were en-bloc resection, R0 resection, procedure time (minutes), dissection speed (mm^2/min), and adverse events. Pooled odds ratios (ORs) and standardized mean difference (SMD), along with 95% confidence intervals (CIs) were calculated.

Results: Seven studies with 1401 patients (UESD, 452; CESD, 949) were included. Mean patient age was 69 years, and 57% of patients were men. UESD had both a shorter procedure time (SMD, –1.33; 95% CI, –2.34 to –.32; P = .010) and greater dissection speed (SMD, 1.01; 95% CI, .35-1.68; P = .003) when compared with CESD. No significant differences were observed between the 2 groups with respect to en-bloc resection (OR, 1.13; 95% CI, .37-3.41), R0 resection (OR, 2.36; 95% CI, .79-7.05), delayed bleeding (OR, 1.34; 95% CI, .65-2.74), perforation (OR, 1.13; 95% CI, .64-2.00), and postresection electrocoagulation syndrome (OR, .38; 95% CI, .10-1.42).

Conclusions: UESD was faster in patients with colorectal lesions but had comparable rates of en-bloc resection, R0 resection, and adverse events when compared with CESD. (Gastrointest Endosc 2025;101:551-7.)

(footnotes appear on last page of article)

Clinical guidelines recommend snare polypectomy (cold or hot) for colorectal polyps up to 20 mm in size and EMR for large polyps (≥20 mm).[1,2] Endoscopic submucosal dissection (ESD) is advised for colorectal lesions with possible limited submucosal invasion, especially for size ≥20 mm.[3] Despite having a high en-bloc resection rate, conventional ESD (CESD) remains technically challenging and may lead to increased risk of incomplete resection and adverse events (some of which can be severe) in the presence of submucosal fibrosis or deeper invasion.[4] Several modifications have been developed to improve the performance of ESD, such as tunneling, pocket-creation method, traction-assisted, and hybrid ESD (in combination with EMR).[5]

Underwater ESD (UESD) is performed after filling up the lumen with saline solution or water and removing intraluminal gas.[5,6] The liquid exerts a buoyancy effect on the mucosal flap and helps in magnification of the view, thereby allowing for easier visualization of the dissection plane. The enhanced visibility can be helpful particularly in cases with submucosal fibrosis and increased submucosal fat.

A limited number of studies have evaluated UESD versus CESD for colorectal lesions to date, with varying results. Hence, we conducted a systematic review and meta-analysis to compare the safety and effectiveness of these 2 ESD techniques for management of colorectal lesions.

METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were used to perform this study.[7] Supplementary Table 1 (available online at www.giejournal.org) shows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist.

TABLE 1. Baseline characteristics of the studies

Study	Type	No. of underwater ESD cases	No. of conventional ESD cases	Inclusion criteria	Exclusion criteria	Follow-up (mo)
Ozeki 2021[13]	Observational (article)	54	79	Lesions expected to have submucosal fibrosis: (1) lesions after previous endoscopic or surgical treatment; (2) lesions with biopsy scars; (3) lesions in patients with ulcerative colitis	Lesions histologically diagnosed as other than epithelial neoplasms	19.6
Cecinato 2022[8]	Observational (abstract)	28	120	Colorectal superficial neoplasms	Patients with IBD, recurrent lesions, and those removed by hybrid technique	—
Koyama 2023[9]	Observational (article)	80	125	Colorectal lesions	ESD combined with snare resection, multiple lesions, or neuroendocrine tumors, and those without blood examination data, with IBD, or with recurrent lesions	—
Kirita 2024[14]	Observational (abstract)	123	167	Colorectal lesions	—	—
Nagata 2024[10]	Randomized controlled trial (abstract)	70	69	Unresectable superficial colorectal neoplasms en bloc by EMR	—	—
Nakajima 2024[11]	Observational (abstract)	69	361	Colorectal lesions	ESD for multiple lesions on the same day or had nonadenocarcinoma	—
Oh 2024[12]	Randomized controlled trial (article)	28	28	Laterally spreading tumor (20-50 mm)	Patients with (1) known or suspected deep invasive neoplasia, previously incomplete resected neoplasia, subepithelial lesion, or pedunculated neoplasia; (2) IBD; (3) uninterrupted use of antithrombotic drugs; and (4) coagulopathies	—

UESD, Underwater endoscopic submucosal dissection; *CESD*, conventional endoscopic submucosal dissection; *IBD*, inflammatory bowel disease; —, data not available.

Search strategy

A systematic search was performed of multiple online databases, including PubMed, MEDLINE, Google Scholar, and Cochrane for studies published since inception until July 5, 2024. The search terms used were "UESD," "CESD," and "colorectal lesions" (Supplementary Table 2, available online at www.giejournal.org). Studies comparing UESD with CESD for colorectal lesions in adult patients and reporting at least 1 outcome of interest were included. Single-arm studies and those with <10 patients were excluded.

Data collection and risk of bias assessment

The studies were screened for eligibility, risk of bias was assessed, and the relevant data were collected by 2 independent reviewers (S.S. and B.P.M.), with any discrepancies being resolved by discussion among the reviewers. Baseline information was obtained on study characteristics, such as type, number of patients, major inclusion and exclusion criteria and follow-up duration, and on patient characteristics, such as age (years), male sex (%), type of lesions, and specimen size (mm). Clinical endpoints of interest were en-bloc resection, R0 resection, procedure time (minutes), dissection speed (mm^2/min), and adverse events including delayed bleeding, perforation, and postresection electrocoagulation syndrome (PECS). The Cochrane risk of bias tool (for randomized controlled trials) and Newcastle-Ottawa Scale (for nonrandomized studies) were used to evaluate the risk of bias.

Study analysis

Cochrane Review Manager statistical software, version 5.4 (Cochrane, London, UK) was used to conduct the analysis. Pooled odds ratios (ORs) for dichotomous variables and standardized mean difference (SMD) for continuous variables, along with 95% confidence intervals (CIs), were calculated using a random-effects model. Mean and standard deviation were estimated from median and range, respectively, wherever applicable. Interstudy heterogeneity was depicted using the I^2 statistic: <25%, minimal; 25% to 50%, mild; 50% to 75% moderate; and >75%, significant. A

TABLE 2. Baseline characteristics of the patients

Study	Age (y)	Male sex (%)	Site of lesions (%)		Morphology (%)		Histology (%)		Specimen size*	
			UESD	CESD	UESD	CESD	UESD	CESD	UESD	CESD
Ozeki 2021[13]	UESD, 69 CESD, 71	66.7 60.8	Right hemisphere, 57.4 Left hemisphere, 29.6 Rectum, 13	57 19 24	LST-granular, 11.1 LST-nongranular, 75.9 0-I, 13	24.1 65.8 10.1	Adenoma, 20.4 Tis, 72.2 T1a, 3.7 T1b, 3.7	22.8 72.2 3.8 1.2	38 mm (30.8-44.3)	38 mm (30-47)
Cecinato 2022[8]	UESD, 68.6 CESD, 69.2	57.1 52.5	Right colon, 42.9 Left colon, 21.4 Rectum, 35.7	18.3 22.5 59.2	LST-nongranular, 35.6 LST-granular, 64.3 Sessile, 0	31.6 50.9 17.5	Low-grade dysplasia, 7.1 High-grade dysplasia, 67.9 T1, 25	3.3 70.8 25	—	—
Koyama 2023[9]	UESD, 72 CESD, 68	60 55	Proximal colon, 68 Distal colon, 25 Rectum, 7	51 16 33	Flat and/or depressed, 67 Elevated, 33	56 44	Adenoma or sessile serrated lesion, 44 Intramucosal carcinoma, 49 Submucosal carcinoma, 7	27 49 24	569 mm^2 (378-822)	730 mm^2 (471-1256)
Kirita 2024[14]	—	—	Colon, 89 Rectum, 11	63 37	—	—	—	—	23 ± 9.3 mm	27 ± 12 mm
Nagata 2024[10]	—	—	—	—	—	—	—	—	—	—
Nakajima 2024[11,†]	73	58.1	Proximal colon, 61.6 Distal colon, 16.1 Rectum, 22.3		Polypoid, 51.6 Flat, 48.4		T1b, 9.8 T1a, 8.8 Tis, 31.2 Adenoma, 44.7 Sessile serrated lesion, 5.6		—	—
Oh 2024[12]	UESD, 67 CESD, 63	50 50	Right colon, 57.1 Left colon, 28.6 Rectum, 14.3	53.6 39.3 7.1	LST-nongranular, 57.1 LST-granular, 42.9	46.4 53.6	Low-grade adenoma, 53.6 High-grade adenoma, 28.6 Intramucosal carcinoma, 7.1 Superficial invasive carcinoma, 10.7	53.6 17.9 17.9 10.7	31.6 mm (8.5)	31.3 mm (7.6)

UESD, Underwater endoscopic submucosal dissection; *CESD*, conventional endoscopic submucosal dissection; LST, laterally spreading tumor; 0-I, protruding tumor; —, data not available.
*Values are mean (standard deviation) or median (range).
†Separate data not available.

$P < .05$ was considered statistically significant. Forest plots were derived to show the differences between UESD and CESD groups for each outcome. Sensitivity analysis was performed by excluding individual studies one at a time from the final results.

RESULTS

One hundred forty-four studies were found on the initial search, of which 7 studies (5 observational and 2 randomized controlled trials) fulfilling the inclusion and exclusion criteria were included in the final analysis (Supplementary Fig. 1, available online at www.giejournal.org).[8-14] Of 1401 patients included in the final analysis, 452 were in the UESD group and 949 in the CESD group. The study and population characteristics are summarized in Table 1. Mean patient age was 69 years, and 57% of patients were men. The site, morphology, and histology of lesions are summarized in Table 2.

Six studies reported en-bloc resection, with no significant difference between the UESD and CESD groups (99% vs 98%; OR, 1.13; 95% CI, .37-3.41; $P = .83$, $I^2 = 0\%$) (Fig. 1A). The R0 resection rate, reported in 4 studies, was higher in the UESD group compared with the CESD group; however, the difference was not statistically significant (98% vs 93%; OR, 2.36; 95% CI, .79-7.05; $P = .13$, $I^2 = 0\%$) (Fig. 1B). UESD had both a shorter overall procedure time (SMD, –1.33; 95% CI, –2.34 to –.32; $P = .010$, $I^2 = 97\%$) and faster dissection speed (SMD, 1.01; 95% CI, .35-1.68; $P = .003$, $I^2 = 87\%$) (Fig. 2A and B).

The adverse events were not statistically different between the UESD and CESD groups. The adverse events were delayed bleeding (3.1% vs 2.5%; OR, 1.34; 95% CI, .65-2.74; $P = .43$, $I^2 = 0\%$), perforation (4.6% vs 4.1%; OR, 1.13; 95% CI, .64-2.00; $P = .68$, $I^2 = 0\%$), and PECS (4.4%

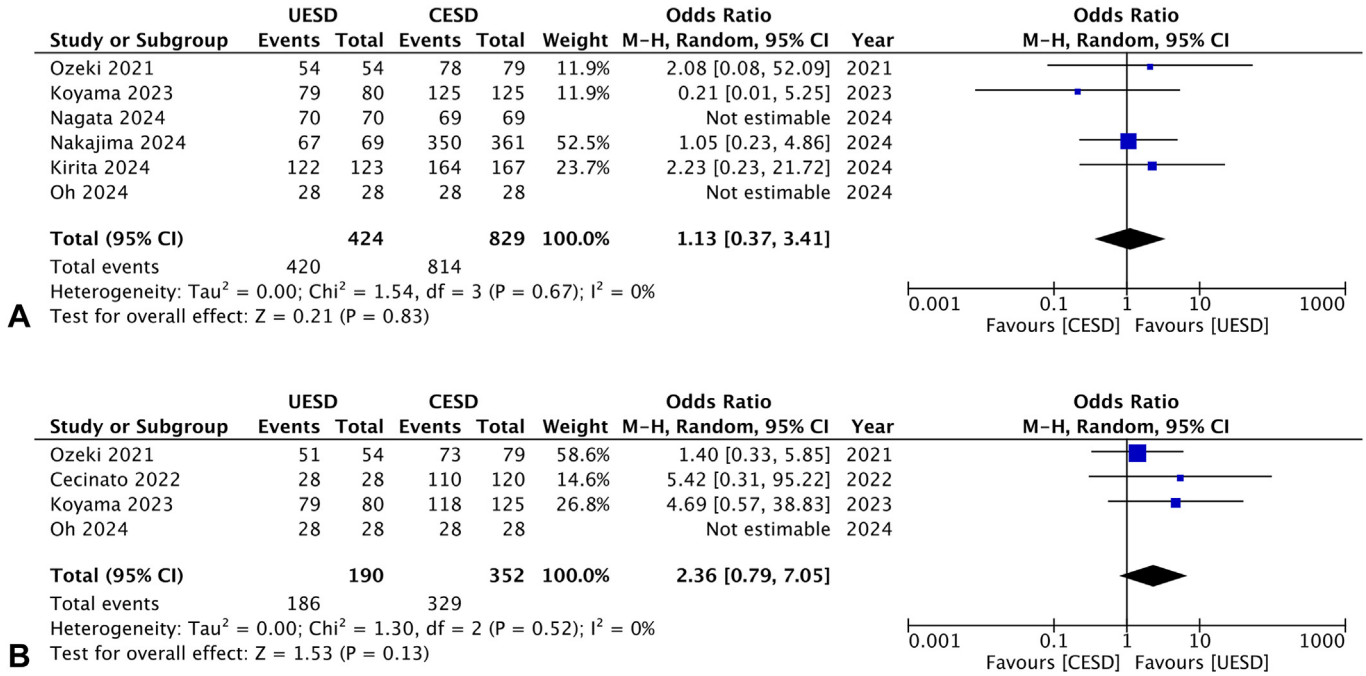

Figure 1. Forest plots comparing UESD and CESD groups. **A,** En-bloc resection. **B,** R0 resection. *UESD*, Underwater endoscopic submucosal dissection; *CESD*, conventional endoscopic submucosal dissection; *CI*, confidence interval.

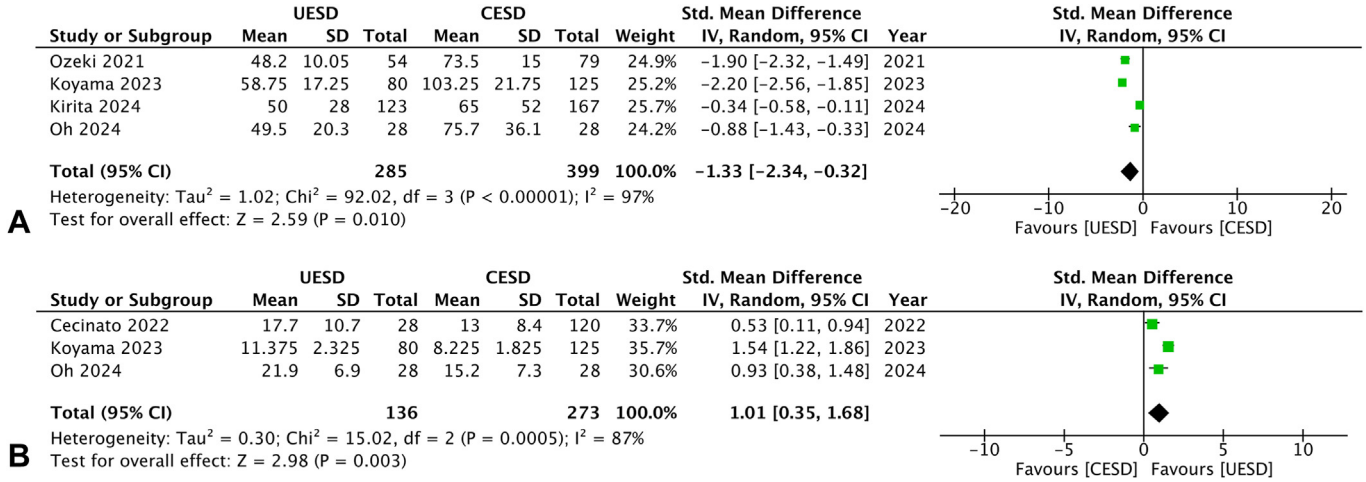

Figure 2. Forest plots comparing UESD and CESD groups. **A,** Procedure time. **B,** Dissection speed. *UESD*, Underwater endoscopic submucosal dissection; *CESD*, conventional endoscopic submucosal dissection; *CI*, confidence interval.

vs 10.4%; OR, .38; 95% CI, .10-1.42; $P = .15$, $I^2 = 41\%$) (Fig. 3A-C).

Sensitivity analysis for the outcomes is presented in Supplementary Table 3 (available online at www.giejournal.org). Risk of bias for the included studies are shown in Supplementary Figure 2 and Supplementary Table 4 (available online at www.giejournal.org). Bias assessment using the Egger test and funnel plots was not performed because the included number of studies was <10.

DISCUSSION

To our knowledge, this is the first meta-analysis assessing UESD versus CESD for colorectal lesions. UESD was faster but had comparable rates of en-bloc resection, R0 resection, and adverse events when compared with CESD.

CESD is a technically difficult procedure requiring creation of a clear submucosal dissection plane and is generally performed only by interventionalists with advanced

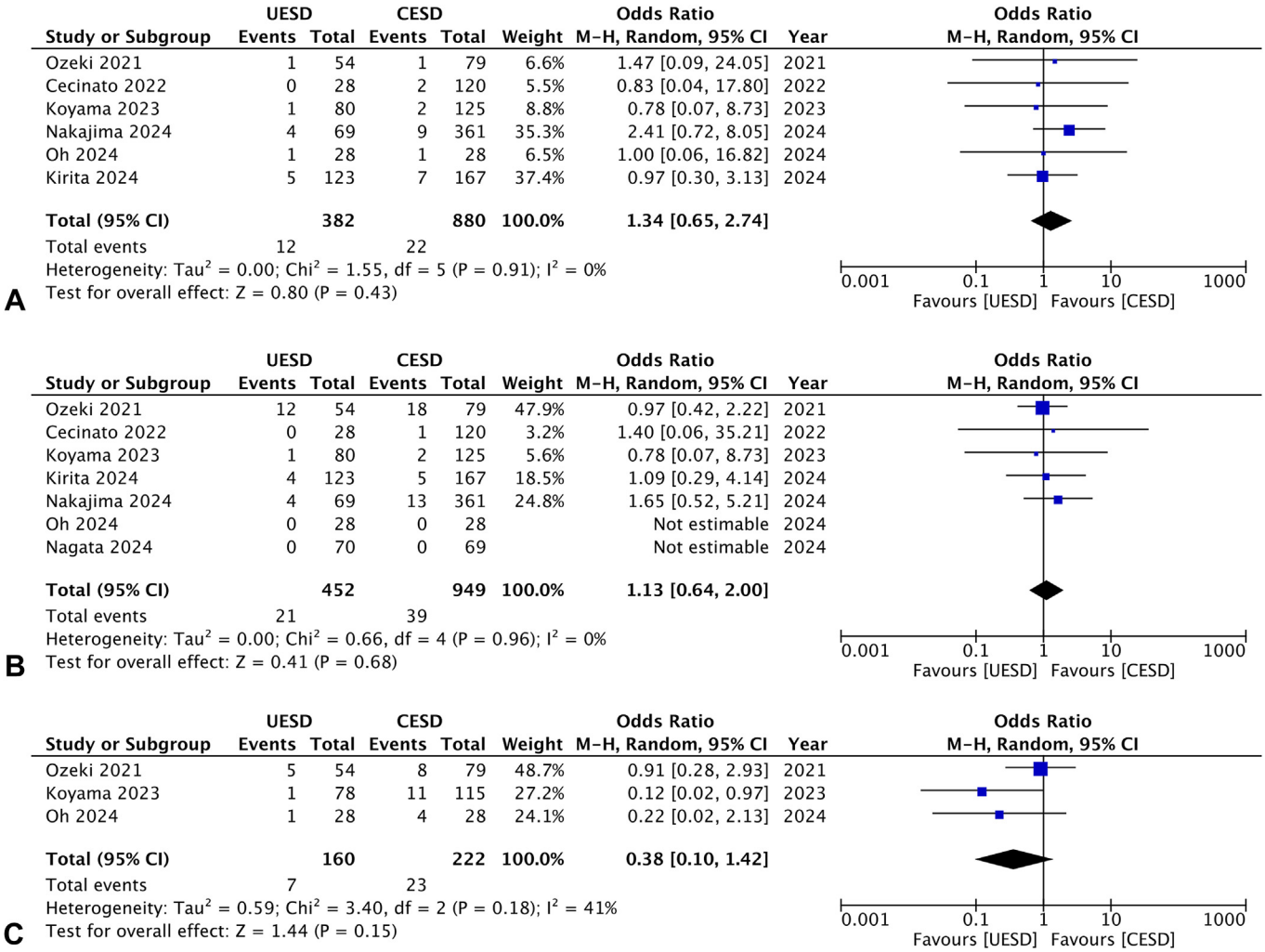

Figure 3. Forest plots comparing UESD and CESD groups. **A,** Delayed bleeding. **B,** Perforation. **C,** Post resection electrocoagulation syndrome. *UESD*, Underwater endoscopic submucosal dissection; *CESD*, conventional endoscopic submucosal dissection; *CI*, confidence interval.

training.[2] Further, the coagulation of submucosal tissue during CESD leads to generation of fumes and liquid droplets, hampering the endoscopic view.[12] UESD helps in reducing the droplets and fumes at the dissection area, theoretically improving the effectiveness and safety of ESD. However, UESD is a relatively new technique, whereas CESD is the currently used modality. Although our results did not show statistically significant differences between the UESD and CESD techniques with respect to en-bloc resection and R0 resection rates, the UESD group had a numerically higher rate of R0 resection.

Perhaps the most widely reported benefit of UESD is the shorter procedure time and higher dissection speed, as seen in our study. UESD leads to a reduction in the time used in generating the field of view and for the scope to enter the submucosa, even when performed by novice endoscopists because of the natural traction provided by the liquid.[15] The ease of combining the UESD method with other ESD modifications (such as the pocket-creation method and traction-assisted methods) can further shorten the procedure time.[16-20]

The liquid immersion during the UESD procedure reduces the thermal energy applied over the tissue through a heat-sink effect (heat dissipation because of the liquid), which can theoretically decrease adverse events such as PECS.[12,21,22] This was reflected in our results with only 4.4% patients having PECS in the UESD group compared with 10.4% in the CESD group, although the difference was not significant. In addition, clear visibility obtained during UESD because of the liquid buoyancy and magnification effect helps in preventing tissue injury, thus reducing the bleeding and perforation risk. On the other hand, the heat generated during UESD can cause the formation of air bubbles, which can potentially interfere with obtaining an unobstructed endoscopic view.[12] However, use of techniques such as cutting current or synchronous water irrigation have been shown to reduce the formation of air bubbles.[12,23] Additionally, intraoperative bleeding in UESD may impede

the visual field as the blood gets rapidly mixed with the liquid.[9] In cases of minor bleeding, the usual practice is to perform irrigation with saline solution, which helps in localizing the bleeding point (like a beacon) and achieving hemostasis. In cases with major bleeding, the liquid is aspirated to stop the bleeding, after which UESD is resumed. Regardless, the perforation and delayed bleeding rates were found to be comparable in the UESD and CESD groups in our study, which confirms the safety of the former technique for patients with colorectal lesions.

Our study has the strength of being the only meta-analysis available comparing UESD and CESD for colorectal lesions. Pooling the data from individual studies increases the overall power of the reported clinical outcomes. As seen with other underwater modalities such as underwater EMR, which is now included in the clinical guidelines, UESD has the potential to be an alternative or replacement for CESD.[1] To that end, adequate patient selection is important for UESD, as reported in a recent randomized controlled trial[12] where UESD showed a time-saving benefit in select patients such as those with lesions sized 31 to 50 mm, laterally spreading tumor with nongranular morphology, and the presence of submucosal fibrosis.[24-27]

Our analysis has limitations as well. First, inclusion of a low number of studies, along with 4 studies being abstracts, limits the overall impact of the results. Second, observational studies carry with them an inherent risk of selection bias. Third, the studies differed in terms of baseline characteristics of patients and lesions, which limits the generalizability of the results to any specific patient population. The high interstudy heterogeneity undermines the validity of the results, which may not provide meaningful insights for clinical practice at this time. Fourth, the effectiveness and safety of ESD techniques are heavily dependent on the experience and training of the endoscopist, with possible variations in operator expertise in the included studies. Fifth, the location of the lesion within the colon affects resection time. Lesions, with the same size, located in the cecum, hepatic flexure, and splenic flexure generally require more time to resect than those in other parts of the colon. A subanalysis could not be performed because of a lack of patient-level data.

In conclusion, UESD led to a reduction in procedure time with improvement in dissection speed when compared with CESD. The 2 groups had comparable en-bloc and R0 resection rates and adverse events. Both modalities appear to be effective for the removal of colorectal lesions. The results of this study are likely only hypothesis-generating given the overall limitations. Future studies are needed to corroborate these findings.

DISCLOSURE

The following authors disclosed financial relationships: N. Sharma: Consultant for Boston Scientific, Olympus, Medtronic, and Mauna Kea; advisory board for Endoscopy Now. D. G. Adler: Consultant for Boston Scientific. All other authors disclosed no financial relationships.

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Abbreviations: CESD, conventional endoscopic submucosal dissection; CI, confidence interval; ESD, endoscopic submucosal dissection; OR, odds ratio; PECS, postresection electrocoagulation syndrome; SMD, standardized mean difference; UESD, underwater endoscopic submucosal dissection.

DIVERSITY, EQUITY, AND INCLUSION: We worked to ensure gender balance in the recruitment of human subjects. We worked to ensure ethnic or other types of diversity in the recruitment of human subjects. While citing references scientifically relevant for this work, we actively worked to promote gender balance in our reference list. The author list of this paper includes contributors from the location where the research was conducted who participated in the data collection, design, analysis, and/or interpretation of the work.

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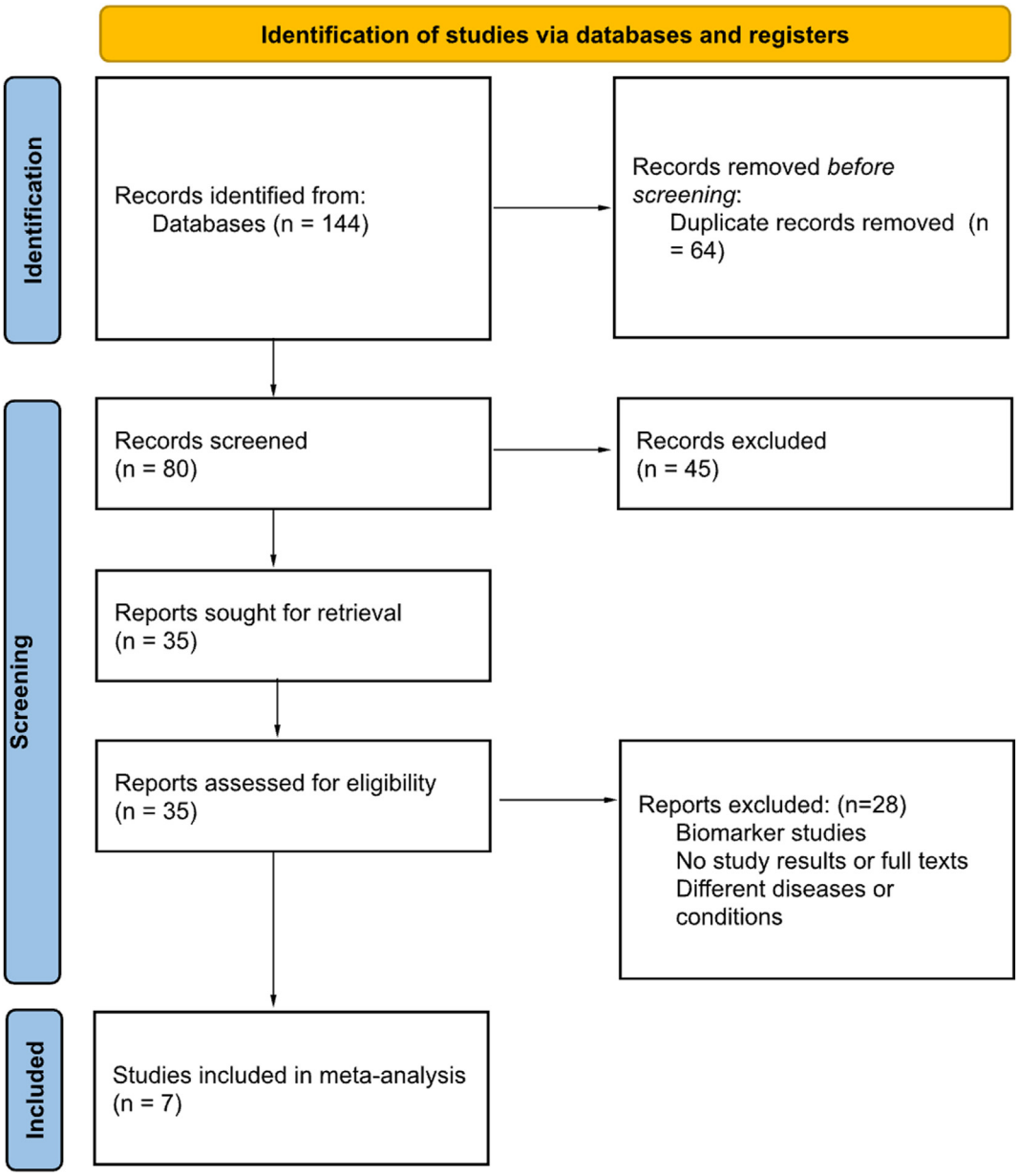
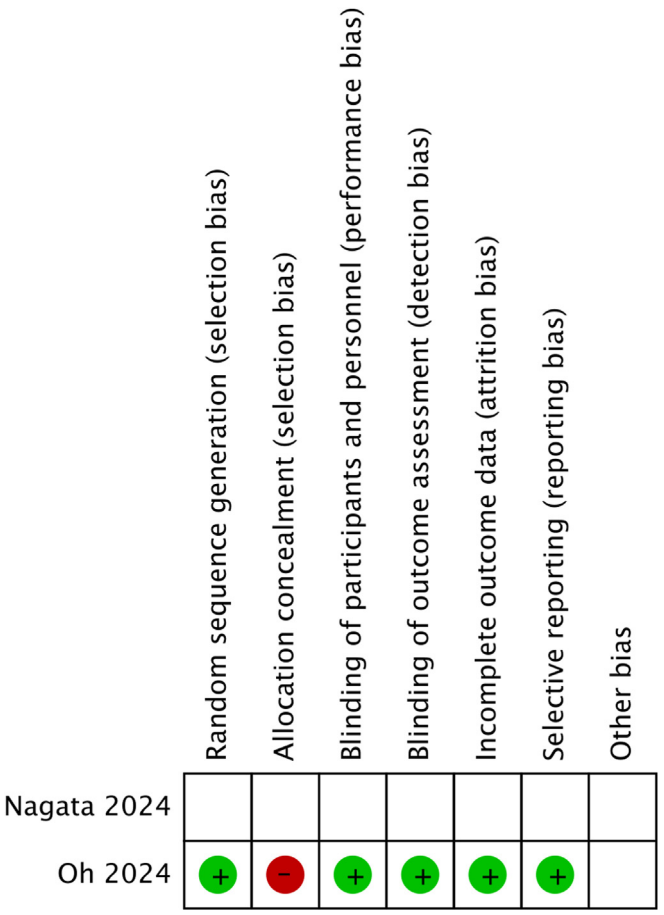


Supplementary Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram depicting the search strategy.



Supplementary Figure 2. Risk of bias for randomized trials.

SUPPLEMENTARY TABLE 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist

Section and topic	Item no.	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the Preferred Reporting Items for Systematic reviews and Meta-Analyses 2020 for Abstracts checklist.	4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organizations, reference lists, and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers, and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and, if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and, if applicable, details of automation tools used in the process.	6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (eg, for all measures, time points, analyses), and, if not, the methods used to decide which results to collect.	6
	10b	List and define all other variables for which data were sought (eg, participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and, if applicable, details of automation tools used in the process.	6
Effect measures	12	Specify for each outcome the effect measure(s) (eg, risk ratio, mean difference) used in the synthesis or presentation of results.	6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (eg, tabulating the study intervention characteristics and comparing against the planned groups for each synthesis [item 5]).	6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (eg, subgroup analysis, meta-regression).	6
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	6

(*continued on the next page*)

SUPPLEMENTARY TABLE 1. Continued

Section and topic	Item no.	Checklist item	Location where item is reported
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	6
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	6
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	7
	16b	Cite studies that might appear to meet the inclusion criteria but which were excluded, and explain why they were excluded.	7
Study characteristics	17	Cite each included study and present its characteristics.	7
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7
Results of individual studies	19	For all outcomes, present, for each study summary statistics for each group (where appropriate) and an effect estimate and its precision (eg, confidence/credible interval), ideally using structured tables or plots.	7
Results of syntheses	20a	For each synthesis, briefly summarize the characteristics and risk of bias among contributing studies.	7
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (eg, confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	7
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	7
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	7
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	7
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	7
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	8, 9
	23b	Discuss any limitations of the evidence included in the review.	8, 9
	23c	Discuss any limitations of the review processes used.	8, 9
	23d	Discuss implications of the results for practice, policy, and future research.	8, 9
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Not registered
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Not prepared
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable
Support	25	Describe sources of financial or nonfinancial support for the review, and the role of the funders or sponsors in the review.	2
Competing interests	26	Declare any competing interests of review authors.	2
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms, data extracted from included studies, data used for all analyses, analytic code, any other materials used in the review.	2

SUPPLEMENTARY TABLE 2. Search strategy

Database	Search strategy	Results
PubMed/MEDLINE	Search: underwater endoscopic submucosal dissection colorectal Sort by: Publication Date "underwater"[All Fields] AND ("endoscopic mucosal resection"[MeSH Terms] OR ("endoscopic"[All Fields] AND "mucosal"[All Fields] AND "resection"[All Fields]) OR "endoscopic mucosal resection"[All Fields] OR ("endoscopic"[All Fields] AND "submucosal"[All Fields] AND "dissection"[All Fields]) OR "endoscopic submucosal dissection"[All Fields]) AND "colorectal"[All Fields] Translations endoscopic submucosal dissection: "endoscopic mucosal resection"[MeSH Terms] OR ("endoscopic"[All Fields] AND "mucosal"[All Fields] AND "resection"[All Fields]) OR "endoscopic mucosal resection"[All Fields] OR ("endoscopic"[All Fields] AND "submucosal"[All Fields] AND "dissection"[All Fields]) OR "endoscopic submucosal dissection"[All Fields]	105
Cochrane	(underwater endoscopic submucosal dissection colorectal):ti,ab,kw (Word variations have been searched)	12
Google Scholar	allintitle: underwater endoscopic submucosal dissection colorectal	27

SUPPLEMENTARY TABLE 3. Sensitivity analysis

Study	En-bloc resection	R0 resection	Procedure time	Dissection speed	Delayed bleeding	Perforation	Postresection electrocoagulation syndrome
Final outcome	1.13 (.37-3.41)	2.36 (.79-7.05)	−1.33 (−2.34 to −.32)	1.01 (.35-1.68)	1.34 (.65-2.74)	1.13 (.64-2.00)	.38 (.10-1.42)
Study excluded							
Ozeki 2021[13]	1.04 (.32-3.38)	4.93 (.90-27.04)	−1.14 (−2.40 to .11)	—	1.33 (.63-2.79)	1.30 (.59-2.88)	.16 (.04-.74)
Cecinato 2022[8]	—	2.04 (.62-6.69)	—	1.28 (.69-1.87)	1.38 (.66-2.88)	1.12 (.63-2.01)	—
Koyama 2023[9]	1.41 (.43-4.60)	1.83 (.51-6.59)	−1.04 (−2.05 to −.02)	.69 (.30-1.07)	1.41 (.67-2.99)	1.15 (.64-2.08)	.63 (.19-2.11)
Kirita 2024[14]	.91 (.26-3.24)	—	−1.69 (−2.39 to −.99)	—	1.62 (.66-4.02)	1.14 (.60-2.15)	—
Nagata 2024[10]	1.13 (.37-3.41)	—	—	—	—	1.13 (.64-2.00)	—
Nakajima 2024[11]	1.21 (.24-6.07)	—	—	—	.97 (.40-2.37)	1.00 (.51-1.93)	—
Oh 2024[12]	1.13 (.37-3.41)	2.36 (.79-7.05)	-1.48 (−2.76 to −.19)	1.04 (.05-2.04)	1.37 (.65-2.86)	1.13 (.64-2.00)	.40 (.05-2.94)

Values are odds ratios (95% confidence intervals) or standardized mean difference (95% confidence interval).
—, data not available.

SUPPLEMENTARY TABLE 4. Risk of bias assessment (nonrandomized studies) with Newcastle-Ottawa Quality Assessment Scale

Study	Representative of the average adult in the community (1, multicenter; 0, single center)	Cohort size (2, >100; 1, 20-100, 0, <20)	Abstract, 0; full article, 1	Primary outcome reported (1, reported with clarity; 0, not reported)	Attrition rate (1, all patients included; .5, <50% not included; >50% not included)	Information reported on adverse events (1, reported; 0, not reported)	Total
Ozeki 2021[13]	0	2	1	1	1	1	6
Cecinato 2022[8]	0	2	0	1	1	1	5
Koyama 2023[9]	1	2	1	1	1	1	7
Kirita 2024[14]	0	2	0	1	1	1	5
Nakajima 2024[11]	0	2	0	1	1	1	5

From Wells G, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. 2013. Available at: https://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.