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ORIGINAL ARTICLE

Efficacy and Safety of Endoscopic Stenting for Crohn's Disease Related Strictures: A Systematic Review and Meta-analysis

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Background/Aims: Endoscopic stenting is an evolving treatment for symptomatic Crohn's strictures. Several case series and small studies have reported its efficacy. Future studies can be designed based on a systematic review of the evaluation of efficacy. Hence, this meta-analysis was conducted to assess the critical role of stents in the management of intestinal strictures associated with Crohn's disease (CD).

Methods: A literature search of various databases from 2000 to February 2022 was conducted for studies evaluating the outcome of stents in patients with CD-related stricture. The outcomes assessed included technical and clinical success, adverse events, symptom recurrence, and the need for a surgical resection. Pooled event rates across studies were expressed with summative statistics.

Results: Ten studies with 170 patients were included in the present analysis. The pooled event rates for technical success, clinical success, stent migration, and post-procedural pain were 98.2% (95% CI, 95.8-100), 71.3% (95% CI, 57.4-85.1), 32% (95% CI, 0.0-65.3) and 20.2% (95% CI, 4.1-36.2), respectively. The cumulative recurrence rate and need for surgery were 40.1% (95% CI, 20.3-59.9) and 8.6% (95% CI, 1.7-15.5), respectively. Subgroup analysis showed that partially-covered (PC) self-expanding metallic stent (SEMS) was significantly better than fully-covered SEMS with a lower stent migration rate and symptom recurrence rate.

Conclusions: Overall efficacy of stents in the management of CD-related stricture remains moderate with a low complication rate. Among the stents, PC-SEMS may be associated with a more favorable outcome. Future studies will be needed to determine the long-term benefits of endoscopic stenting. **(Korean J Gastroenterol 2022;80:177-185)**

Key Words: Crohn disease; Strictures; Self expandable metallic stents; Meta-analysis

INTRODUCTION

Intestinal stricture remains a common complication associated with Crohn's disease (CD), significantly affecting the patients' quality of life. The etiology of strictures in CD can be inflammatory, fibrotic, or a combination of both and management is determined by the degree of inflammatory activity. In the case of predominantly inflammatory strictures, medical therapy is the first therapeutic option, while surgical resection is reserved for irreversible fibrotic strictures.[1] Within a decade of initial diagnosis, around one-third of the patients with CD develop stricture, and up to 50% require at least one surgical resection.[2,3] After the initial ileal resection, approximately 40% of the patients have a recurrence of obstructive symptoms after four years, and more than 50% of the patients require a repeat operation after 15 years.[4]

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Although the use of biologicals has revolutionized the management of CD, which may have led to reduced rates of recurrence and surgery, the morbidity with a surgical resection remains high. Apart from bowel resection, strictureplasty is another surgical option, conserving bowel length and minimizing the risk of short bowel syndrome. However, it has a higher risk of disease recurrence than a resection (OR, 1.61; 95% CI, 1.03-2.52).[5] Hence, it is crucial to explore alternative therapies to avoid or delay surgery for CD-related strictures.

The most common endoscopic therapy for CD-related stricture is endoscopic balloon dilatation (EBD). A previous meta-analysis on the efficacy and safety of EBD in CD-related strictures reported a pooled clinical success rate of 70% and complication rate of 6.4%, with no difference in the outcome of anastomotic and de-novo strictures.[6] On the other hand, the stricture recurrence rate and cumulative surgery rate 5 years after EBD remain as high as 60%[7] and 75%,[6] respectively.

Recent advances in stents with their efficacy in malignant gastrointestinal (GI) strictures have led to an examination of their role in benign GI strictures. Endoscopic stenting is evolving as an alternative therapy to EBD in CD, but the data are limited and show inconsistent results. This inconsistency may be due to the difference in the technique, type of stent used, and definition of endpoints. Thus, this meta-analysis was conducted to assess the efficacy and safety of stents in treating CD-related strictures.

SUBJECTS AND METHODS

The current meta-analysis was conducted as per the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines (Supplementary Table 1).[8] Institutional Review Board clearance is not required for meta-analysis.

1. Database search

Electronic databases of MEDLINE, and ScienceDirect were searched from 2000 to February 2022 for all relevant studies using the keywords: Crohn AND Stent. There was no bar on language, provided the study outcomes were mentioned in the text. Initially, screening of the title and abstract of studies retrieved using the search strategy was conducted by two independent reviewers. Two researchers independently assessed the eligibility of the studies before including them. The bibliography of the included studies was also searched for any relevant studies. A third reviewer resolved any disagreement.

2. Study Inclusion

The studies included in this analysis were prospective and retrospective studies fulfilling the following criteria: a) Study population – patients with small intestinal or colonic stricture (both anastomotic and *de novo*) associated with CD; b) Intervention – any stent placement for CD-related stricture; c) Outcomes – efficacy and safety of stents in CD-related stricture. Studies with a total number of patients <5, review articles, correspondences, and editorials were excluded. Studies without relevant clinical data or incomplete data were also excluded.

3. Data extraction and quality assessment

The collected data was entered into a structured form by two reviewers. The form contained the following parameters of each study: first author, year of publication, country, number of patients, age and gender, details of stricture, type of stent placed, outcome measures, and duration of follow-up. A scale modified from the Newcastle–Ottawa scale for cohort studies was used to assess the quality of the included studies.[9] A third independent individual was consulted in the case of a discrepancy.

4. Outcomes assessed

Technical success was defined as the successful placement of the stent across the stricture, as observed on fluoroscopy. Clinical success was defined as the resolution of the signs and symptoms in patients in whom technical success could be achieved. Recurrence was defined by the recurrent symptoms after the initial success of stenting. Surgery was required for the complication of stenting-like perforation, embedment of the stent, or failure to improve after stenting with persistent or recurrent symptoms. On the other hand, to assess the long-term efficacy of stents, this study analyzed only the surgeries for persistent or recurrent symptoms after stenting.

5. Data analysis

The pooled proportions were computed using a random-effects inverse-variance model with a DerSimonian-Laird estimate of tau^2.[10] Before statistical analysis, a continuity correction of 0.5 was applied when the incidence of an outcome

was zero in a study. The I^2 and p-values were used to assess the heterogeneity. A p<0.10 was taken as statistically significant while I^2 values <30%, 30% to 60%, 61% to 75%, and >75% were considered as low, moderate, substantial, and considerable heterogeneity, respectively.[11] A leave-one-out meta-analysis was performed as a part of sensitivity analysis to investigate the influence of each study on the overall effect-size estimate and identify influential studies. The publication bias assessment was conducted by evaluating the funnel plot asymmetry and quantified using Egger's test.[12] The meta-analysis was performed using Stata 17.0 software package (Stata Corp LP, College Station, TX, USA).

RESULTS

One hundred and eighty-two records were identified after a search from databases, of which 165 records were screened after removing duplicate studies (Fig. 1). After screening, six case reports and three case series, which included two patients each, were excluded. Overall, 10 studies[13-22] were included in the final analysis (Table 1). The number of patients in the studies varied from five to 46, with a disease duration from 2 weeks to 41 years and stricture length varying from 5 mm to 60 mm. Four studies included partially-covered self-expanding metallic stents (PC-SEMS),[15,19-21] three studies used fully-covered (FC)-SEMS,[14,16,22] two studies used biodegradable stents[13,18] and one study used uncovered (UC)-SEMS.[17] Among the studies included, two studies were of high quality,[19,22] six were of medium quality,[13-17,20,21] and two were of low quality (Supplementary Table 2).[17,18]

1. Technical success

The technical success of the procedure was reported in all 10 studies[13-22] with 170 patients. The pooled technical success rate was 98.2% (95% CI, 95.8-100; I^2 0.0%), with no overall heterogeneity or heterogeneity between the sub-

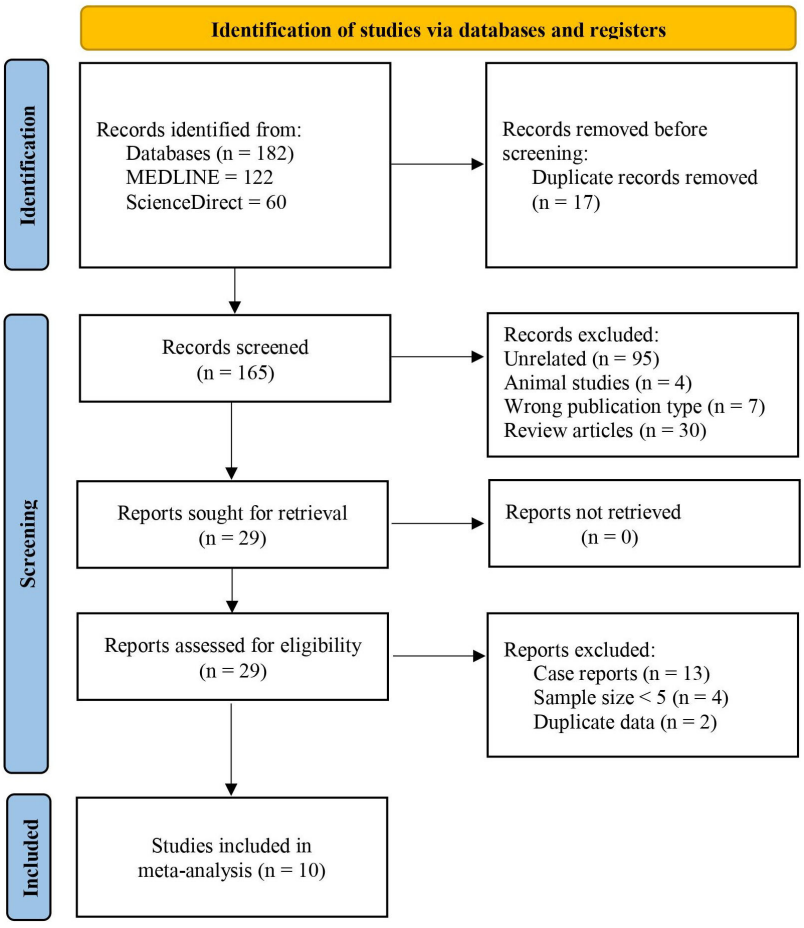

Fig. 1. PRISMA 2020 flow diagram for study selection for systematic review and meta-analysis.

Table 1. Study Characteristics

Study	Country	Study design	No. of patients	Male/ female	Age (years)	Disease duration	Stricture type and location	Stricture length (mm)	Previous balloon dilatation	Stent type	Follow up (months)
Rejchrt et al.[13] (2011)	Czech Republic	Prospective	11	8/3	42 (32-58)	2-41 years	5 IAA, 1 ISA, 1 ITA, 1 TC, 1 DC, 1 ICV, 1 SC	15-50	7 (63.6%)	SXELLA BD biodegradable stent; ELLA-CS, Hradec Kralove, Czech Republic	17 (12-29)
Attar et al.[14] (2012)	France	Prospective	11	6/5	34 (18-66)	11 years (4-24)	8 ICA, 2 SI, 1 ISA	10-40	9 (81.8%)	FCSEMS (7 Hanarostent, 4 Niti-S)	49.1 (24.8-73.2)
Branche et al.[15] (2012)	France	Prospective	7	4/3	50 (36-59)	20 years (14-29)	5 IAA, 2 ISA	<50	7 (100%)	PCSEMS (Hanarostent)	10 (6-18)
Levine et al.[16] (2012)	Spain	Retrospective	17	7/10	45.7	15 years (1-30)	9 ICA, 4 SC, 1 IRA, 5 Colon	20-60	14 (82.3%)	14 FCSEMS, 3 Combined	67 weeks (11-272)
Loras et al.[17] (2012)	USA	Retrospective	5	4/1	49.8 (29-67)	149.2 m (7m -27 y)	4 ICA, 1 ISA	10-50	2 (40%)	UCSEMS (1 Wallstent UC, 4 Wallflex UC)	28 m (3 w-109 m)
Karstensen et al.[18] (2016)	Denmark	Retrospective	6	2/4	51 (25-60)	9-67 m	3 ICA, 2 colon, 1 SI	2-10	5 (100%)	SXELLA BD biodegradable stent; ELLA-CS, Hradec Kralove, Czech Republic	4-42
Attar et al.[19] (2021)	France	Ambispective	46	19/27	46.4±14.2	19 m (0.5-30)	32 ICA, 10 Colon, 4 SI	5-50	36 (73.8%)	PCSEMS (Hanarostent)	26 (8-41)
Das et al.[20] (2020)	UK	Prospective	21	8/13	48.1 (28-67)	19 (1-43)	19 Anastomotic, 2 de novo	20-55	-	PCSEMS (Hanarostent)	3-50
Hedenström et al.[21] (2021)	Sweden	RCT	13	5/8	40-74	20 years (12-30)	12 de novo (ICV), 1 ICA	-	-	PCSEMS (Hanarostent)	69 (28-91)
Loras et al.[22] (2022)	Spain	RCT	80	41/39	45 (38-55)	17 years (8-24)	34 Anastomotic, 56 De novo	20-56	-	FCSEMS (Niti-S)	12

FCSEMS, fully covered self-expanding metallic stent; PCSEMS, partially covered self-expanding metallic stent; UCSEMS, uncovered self-expanding metallic stent; ICA, ileo-cecal anastomosis; IAA, ileo-ascending anastomosis; ITA, ileo-transverse anastomosis; ISA, ileo-sigmoid anastomosis; IRA, ileo-rectal anastomosis; ICV, ileo-cecal valve; TC, transverse colon; DC, descending colon; SC, sigmoid colon; SI, small intestine.

groups (Fig. 2).

2. Clinical success

The clinical success rate of the procedure was reported in nine studies[13-21] with 122 patients. The pooled clinical success rate was 71.3% (95% CI, 57.4-85.1; I^2 68.4%; p=0.001), with substantial heterogeneity among the studies (Fig. 3). On subgroup analysis, the pooled clinical success rate with PC-SEMS (80.9%; 95% CI, 60.9-100) was higher compared to FC-SEMS (65.6%; 95% CI, 47.4-83.8) and biodegradable stent (46.1%; 95% CI, 0.0-95.1), even though it was not statistically significant.

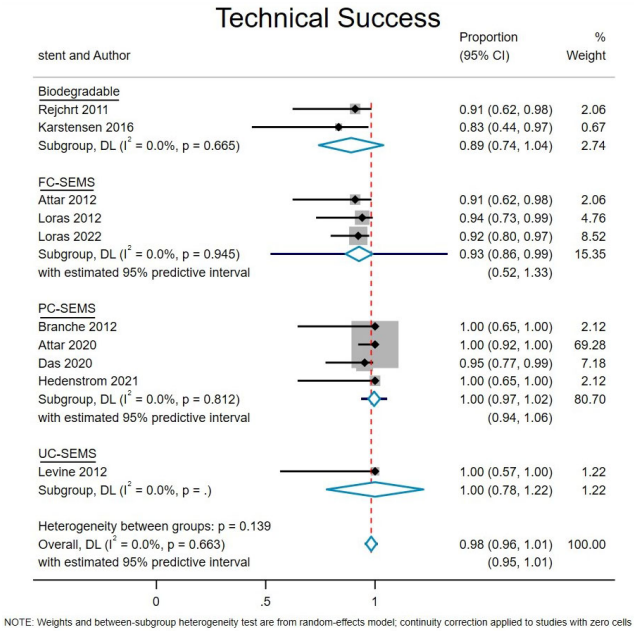

Fig. 2. Forest plot for the technical success of endoscopic stenting in Crohn's disease-related stricture with subgroup analysis based on stent type.

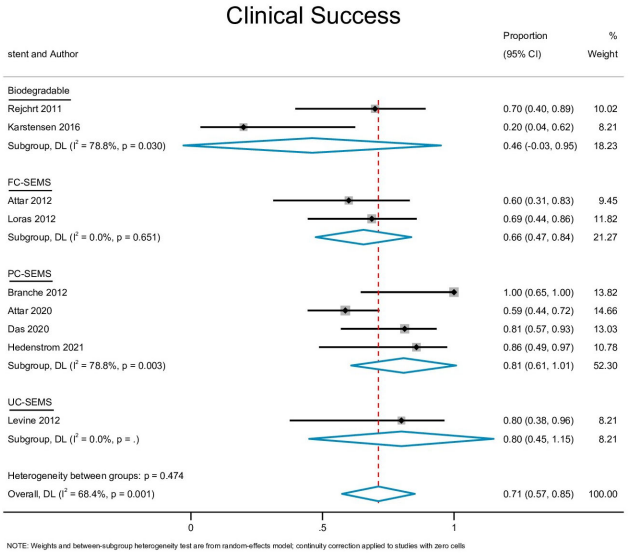

Fig. 3. Forest plot for clinical success of endoscopic stenting in Crohn's disease-related stricture with subgroup analysis based on stent type.

3. Stent migration

The incidence of stent migration was reported in 10 studies[13-22] with 165 patients. The pooled stent migration rate was 32% (95% CI, 0.0-65.3; I^2 98.4%; p=0.0001) with considerable heterogeneity among the studies (Fig. 4). Subgroup analysis showed that the migration rate with PC-SEMS was 6.1% (95% CI, 0.5-11.8), which was significantly lower than FC-SEMS (87.2%; 95% CI, 71.2-100) (p=0.000) but not biodegradable stents (23.7%; 95% CI, 3.1-44.2) (p=0.108).

4. Adverse events

Only one severe adverse event (perforation) associated with stent placement was reported by Loras et al.[22]. The patient had distal migration of the FCSEMS, which was trapped in a diverticulum in a tortuous sigmoid colon, leading to perforation, for which a sigmoid resection was performed. Post-procedural pain increasing the duration of hospitalization was reported in four studies[14,15,20,21] with a pooled incidence of 20.2% (95% CI, 4.1-36.2; I^2 67.6%; p=0.026) with substantial heterogeneity among the studies (Supplementary Fig. 1).

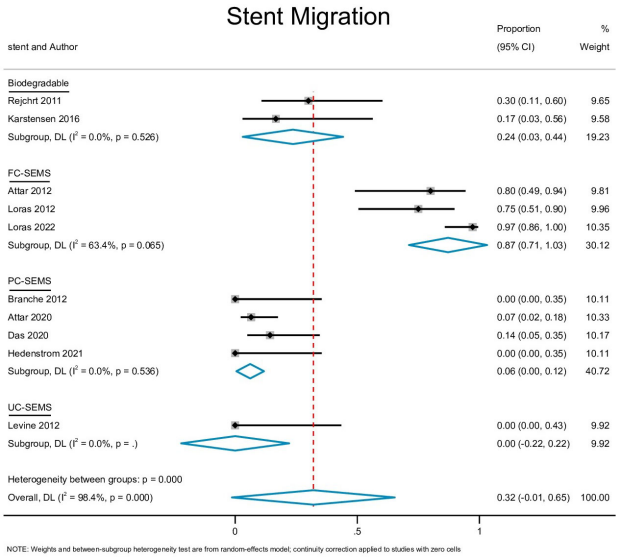

Fig. 4. Forest plot for stent migration with subgroup analysis based on the stent type.

5. Recurrence

Ten studies[13-22] with 165 patients reported the recurrence of symptoms with or without an additional procedure. The pooled recurrence rate was 40.1% (95% CI, 20.3-59.9; I^2 89.9%; p=0.0001) with considerable heterogeneity among the studies (Fig. 5). On subgroup analysis, the recurrence rate using PC-SEMS was 19.4% (95% CI, 5.4-33.4), which was significantly lower compared to FC-SEMS (61.2%; 95% CI, 32.2-90.2; p=0.011).

6. Surgical resection on follow-up

Surgical resection for indications other than an immediate complication of stenting was reported in seven studies[14-18,20,21] with 66 patients. The indications included failure to improve,[16,20] symptomatic recurrence after the initial clinical response,[16,17,21] and stent embedment.[14,16,18] The pooled surgical resection rate was 8.6% (95% CI, 1.7-15.5; I^2 2.2%; p=0.408), with low heterogeneity among the studies (Fig. 6).

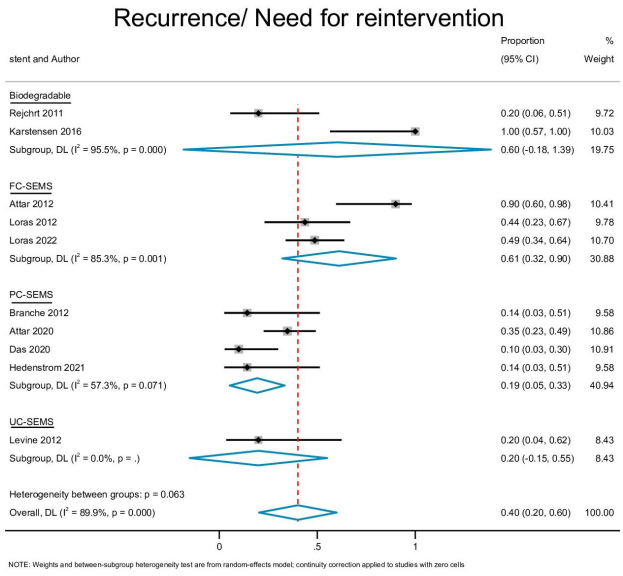

Fig. 5. Forest plot for recurrence rate with subgroup analysis based on stent type.

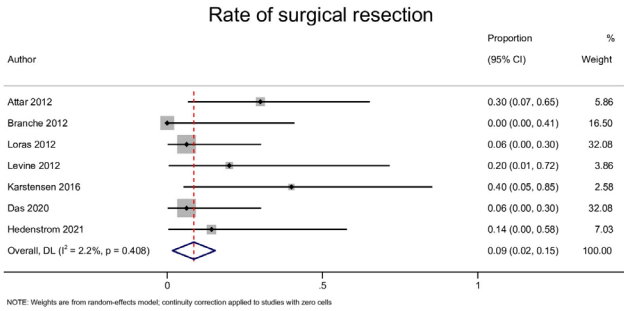

Fig. 6. Forest plot for the need for surgery due to failure to improve or recurrence after stenting.

7. Publication bias and sensitivity analysis

The outcomes of technical success and stent migration were associated with publication bias (Supplementary Fig. 2, Supplementary Table 3). Sensitivity analysis was performed by excluding one study from each analysis to account for the studies that may distort the overall results. On the leave-one-out meta-analysis, none of the outcomes except for stent migration showed any significant difference in the pooled proportions (Supplementary Figs. 3-7). With the exclusion of the study by Loras et al.[22], the pooled proportion of stent migration was reduced to 24% (95% CI, 6-41).

DISCUSSION

This study focused on the utility of bowel preserving procedures in the current era of non-invasive patient care using endoscopically deployed stents for CD-related strictures. The pooled technical success rate for endoscopic stent placement was 98.2%, without heterogeneity among the studies. The present analysis reports a higher clinical success rate, a lower migration rate, and a lower recurrence rate with PC-SEMS compared to FC-SEMS and biodegradable stents. Serious adverse events are rare, with post-procedural pain being the commonest adverse event with a pooled incidence of 20.2%. The pooled surgical resection rate was 8.6% on the follow-up, but the sample size was small.

An initial systematic review for self-expanding stents in the management of benign colorectal obstruction reported a clinical success of 87%, with a perforation rate of 12% and a re-obstruction rate of 14%.[23] Based on the high complication rate compared to colonic stenting for malignant etiologies, the previous review concluded that stenting could not be recommended for benign colorectal obstruction. In the previous review, however, only three patients had a CD-related stricture, while a majority (66/122, 54%) had an obstruction due to diverticulitis. This high rate of complications may be due to persisting sepsis or inflammatory activity at the site of diverticulitis, making the bowel friable and susceptible to local damage. Hence, stent placement in patients with a CD-related stricture should be avoided in those predominantly with in-

flammation and limited to fibrotic or anastomotic strictures.

The ideal stent type for the management of CD-related strictures remains an unresolved issue as the current stents are not explicitly designed for this purpose. FC-SEMS do not adhere to mucous membranes, making them easier to remove but at the cost of an increased rate of distal migration. In contrast, PC-SEMS may prevent possible distal migration, but they are more likely to adhere to the mucosa, making their removal more difficult. Biodegradable stents combined the benefits of avoiding hyperplastic mucosal reaction in FC-SEMS and the non-requirement of removal as in UC-SEMS into one device. They were believed to provide an extended period of dilation compared to other stents, with stent integrity and radial force being maintained for 6-8 weeks.[24] However, the initial study by Rejchrt et al.[13] showed a 30% migration rate with biodegradable stents. They used three different designs varying in the type of anchorage: a dual flare end, a wavy-bodied stent, and a straight stent without flared ends. As expected, the stents without flared ends (1/6) and the ones with wavy ends (2/3) were the ones to migrate. Karstensen et al.[18] reported a poor clinical response to biodegradable stents with severe hypergranulation requiring stent removal or surgery. The technical difficulties of inserting biodegradable stents through the endoscopic channel with limited clinical success make it unappealing. The present analysis showed the best outcome with PC-SEMS regarding clinical success, stent migration, and recurrence. Hence, there is a need for dedicated PC-SEMS like double flare anti-migration stents, which may improve the efficacy of stenting in CD-related strictures.

There is also a paucity of data concerning the predictors of therapeutic failure. Attar et al.[14] reported the associated perianal disease and discontinuation of the immunosuppressant as independent predictors of therapeutic failure (HR, 0.1; 95% CI, 0.02-0.58 and 0.12; 95% CI, 0.02-0.86, respectively). Thus, reducing the inflammatory burden associated with stricture rather than mechanical dilation is the primary driver of clinical success. On the other hand, performing small bowel MRI before stent placement was associated with a significantly higher probability of therapeutic success (HR, 5.3; 95% CI, 1.2-23.5). Hence, pre-procedural assessment of the stricture characteristics can aid in selecting suitable patients for endoscopic therapy.

The patient profile eligible for stenting procedures are largely similar to EBD, hence the interest in comparing these two groups. Theoretically, stents could be more effective because they allow constant lumen dilation over a more extended period than EBD. In the first-ever RCT comparing EBD with SEMS, clinical success was significantly higher in the PC-SEMS group (86% vs. 20% in the EBD group). However, the post-procedural pain was significantly higher in the PC-SEMS group, leading to the premature termination of the study. The study changed the protocol midway to perform a session of EBD-only pre-stent placement in the SEMS group because the first three patients in the SEMS group complained of post-procedural pain. The most recent RCT by Loras et al.[22] compared the outcome of SEMS with EBD in CD with a predominantly fibrotic stricture. The 1-year symptom-free survival with any additional intervention was significantly higher in the EBD group than the SEMS group (80% vs. 51%, p=0.0061) with a similar rate of adverse events (including post-procedural pain). However, for patients with a stricture length >3 cm, the treatment outcome was similar in the two groups.

In a previous meta-analysis on the outcome of EBD for CD-related stricture,[6] the pooled technical and clinical success rates were 90.6% (95% CI, 87.8-92.8) and 70.2% (95% CI, 60-78.8), respectively. The pooled rate of complications and perforation were 6.4% (95% CI, 5.0-8.2) and 3% (95% CI, 2.2-4.0) respectively. The present analysis also showed a similar outcome with stent placement but a significantly lower perforation rate. Hence, given their lower incidence of perforation, SEMS can be used in those with complex and longer strictures and those requiring repeated sessions of EBD.

Despite the low rate of perforation, there are a few practical issues with the use of stents for CD-related strictures. Attar et al.[14] reported that stent retrieval was difficult in one case due to embedment in the stricture requiring surgery, while Loras et al.[17] reported difficult stent retrieval in four out of 17 patients due to stent impaction (two with PC-SEMS and two with FC-SEMS). However, Das et al. reported a 100% success rate for stent removal. Proximal migration of the stent was another complication in two studies. In the first case,[14] the stent could be retrieved after EBD, while the second case[17] required surgery to remove the stent. Hence, the risk of post-procedural pain, embedment, and proximal migration need to be considered and handled if endoscopic stenting should be considered and justified.

This systematic review is limited by the quality of evidence

available, despite the systematic literature search and inclusion of the most recent publications. Most studies were observational with a small sample size, making them susceptible to bias. Selection bias is a reasonable risk in this study, but it is the only published synthesis of the outcome of stenting for CD-related strictures. Although this study compared the outcome of UC-SEMS with other stents, no definite conclusion could be drawn as there was only one study on UC-SEMS. The difference in effect concerning the location and type of stricture could not be assessed. Anastomotic strictures are more likely to be short segments than de-novo strictures. Thus, they are theoretically likely to have a better outcome. Given that the number of anastomotic strictures was higher than de-novo strictures in the included studies, stents may play a greater role in anastomotic strictures than de-novo strictures. Technical success in strictures involving the left colon is expected to be higher than proximal colonic strictures because of the short distance and less angulation. The optimal timing of stent placement for achieving a better outcome could not be evaluated due to premature migration of stents. In addition, the follow-up duration was inconsistent, making it difficult to assess the long-term effects of stenting. Finally, this study could not analyze the predictors of a successful outcome and a detailed, cost-effective analysis. All these limitations are areas for future research.

In conclusion, the place for endoscopic stenting in managing CD-related strictures may need to be redefined. The present analysis provides insight into stent safety and efficacy for managing CD-related strictures. While a clinical success rate of 71.3% indicates short-term benefit, the long-term data on avoidance of surgery needs to be studied. Although the present meta-analysis showed a benefit of PC-SEMS concerning various outcomes, it is underpowered to make definite conclusions. Further studies will be needed to compare the outcome of SEMS with EBD and different stent types before recommending one above the other.

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Supplementary Table 1. MOOSE Guidelines for Meta-analyses and Systematic Reviews of Observational Studies[8]

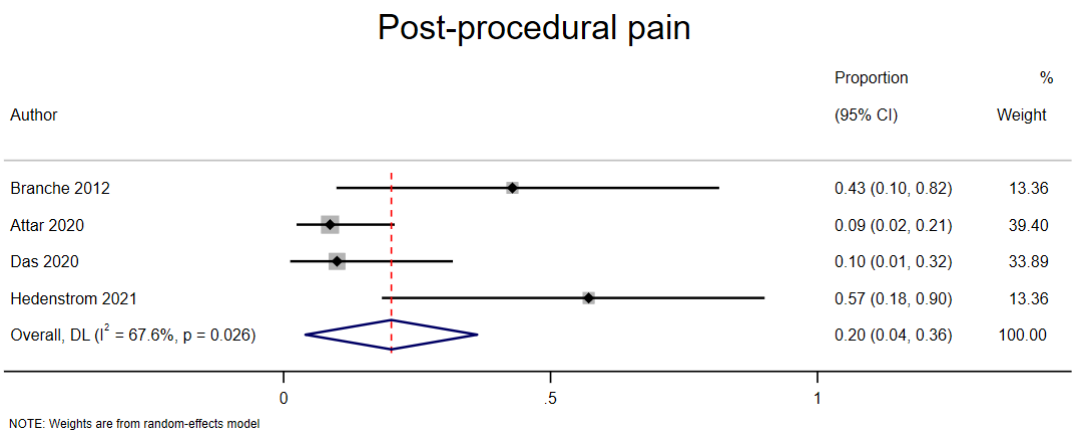
	Topic	Page number
Title	Identify the study as a meta-analysis (or systematic review)	Title page
Abstract	Use the journal's structured format	1
Introduction	Present:	
	The clinical problem	3
	The hypothesis	3
	A statement of objectives that includes the study population, the condition of interest, the exposure or intervention, and the outcome(s) considered	3
Sources	Describe:	
	Qualifications of searchers (eg, librarians and investigators)	4
	Search strategy, including time period included in the synthesis and keywords	4
	Effort to include all available studies, including contact with authors	4
	Databases and registries searched	4
	Search software used, name and version, including special features used (e.g.explosion)	4
	Use of hand searching (e.g, reference lists of obtained articles)	4
	List of citations located and those excluded, including justification	4
	Method of addressing articles published in languages other than English	4
	Method of handling abstracts and unpublished studies	N/A
	Description of any contact with authors	N/A
Study Selection	Describe	
	Types of study designs considered	4
	Relevance or appropriateness of studies gathered for assessing the hypothesis to be tested	4
	Rationale for the selection and coding of data (e.g., sound clinical principles or convenience)	4
	Documentation of how data were classified and coded (e.g., multiple raters, blinding, and inter-rater reliability)	4
	Assessment of confounding (e.g., comparability of cases and controls in studies where appropriate)	4
	Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	4
	Assessment of heterogeneity	5
	Statistical methods (e.g., complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	5
Results	Present	
	A graph summarizing individual study estimates and the overall estimate	Figs. 2-6
	A table giving descriptive information for each included study	Table 1
	Results of sensitivity testing (e.g., subgroup analysis)	6 ,7
	Indication of statistical uncertainty of findings	7
Discussion	Discuss	
	Strengths and weaknesses	10
	Potential biases in the review process (e.g., publication bias)	7
	Assessment of quality of included studies	Supplementary Table 2
	Consideration of alternative explanations for observed results	8, 9
	Generalization of the conclusions (i.e., appropriate for the data presented and within the domain of the literature review)	11
	Guidelines for future research	10
	Disclosure of funding source	Title page

Supplementary Table 2. Assessment of the Study Quality

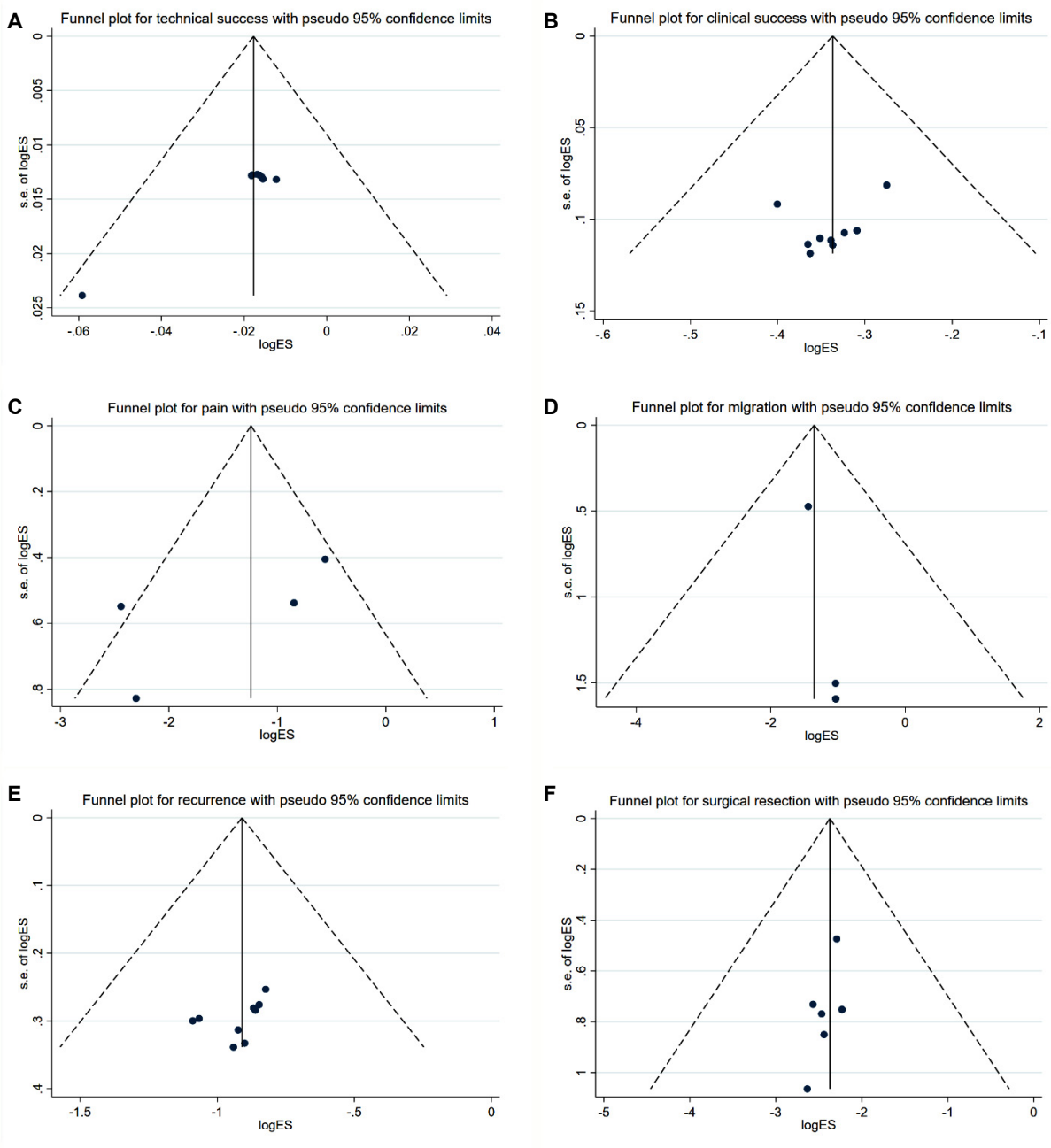
Study	Representative of the average adult in the community	Cohort size	Type of study	Definite information on technical and clinical success	Information reported on adverse events	Length of follow-up	Adequacy of follow-up	Total
	1-point, population-based studies; 0.5-point, multi-center studies; 0-point, single-center hospital-based study	1-point, >30 patients; 0.5-point, 30-15 patients; 0-point, <15 patients	1-point, Prospective; 0.5-point, Ambispective; 0-point, Retrospective	1-point, reported with clarity; 0.5-point if value had to be derived; 0-point, not reported	1-point, adequate information reported; 0-point, not reported	1-point, adequate duration for outcome of interest; 0-point, inadequate or not reported	1-point, all patients accounted for; 0.5-point, <50% not accounted for; 0-point, >50 not accounted for	Maximum, 7; high, >6; medium 4-6; low, <4
Rejchrt et al.[13] (2011)	0	0	1	1	1	1	1	5: Medium
Attar et al.[14] (2012)	0.5	0	1	1	1	1	1	5.5: Medium
Branche et al.[15] (2012)	0	0	1	1	1	1	1	5: Medium
Levine et al.[16] (2012)	0.5	0.5	0	1	1	1	0.5	4.5: Medium
Loras et al.[17] (2012)	0	0	0	1	1	1	0.5	3.5: Low
Karstensen et al.[18] (2016)	0	0	0	1	1	0	1	3: Low
Attar et al.[19] (2021)	0.5	1	0.5	1	1	1	1	6: High
Das et al.[20] (2020)	0	0.5	1	1	1	1	0.5	5: Medium
Hedenström et al.[21] (2021)	0	0	1	1	1	1	1	5: Medium
Loras et al.[22] (2022)	0.5	1	1	0.5	1	1	1	6: High

Supplementary Table 3. Egger's Test for an Assessment of Small-study Effect for Various Outcomes

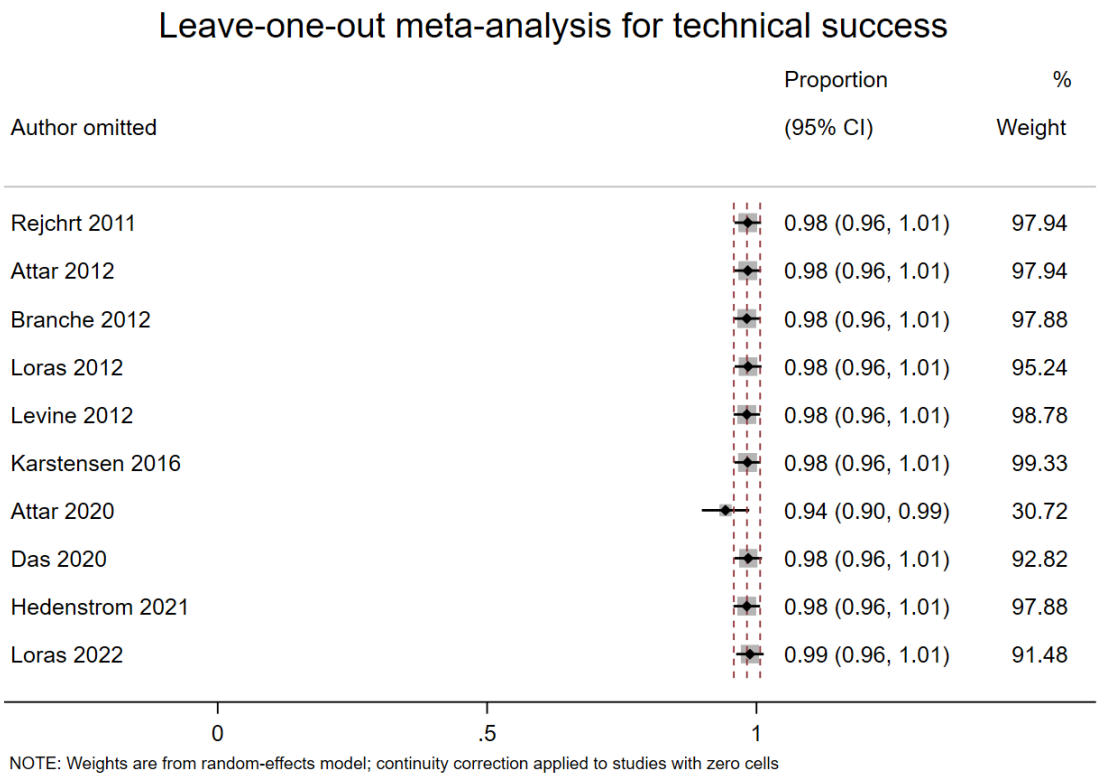
Outcome	Intercept	95% confidence interval		p-value
		Lower limit	Upper limit	
Technical success	-3.817	-4.761	-2.872	0.000
Clinical success	-1.242	-3.756	1.270	0.281
Post-procedural pain	-4.702	-18.994	9.590	0.293
Stent migration	0.375	0.326	0.423	0.001
Recurrence	-1.730	-4.286	0.825	0.157
Surgical resection	-0.447	-1.213	0.318	0.194



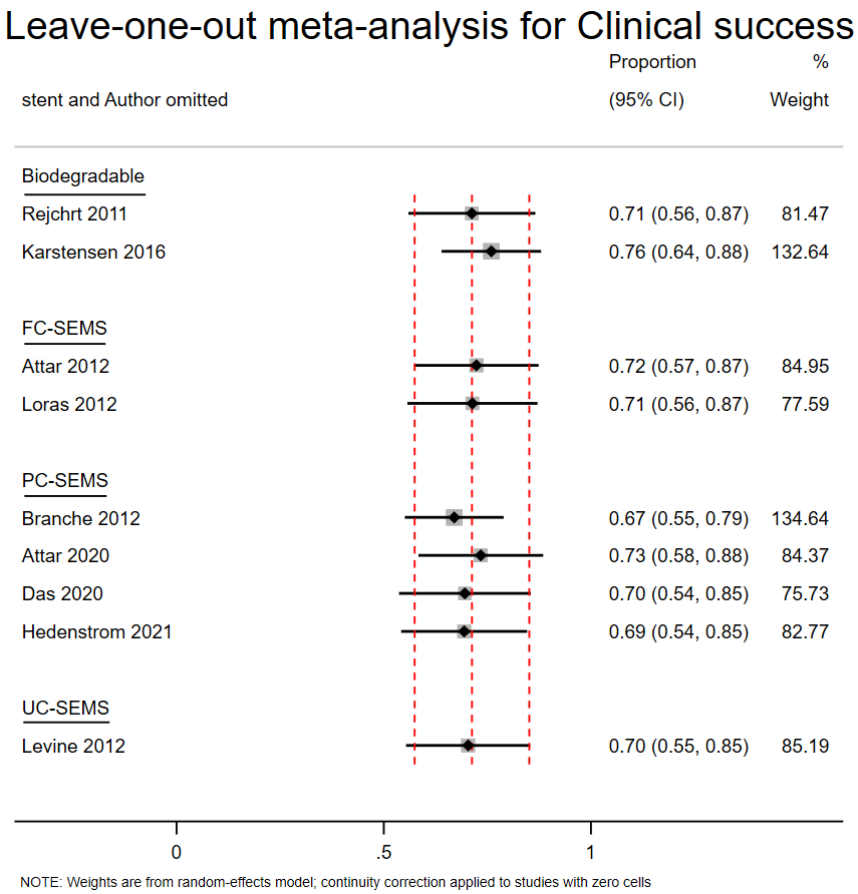
Supplementary Fig. 1. Forest plot for significant post-procedural pain after stent placement.



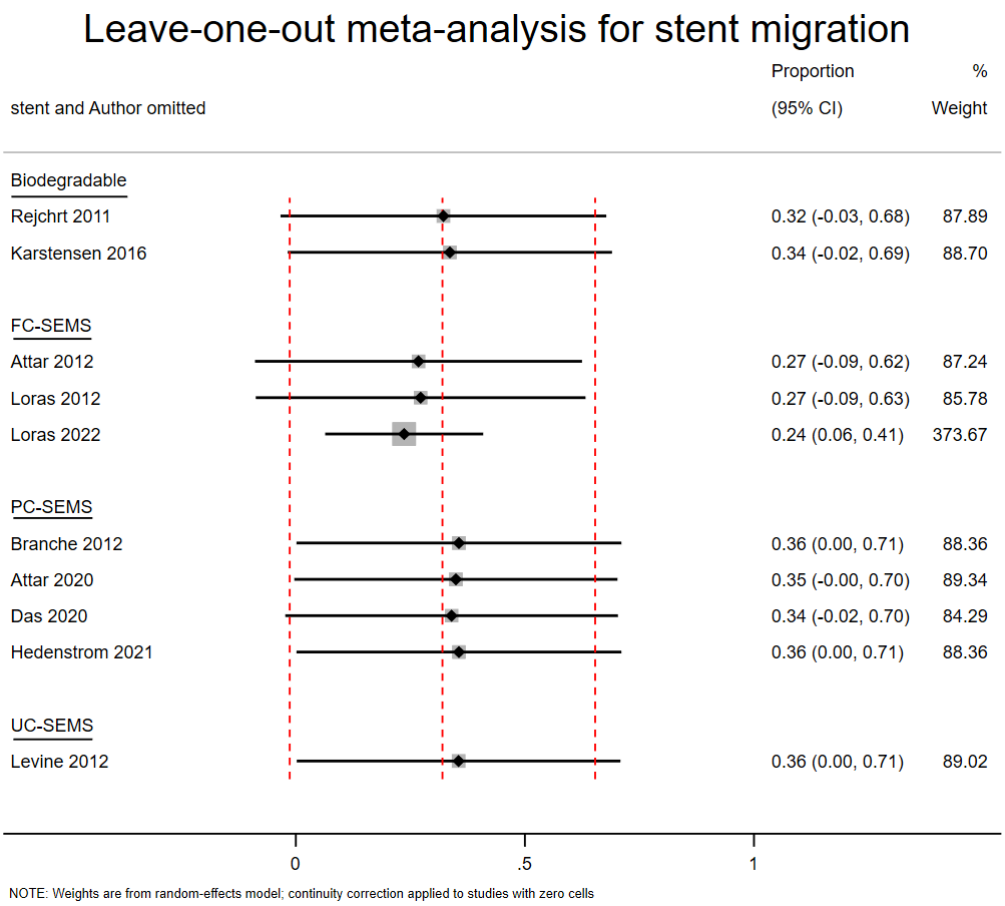
Supplementary Fig. 2. (A-F) Funnel plot for an assessment of publication bias.



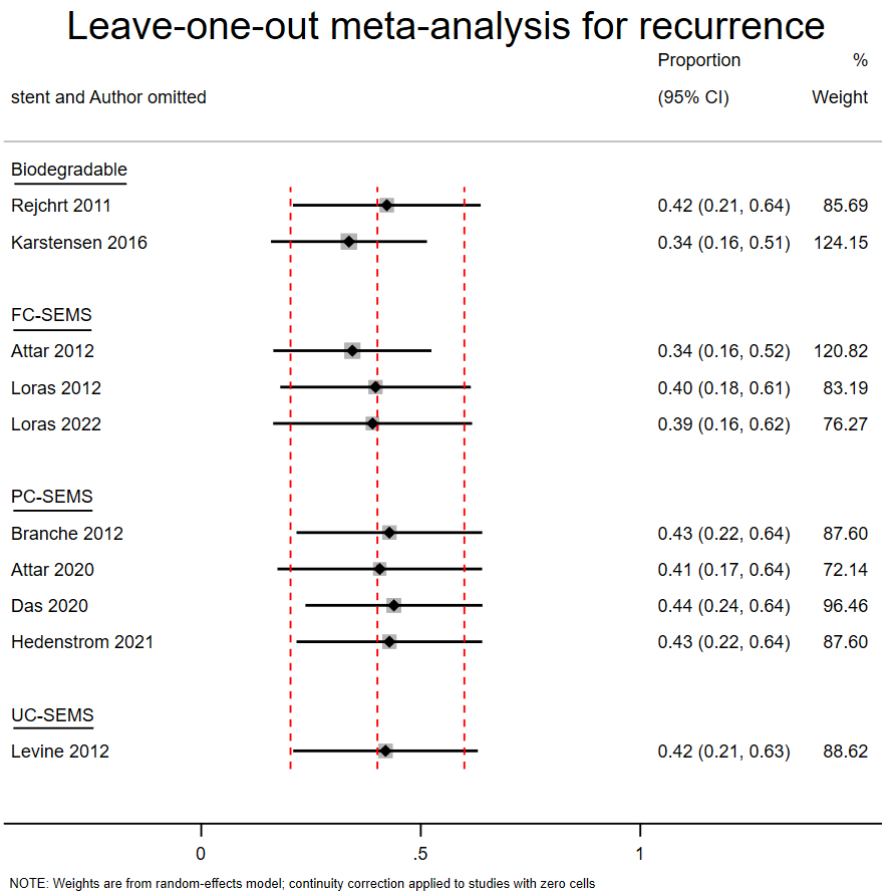
Supplementary Fig. 3. Leave-one-out meta-analysis for the technical success of stenting.



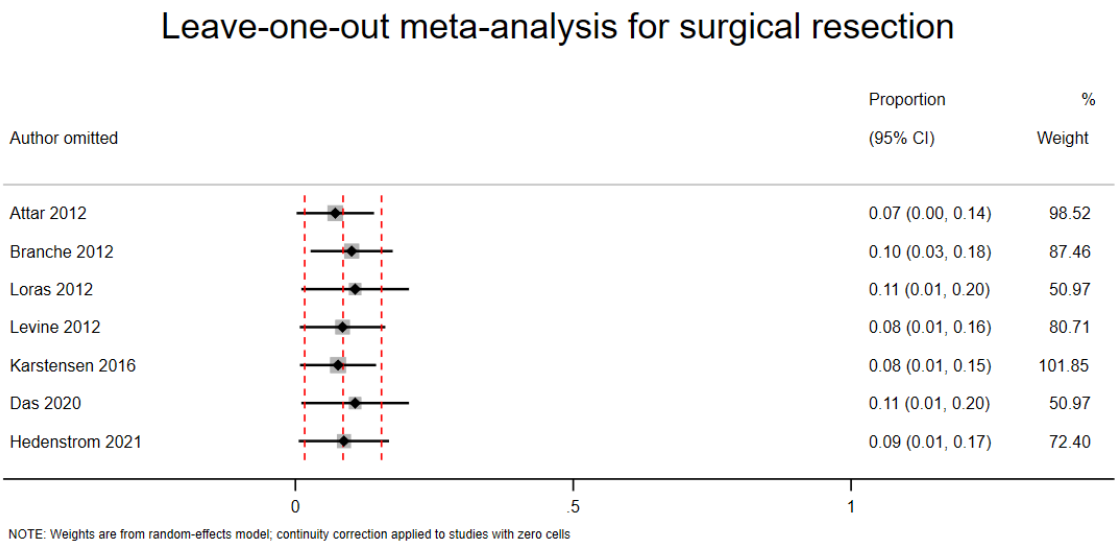
Supplementary Fig. 4. Leave-one-out meta-analysis for the clinical success of stenting.



Supplementary Fig. 5. Leave-one-out meta-analysis for the rate of stent migration.



Supplementary Fig. 6. Leave-one-out meta-analysis for recurrence of stricture symptoms.



Supplementary Fig. 7. Leave-one-out meta-analysis for the rate of surgical resection.