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RESEARCH

Anastomotic configurations and early endoscopic recurrence following ileocolonic resection in Crohn's disease: systematic review and meta-analysis

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Abstract

Purpose Crohn's disease (CD) frequently requires surgery, with ileocolonic resection being the most common procedure. Postoperative endoscopic recurrence remains a major concern, and the role of anastomotic configuration is still debated. This systematic review and meta-analysis aimed to evaluate the impact of different anastomotic techniques on early endoscopic recurrence following ileocolonic resection for CD.

Methods A systematic search of PubMed, Embase, and Web of Science was performed up to July 2025. Studies comparing stapled side-to-side anastomosis (SSA), handsewn end-to-end anastomosis (EEA), and Kono-S anastomosis (KSA) with postoperative endoscopic follow-up at 6–12 months were included. Study quality was assessed using the Newcastle–Ottawa Scale. Pooled analyses were conducted to compare recurrence rates across anastomotic types.

Results Eleven studies were included (four comparing SSA vs. EEA; seven comparing KSA vs. SSA), for a total of 1505 patients. Most were retrospective, with three randomised controlled trials available. In pooled analysis, no significant difference was found between SSA and EEA (48.5% vs. 46.7%, test for overall effect $Z = 0.41$, $p = 0.6795$). KSA showed a trend towards lower recurrences compared with SSA (31.8% vs. 39.8%, test for overall effect $Z = -1.96$, $p = 0.0495$), although heterogeneity in study design, definitions, and postoperative management limits firm conclusions.

Conclusions Current evidence does not support a difference in early endoscopic recurrence between SSA and EEA and a potential but weak overall association with lower recurrences for KSA compared to SSA. Large, high-quality prospective trials with standardised definitions, postoperative medical therapy, and follow-up protocols are warranted to clarify the true impact of anastomotic configuration on outcomes in CD.

Keywords Crohn's disease · Endoscopic recurrence · Side-to-side anastomosis · End-to-end anastomosis · Kono-s anastomosis

Introduction

Crohn's disease (CD) is a chronic inflammatory bowel disorder characterised by transmural inflammation and a relapsing–remitting course. Up to 70–80% of patients require surgery during their lifetime, most commonly ileocolonic resection [1, 2]. However, endoscopic recurrence occurs in 5–93% of cases within 12 months, and approximately 18% of patients undergo repeat surgery within 5 years due to symptomatic anastomotic stenosis [3, 4]. Immunosuppressive agents and biologics can reduce recurrence rates; therefore, early postoperative initiation—within 8 weeks—is suggested for patients at high risk [5]. Consequently, guidelines recommend early postoperative colonoscopy within 6–12 months after resection to assess for recurrence and to guide initiation or adjustment of medical therapy [5, 6]. Importantly, early endoscopic recurrence assessed within

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6–12 months represents a clinically relevant endpoint, as it directly informs postoperative risk stratification and therapeutic escalation. Focusing on this early time window allows evaluation of surgical factors, such as anastomotic configuration, before longer-term disease progression and treatment intensification become dominant confounders.

Most recurrences occur at the anastomotic site, suggesting a link between anastomotic configuration and disease recurrence [7]. Over the past two decades, substantial research has aimed to optimise surgical techniques to reduce recurrence, investigating factors such as construction method (stapled vs. handsewn), lumen diameter, and configuration, with conflicting results [7–12]. In recent years, Kono et al. introduced a technique designed to exclude the mesentery—implicated in CD pathogenesis and recurrence—and to create a wide lumen to minimise distortion and stenosis [13]. The advent of the Kono-S anastomosis (KSA) renewed interest in the influence of anastomotic configuration on recurrence, prompting a growing body of comparative studies between conventional stapled side-to-side anastomosis (SSA) and the KSA [14–18]. In this context, a focused assessment of the impact of anastomotic configuration on early endoscopic recurrence, using a homogeneous and guideline-driven definition of follow-up, is useful to better clarify its true clinical relevance.

This systematic review and meta-analysis critically appraises the evidence on different anastomotic configurations, focusing on their impact on early endoscopic recurrence, and explores the implications for surgical practice.

Materials and methods

A systematic review was conducted in accordance with the PRISMA 2020 guidelines for the reporting of systematic reviews [19]. The protocol was registered (registration number: CRD420251127888) a priori in the International Prospective Register of Systematic Reviews (PROSPERO, https://www.crd.york.ac.uk/PROSPERO/view/CRD420251127888). Included were articles comparing end-to-end anastomosis (EEA), end-to-side anastomosis (ESA), SSA, or KSA, in which recurrences were detected by early postoperative endoscopy (6–12 months) following ileocolonic resection and could be clearly attributed to one anastomotic technique or another. Excluded were studies in which the surgical indication was not CD, those in which endoscopy was performed more than 12 months postoperatively, or in which endoscopic recurrences could not be clearly attributed to the anastomotic technique. Studies lacking detailed information on the surgical approach, case reports, correspondence, letters to the editor, editorials, video vignettes, and studies not involving human subjects were also excluded. Reviews, systematic reviews, and meta-analyses were screened for additional references and further discussed in the text.

The literature search was conducted across three major electronic databases: PubMed, Embase, and Web of Science databases. The search strategy included a combination of keywords related to the disease such as "*Crohn's disease*," terms related to the procedure such as "*ileocolonic resection*","*end-to-end anastomosis*", "*side-toside anastomosis*", "*side-to-side anastomosis*", "*Kono-S anastomosis*", and terms related to outcomes such as "*endoscopy*", "*colonoscopy*" "*recurrence*". Each database was last consulted on the 30th of July 2025. Two reviewers (AV and GGa) independently screened titles and abstracts to identify potentially eligible studies. Full texts were retrieved for all studies meeting the inclusion criteria or for which eligibility was unclear. Disagreements at any stage of the screening process were resolved through discussion, and when necessary, a third reviewer (GGr) was consulted to reach consensus.

Studies were categorized into two groups according to the anastomotic technique used: those not involving the KSA (i.e., EEA vs. SSA) and those involving the KSA (i.e., KSA vs. SSA). Data from each included study were extracted using a standardized form specifically developed for this systematic review and allocated to the appropriate group. Extracted variables included year of publication, number of patients, anastomotic technique, endoscopic follow-up timing, endoscopic recurrences, and statistical significance between groups. Study quality and risk of bias were independently assessed by two authors (AV and GGa) using Version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2) for RCTs and the Newcastle–Ottawa Scale for non-RCTs [20].

Outcomes

Primary outcomes of the study were to evaluate the early endoscopic recurrence rates according to the anastomotic technique, differentiating the analysis into two subgroups: EEA vs. SSA and KSA vs. SSA.

Statistical analysis

All data were stored using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and analysed with SPSS version 26 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies and percentages. Analysis of comparison between groups was conducted with the Chi-Square test for categorical variables (Fisher's exact test if the counts in cells were inferior to 5). The meta-analysis of pooled results was conducted using a fixed effect model. When at least two studies were available, subgroup meta-analyses were conducted separately for RCTs and

non-RCTs. p value less than 0.05 was considered statistically significant.

Results

A PRISMA flow diagram outlining the study selection process is presented in Fig. 1. After screening titles, abstracts, and references, 11 articles published between 2009 and 2025 met the eligibility criteria and were included in this systematic review (1505 patients; Table 1) [8, 10, 11, 14, 16, 21–26]. Four studies involved SSA vs. EEA [8, 10, 11, 21], seven studies KSA vs. SSA [14, 16, 22–26]. All included studies were retrospective, with the exception of three randomised controlled trials (RCTs) [10, 16, 25]. Two KSA series were compared against historical SSA cohorts [14, 23]. Additionally, two studies were available only as conference abstracts [24, 25].

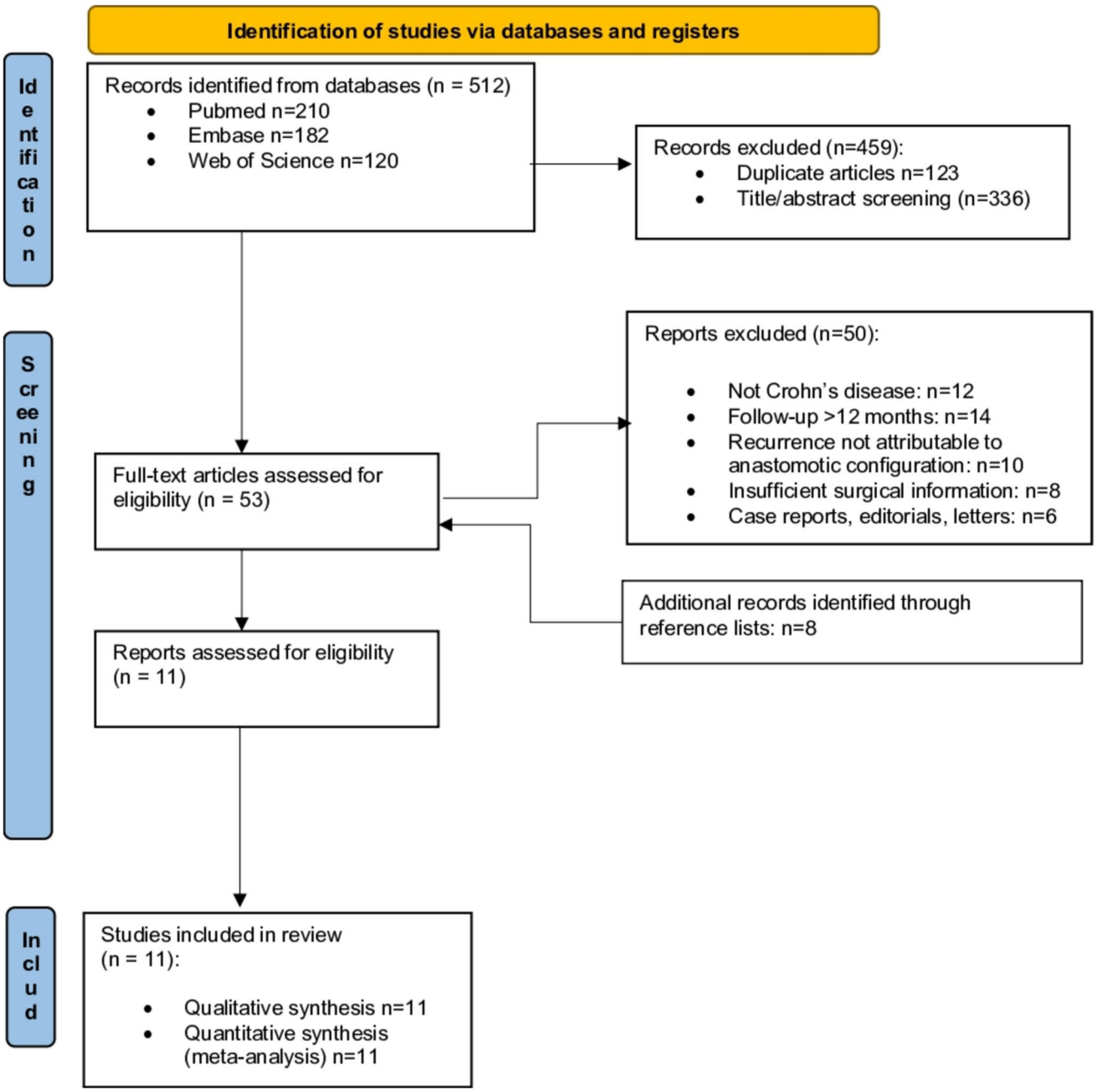

Fig. 1 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flow diagram

Table 1 Studies comparing side-to-side, end-to-end and Kono-S anastomosis. SSA, side-to-side anastomosis; EEA, end-to-end anastomosis, KSA, Kono-S anastomosis; RCT, Randomised controlled trial. * = KSA patients recruited prospectively, SSA derived from historical controls. ** = conference paper

Study	Year	Country	Setting	Type of study	No of patients	Sex (men, %)	Age (years)	Endoscopy follow-up (months)
Mcleod et al. [10]	2009	Canada	Multicentric	RCT	84 SSA 86 EEA	30 (35.7%) SSA 32 (37.2%) EEA	40 SSA 38 EEA	11.9
De Barcelos et al. [8]	2017	Brazil	Multicentric	Retrospective	94 SSA 33 EEA	75 (59.1%)	33±1	6–12
Thin et al. [21]	2021	Australia	Multicentric	Retrospective	37 SSA 55 EEA	49 (53.3%)	41±2	12
Bislenghi et al. [11]	2023	Belgium	Single centre	Retrospective	76 SSA 51 EEA	36 (47.4%) SSA 16 (31.4%) EEA	31 SSA 33 EEA	6
Luglio et al. [16]	2021	Italy	Single centre	RCT	36 KSA 43 SSA	18 (50.0%) KSA 22 (51.2%) SSA	34 (25–50) KSA 43 (27–60) SSA	6
Kelm et al. [22]	2022	Germany	Single centre	Retrospective	22 KSA 29 SSA	14 (63.6%) KSA 14 (48.3%) SSA	37 (20–62) KSA 37 (16–71) SSA	9
Alibert et al. [23]*	2024	France	Multicentric	Prospective/ Hystorical	61 KSA 122 SSA	26 (42.6%) KSA 55 (45.1%) SSA	37 (31–50) KSA 34 (27–45) SSA	7
Tyrode et al. [14]*	2024	France	Single centre	Prospective/ Hystorical	30 KSA 55 SSA	13 (43.3%) KSA 19 (34.5%) SSA	32 (26–43) KSA 36 (28–48) SSA	6 to 12
Uchino et al. [24]**	2024	United States	Single centre	Retrospective	83 KSA 91 SSA	-	-	12
Trencheva et al. [25]**	2024	-	Multicentric	RCT	154 KSA 134 SSA	-	-	3–6
Song T et al. [26]	2025	China	Single centre	Retrospective	63 KSA 66 SSA	47 (75%) KSA 91 (67%) SSA	34 (27−46) KSA 33 (26−42) SSA	-

SSA vs. EEA

This topic has been addressed in several individual studies (Tables 1, 2) [8, 10, 11, 21] and meta-analyses [9, 27–29]. The majority of individual studies reported were retrospective [8, 11, 21], involved small series, and only one RCT has been published to date [10]. Recurrence was defined as a Rutgeerts score or Modified Rutgeerts score ≥ i2. Overall, the results showed either no significant difference between the two configurations or a trend toward lower endoscopic recurrence rates in patients undergoing EEA (Table 2). The only RCT available—the CAST trial from North America—compared EEA and SSA in terms of disease recurrence rates, operative outcomes, and postoperative complications [13].

Table 2 Individual and pooled results of the meta-analysis

Study	SSA	CI95% (min–max)	EEA	CI95% (min–max)	*p*
Mcleod et al. [10]	32/84 (37.9%)	(27.5%–48.3%)	37/86 (42.5%)	(32.1%–52.9%)	0.55
De Barcelos et al. [8]	30/94 (32.0%)	(22.6%–41.4%)	13/33 (39.0%)	(22.4%–55.6%)	0.57
Thin et al. [21]	19/37 (51.4%)	(35.3%–67.5%)	18/55 (32.7%)	(20.3%–45.1%)	0.09
Bislenghi et al. [11]	60/76 (78.9%)	(69.7%–88.1%)	37/51 (72.5%)	(60.2%–84.8%)	0.37
Total	**141/291 (48.5%)**	**(42.8%–54.2%)**	**105/225 (46.7%)**	**(40.2%–53.2%)**	**0.61**
Study	KSA	CI95% (min–max)	SSA	CI95% (min–max)	p
Luglio et al. [16]	8/36 (22.2%)	(8.6%–35.8%)	27/43 (62.8%)	(48.4%–77.2%)	0.001
Kelm et al. [22]	7/22 (31.8%)	(12.3%–51.3%)	13/29 (44.8%)	(26.7%–62.9%)	0.36
Alibert et al. [23]	29/61 (47.5%)	(35.0%–60.0%)	54/122 (44.3%)	(35.5%–53.1%)	0.67
Tyrode et al. [14]	17/30 (56.7%)	(39.0%–74.4%)	27/55 (49.1%)	(35.9%–62.3%)	0.55
Uchino et al. [24]	25/83 (30.0%)	(20.1%–39.9%)	32/91 (35.0%)	(25.2%–44.8%)	0.81
Trencheva et al. [25]	49/154 (31.6%)	(24.3%–38.9%)	45/134 (33.3%)	(25.3%–41.3%)	0.88
Song T et al. [26]	8/63 (12.7%)	(4.5%–20.9%)	17/66 (25.4%)	(14.9%–35.9%)	0.07
Total	**143/449 (31.8%)**	**(27.5%–36.1%)**	**215/540 (39.8%)**	**(35.7%–43.9%)**	**0.01**

Patients were stratified according to postoperative medical management, initially with 5-aminosalicylic acid during early recruitment, and subsequently with azathioprine. On multivariate analysis, a history of multiple previous intestinal resections was the only independent factor associated with recurrence; however, the trial was underpowered relative to its original design and was closed prematurely [10]. Similarly, another RCT from Germany, primarily aimed at evaluating the impact of the two anastomotic techniques on endoscopic recurrence rates, was also terminated early following recommendations for postoperative azathioprine prophylaxis in all complicated CD cases; no data were reported on endoscopic recurrence [30].

Several meta-analyses also compared SSA and EEA in terms of short- and long-term complications, including endoscopic and clinical recurrence [9, 27–29]. Guo et al. and Simillis et al. which included three and five studies respectively, focused solely on endoscopic recurrence and found no significant difference in perianastomotic recurrence between the two techniques [9, 27]. In contrast, He et al. in a larger meta-analysis involving 821 patients, reported a significantly lower incidence of both endoscopic and clinical recurrence with SSA compared to EEA [29]. In our pooled analysis, no significant difference in early endoscopic recurrence was observed between SSA and EEA (48.5% vs. 46.7%—test for overall effect Z = 0.41,

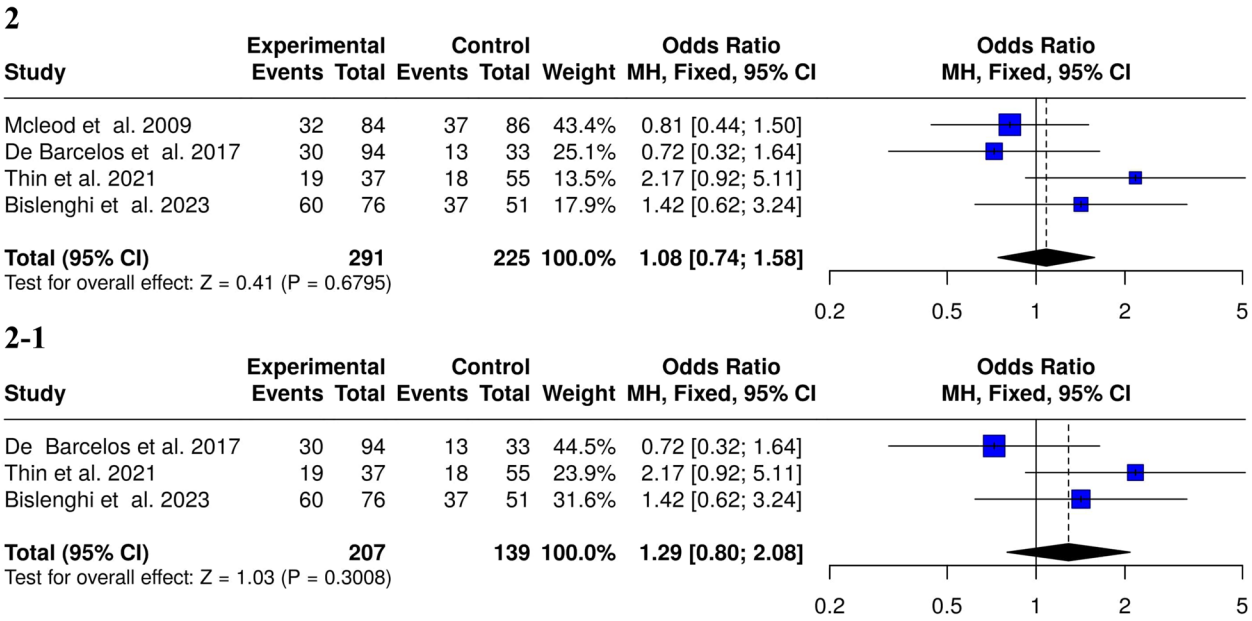

Fig. 2 Standard forest plots showing results of side-to-side anastomosis (SSA) vs. end-to-end anastomosis (EEA) for the Odds Ratio of postoperative early endoscopic recurrences. The estimated mean Odds Ratio and 95% Confidence Intervals are shown for each study, and the overall estimated Odds Ratio is indicated by the dotted line. The fixed effect was used

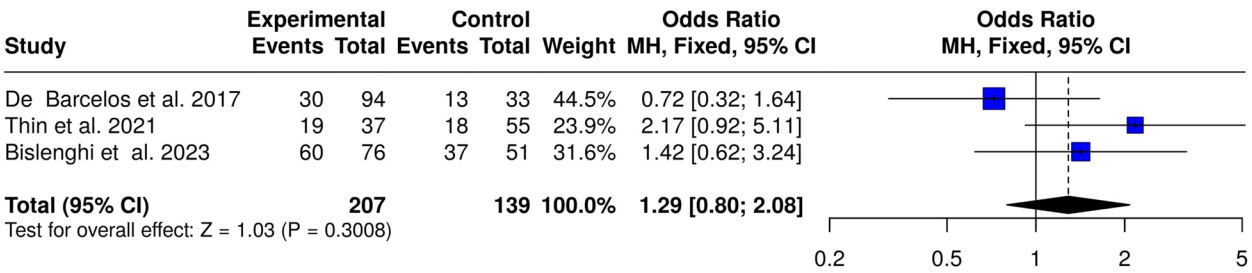

Fig. 3 Standard forest plots showing results of side-to-side anastomosis (SSA) vs. end-to-end anastomosis (EEA) for the Odds Ratio of postoperative early endoscopic recurrences in non-RCTS studies. The estimated mean Odds Ratio and 95% Confidence Intervals are shown for each study, and the overall estimated Odds Ratio is indicated by the dotted line. The fixed effect was used

$p = 0.6795$; Table 2, Fig. 2). A subgroup meta-analysis of non-RCT studies ($n = 3$) confirmed these findings (Fig. 3).

KSA vs. SSA

Due to the limited data available at the time of drafting, the ECCO guidelines did not consider the KSA [6]. The first clinical KSA results, published in 2011, compared 69 patients who underwent KSA with 73 historical controls receiving a conventional anastomosis [13]. The 1-year rate of endoscopic recurrence at the anastomotic site was similar between groups (83% vs 79%), but the median endoscopic recurrence score was significantly lower with KSA (2.6 vs 3.4; $p = 0.008$). Kaplan–Meier analysis also demonstrated a lower probability of surgical recurrence in the KSA group (0% vs 15%; $p = 0.0013$).

The SuPREMe-CD trial is the only RCT currently available that has compared KSA ($n = 36$) with SSA ($n = 46$) in CD patients with medically refractory disease or stricturing/penetrating complications [16]. The primary endpoint was endoscopic recurrence at 6 months (Rutgeerts score ≥ i2), with secondary endpoints including clinical recurrence at 12 and 24 months, endoscopic recurrence at 18 months, and surgical recurrence at 24 months. KSA significantly reduced endoscopic recurrence at 6 months compared to SSA (22.2% vs 62.8%; $p = 0.001$; Table 2), with consistent benefits for endoscopic recurrence at 18 months and clinical recurrence at 24 months. On logistic regression, KSA emerged as the only variable independently associated with reduced recurrence risk [16]. Except for the SuPREMe-CD RCT, most studies did not demonstrate a statistically significant advantage for KSA over SSA (Table 2). The majority of these were small retrospective series. Moreover, heterogeneity in study design limits the interpretability of the results: definitions of endoscopic recurrence varied (e.g., > i2, > i2b), central reading of histologic specimens was absent in most studies, timing of endoscopic follow-up differed, anastomotic construction methods varied (stapled vs. hand-sewn in the SSA group), postoperative medical therapy (including biologics and anti-TNF agents) was inconsistent, and in several cases, KSA patients were compared with historical cohorts.

Conflicting results have also emerged from previous KSA meta-analyses [17, 31, 32]. Ng et al. (676 patients) found no significant superiority of KSA over conventional anastomoses in endoscopic recurrence (OR 0.46; 95% CI 0.06–3.45; $p = 0.45$) [31], Nardone et al. (2087 patients) observed a non-significant trend favouring KSA over ESA and SSA (24.7% vs 31.9% vs 40.1%; $p = 0.09$) [15], whereas Lin et al. (1501 patients) reported a modest but significant reduction in recurrence with KSA (41% vs 48%; 95% CI 0.73–1; $p = 0.05$) [32]. In our pooled analysis, a potential but weak overall association with less early endoscopic recurrence was observed for KAS compared to SSA (31.8% vs.39.8%—test for overall effect $Z = -1.96$, $p = 0.0495$; Table 2, Fig. 2). These results were confirmed in the subgroup meta-analysis of RCTs ($n = 2$; Figs. 4, 5), but not in non-RCTs ($n = 5$; Fig. 6).

Quality analysis

Among the three available RCTs, only the SuPREMe-CD trial showed a low overall risk of bias [16], while the CAST trial and the study by Trencheva et al. were judged at high risk (Table 3) [10, 25]. According to the Newcastle–Ottawa Scale (Table 4), non-RCTs' studies demonstrated high methodological quality: cohorts generally included consecutive CD patients undergoing ileocolic resection, outcomes were consistently defined by the Rutgeerts score, and multivariable analyses accounted for key confounders (e.g., smoking, anastomotic technique, postoperative therapy). The main limitations were incomplete endoscopic follow-up

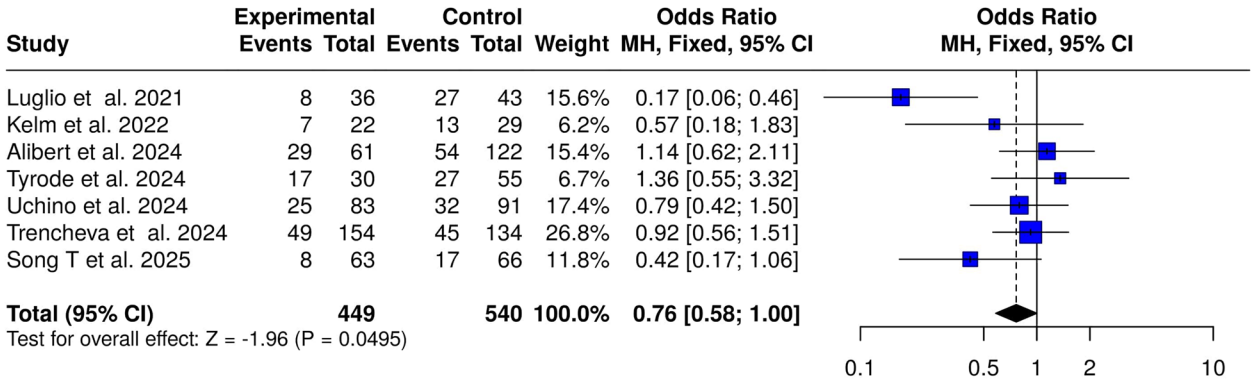

Fig. 4 Standard forest plots showing results of Kono-S anastomosis (KSA) vs. side-to-side anastomosis (SSA) for the Odds Ratio of postoperative early endoscopic recurrences. The estimated mean Odds Ratio and 95% Confidence Intervals are shown for each study, and the overall estimated Odds Ratio is indicated by the dotted line. The fixed effect was used

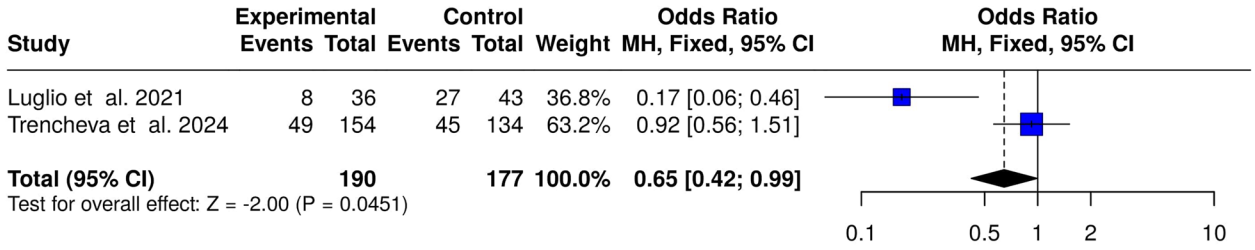

Fig. 5 Standard forest plots showing results of Kono-S anastomosis (KSA) vs. side-to-side anastomosis (SSA) for the Odds Ratio of postoperative early endoscopic recurrences in RCTS studies. The estimated mean Odds Ratio and 95% Confidence Intervals are shown for each study, and the overall estimated Odds Ratio is indicated by the dotted line. The fixed effect was used

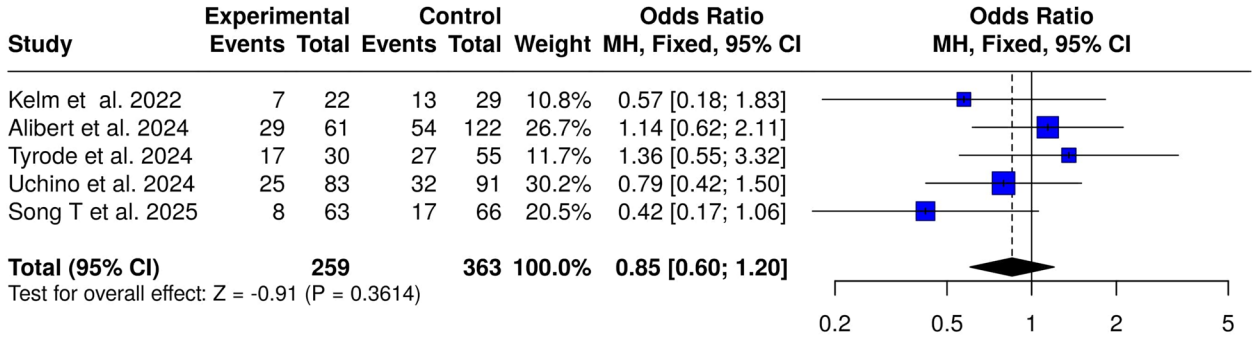

Fig. 6 Standard forest plots showing results of Kono-S anastomosis (KSA) vs. side-to-side anastomosis (SSA) for the Odds Ratio of postoperative early endoscopic recurrences in non-RCTS studies. The estimated mean Odds Ratio and 95% Confidence Intervals are shown for each study, and the overall estimated Odds Ratio is indicated by the dotted line. The fixed effect was used

Table 3 Quality control of randomised controlled trials using the Version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2)

Study	Randomization	Deviations	Missing data	Outcome measurement	Reporting bias	Overall
Mcleod et al. (10)	+	−	×	+	−	×
Luglio et al. (16)	+	+	+	+	+	+
Trencheva et al. (25)*	−	−	−	−	×	×

(with >20% of patients often missing scheduled colonoscopy), potential selection bias from these exclusions, use of historical controls in some cohorts (temporal bias), and heterogeneity in endpoint definitions (Rutgeerts i2 vs. modified i2a/i2b).

Discussion

The type of surgical anastomosis performed after ileocecal resection in CD represents a truly modifiable factor and warrants particular attention. Fecal stasis and bacterial overgrowth play a pivotal role in disease recurrence, and the anastomotic lumen—hence its configuration—has a direct influence on the fecal stream. Restoration of bowel continuity after ileocecal resection for CD can be achieved through various anastomotic configurations, performed either with hand-sewn or stapled techniques, most commonly in an EEA or SSA fashion. Table 5 summarizes the technical features of the four main anastomotic types, highlighting their theoretical advantages, disadvantages, and potential pitfalls that may predispose to endoscopic recurrence. SSA and KSA create a wide lumen; however, their saccular configuration may promote fecal stasis, which has been hypothesized as a risk factor for endoscopic recurrence [33]. The emphasis on early endoscopic

Table 4 Quality control of non-randomised controlled trials using the Newcastle–Ottawa scale

	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Outcome not present at baseline	Comparability of cohorts	Assessment of outcome	Follow-up long enough	Adequacy of follow-up of cohorts	POINTS	Quality rating
De Barcelos et al. (8)	+	+	+	+	+	+	+	−	8/9	Good
Thin et al. (21)	+	+	+	+	+	+	+	−	8/9	Good
Bislenghi et al. (11)	+	+	+	+	+	+	+	−	8/9	Good
Kelm et al. (22)	+	+	+	+	+	+	+	−	8/9	Good
Alibert et al. (23)	+	+	+	+	+	+	+	−	8/9	Good
Tyrode et al. (14)	+	+	+	+	+	+	+	−	8/9	Good
Uchino et al. (24)*	+	+	+	+	+	+	+	+	9/9	Very Good
Song T et al. (26)	+	+	+	+	+	+	+	−	8/9	Good

Table 5 Anastomosis technique after ileocolic resection and theoretical advantages and disadvantages

Technique	Advantages	Disadvantages
Stapled Side-to-Side (SSA)	- Fast and easy to perform - Lower leak rate and overall complications rate - Reduced operative time	- Higher costs - Potential for ischemia (if not properly aligned) - Might predispose to fecal stasis
Handsewn End-to-End (EEA)	- Anatomically physiological - Potential for better mucosal healing - Lower costs	- Longer operative time - Smaller lumen if inappropriately made - Tension risk in retracted segments
Handsewn End-to-Side (ESA)	- Useful when bowel ends are too different in size - Good blood supply - May help preserve bowel length	- Higher risk of stenosis - Technically more demanding
Kono-S (KSA)	- Wide, antimesenteric, hand-sewn anastomosis - May reduce tension and ischemia - Maintains normal anatomy and motility	- Technically complex/longer learning curve - Requires advanced surgical skills - Might predispose to fecal stasis

recurrence in our analysis is not merely methodological but reflects current clinical practice, where colonoscopy at 6–12 months represents the key decision point for post-operative management. By restricting the analysis to this early phase, we aimed to reduce heterogeneity related to follow-up duration and to better isolate the potential effect of anastomotic configuration, before subsequent disease evolution and medical escalation obscure surgical influences. Within this framework, any observed signal favoring one anastomotic configuration over the other may reflect a true early protective effect at the anastomotic site, which could have been diluted in previous meta-analyses including later or composite outcomes.

Handsewn ESA is rarely used due to its high risk of stenosis, technical complexity, and the paucity of data available in the literature.

EEA does not promote fecal stasis due to its linear configuration, but its narrower lumen could predispose to stenosis. Notably, variations in EEA technique exist: if no widening of the small bowel limb is performed, the risk of stenosis is likely to increase [34]. A recent two-center U.S. cohort study employing a stapled ESA reported a two-year overall recurrence-free and endoscopic recurrence-free survival of 74% and 85%, respectively, with 67% of patients receiving postoperative anti-TNF prophylaxis [35]. Nevertheless, recent studies have failed to demonstrate a significant association between anastomotic configuration and postoperative stenosis [34, 36].

Before the widespread adoption of the KSA, most studies focused on comparing SSA and EEA, the two most frequently performed configurations after ileocecal resection for CD. In 2020, ECCO published evidence-based guidelines [6] recommended stapled SSA anastomosis for small-bowel or ileocolic reconstruction. This recommendation was supported by technical simplicity, lower complication rates, and, according to available evidence [21, 29, 37], reduced rates of both endoscopic and clinical recurrence. Our meta-analysis confirms the absence of significant differences in early endoscopic recurrence between SSA and ESA. Importantly, by applying stricter inclusion criteria based on current guidelines [5, 6], we achieved greater homogeneity among the included studies and improved the reliability of the results.

At the time of the ECCO guidelines, evidence for KSA was limited; despite initial encouraging findings, the technical complexity of KSA initially limited its widespread adoption [18, 38]. Over the following years, however, several individual studies compared KSA with SSA in terms of both endoscopic and clinical recurrence [14, 16, 22, 23, 26] and their results were subsequently analysed in systematic reviews/meta-analyses [15, 17, 31, 32, 39, 40]. Heterogeneity in the individual studies made it difficult to draw firm conclusions (Table 2). Furthermore, the wide variability observed in recurrence rates (5–93%) raised concerns over the consistency of endoscopic scoring. The Rutgeerts score was originally developed for hand-sewn techniques and later modified to account for staple-line ulcers [41]. Inverted stapled anastomoses (serosa–serosa) often develop ulcerations along the staple line—first described in the 1990s—which may be misclassified as recurrence, a phenomenon less common in hand-sewn EEA or KSA (mucosa–mucosa) anastomoses [42, 43]. The choice between the original and modified Rutgeerts score can alter recurrence estimates by up to 20%, largely due to interobserver variability, absence of central reading of histological specimens, and differences in anastomotic healing [4]. Two recent French studies comparing KSA with mainly hand-sewn conventional anastomoses failed to show a significant advantage for KSA, supporting the above hypothesis [14, 22]. Definitive evidence is expected from two ongoing RCTs comparing hand-sewn EEA with KSA, and stapled SSA with KSA [44]. Our meta-analysis adopted the same inclusion criteria as Lin et al., in contrast to previous meta-analyses that applied broader criteria (e.g., endoscopic assessment beyond 12 months or composite outcomes including endoscopic, clinical, and surgical follow-up) [15, 31]. Consistently, our results confirmed a potential but weak overall association with a reduction in endoscopic recurrence rates following KSA compared to SSA (Figs. 4, 6).

This study has several limitations that should be acknowledged. First, only a limited number of the included studies were RCTs, reflecting the overall scarcity of high-quality comparative evidence on anastomotic configuration in Crohn's disease. In addition, two studies addressing this topic were available only as conference abstracts at the time of our search, including one randomized controlled trial with prospective design, and they become a significant contribution when, in the specific context of Kono-S anastomosis, the available literature remains limited. These abstracts were included to avoid selective reporting and publication bias, and to provide a comprehensive overview of all available comparative evidence on early endoscopic recurrence, but their presence is acknowledged as a limitation. Second, heterogeneity in the definition of endoscopic recurrence (original versus modified Rutgeerts score), postoperative treatment, lack of central endoscopic or histological reading introduced variability across studies. However, the limited studies available prevented a reliable subgroups analysis. Third, some cohorts relied on historical controls, raising concerns regarding temporal bias, while postoperative medical therapy was inconsistently reported or applied, limiting the ability to isolate the independent effect of anastomotic configuration. Finally, not all studies consistently reported outcomes stratified by anastomotic technique, introducing a potential selection bias. For these reasons, large, high-quality prospective randomized trials with standardized definitions, uniform follow-up protocols, and consistent reporting of postoperative medical management are urgently needed.

Conclusions

Unlike previous meta-analyses, which included multiple sources of heterogeneity such as broader endoscopic follow-up periods, different histological assessments, scoring systems, and variable postoperative treatments, our study sought to address at least one of these factors by applying stricter inclusion criteria for endoscopic follow-up, in line with current guidelines. By focusing on early endoscopic recurrence (6–12 months post-surgery), our analysis appeared to highlight a potential benefit of Kono-S anastomosis (KSA) in reducing early recurrence, an effect that

may have been partially obscured in prior analyses. Considering the remaining sources of heterogeneity, definitive confirmation will require larger, high-quality RCTs with more selective and standardized inclusion criteria, particularly with respect to outcome assessment and postoperative management.

Author contributions AV, GGa, GGr, VDS & PS contributed equally to this work: substantial contributions to the conception and design of the work, acquisition, analysis and interpretation of data for the work, draughting and revising the work critically for important intellectual content. Final approval of the version to be published. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy and integrity of any part of the work were appropriately investigated and resolved. GP & AGG: analysis and interpretation of data for the work, revising the work critically for important intellectual content. Final approval of the version to be published. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy and integrity of any part of the work were appropriately investigated and resolved. All the other authors: revising the work critically for important intellectual content. Final approval of the version to be published. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy and integrity of any part of the work were appropriately investigated and resolved.

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Data availability The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. This article does not contain any studies using animals.

Informed consent Not required.

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