

SYSTEMATIC REVIEW

Different segmental resection techniques and postoperative complications in patients with colorectal endometriosis: A systematic review

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Abstract

Introduction: The aim of this study was to analyze the available literature by conducting a systematic review to assess the possible effects of nerve-sparing segmental resection and conventional bowel resection on postoperative complications for the treatment of colorectal endometriosis.

Material and methods: Pubmed, Clinical [Trials.gov](https://www.trials.gov), Cochrane Library, and Web of Science were comprehensively searched from 1997 to 2021 in order to perform a systematic review. Studies including patients undergoing segmental resection for colorectal endometriosis including adequate follow-up, data on postoperative complications and postoperative sequelae were enrolled in this review. Selected articles were evaluated and divided in two groups: Nerve-sparing resection (NSR), and conventional segmental resection not otherwise specified (SRNOS). Within the NSRs, studies mentioning preservation of the rectal artery supply (artery and nerve-sparing SR – ANSR) and not reporting preservation of the artery supply (NSR not otherwise specified – NSRNOS) were further analyzed. PROSPERO ID: CRD42021250974.

Results: A total of 7549 patients from 63 studies were included in the data analysis. Forty-three of these publications did not mention the preservation or the removal of the hypogastric nerve plexus, or main rectal artery supply and were summarized as SRNOS. The remaining 22 studies were listed under the NSR group. The mean size of the resected deep endometriosis lesions and patients' body mass index were comparable between SRNOS and NSR. A mean of 3.6% (0–16.6) and 2.3% (0–10.5%) of rectovaginal fistula development was reported in patients who underwent SRNOS and NSR, respectively. Anastomotic leakage rates varied from 0% to 8.6% (mean $1.7 \pm 2\%$) in SRNOS compared with 0% to 8% (mean $1.7 \pm 2\%$) in patients undergoing NSR. Urinary retention (4.5% and 4.9%) and long-term bladder catheterization (4.9%

Abbreviations: ANSR, artery and nerve-sparing resection; DE, deep endometriosis; LARS, low anterior resection syndrome; NSR, nerve-sparing resection; NSRNOS, NSR not otherwise specified; SRNOS, conventional segmental resection not otherwise specified.

Ezgi Darici and Mohamed Salama contributed equally to this work.

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and 5.6%) were frequently reported in SRNOS and NSR. There was insufficient information about pain or the recurrence rates for women undergoing SRNOS and NSR.

Conclusions: Current data describe the outcomes of different segmental resection techniques. However, the data are inhomogeneous and not sufficient to reach a conclusion regarding a possible advantage of one technique over the other.

KEYWORDS

endometriosis, endoscopic surgery, laparoscopy, morbidity, surgical techniques

1 | INTRODUCTION

Intestinal involvement is estimated to affect 3.8%–37% of the patients diagnosed with endometriosis.¹ Treatment of colorectal endometriosis is very challenging and commonly preferred methods include medical therapy and surgical interventions. Medical therapies offer a valuable therapeutic option in some cases but are not curative.² Bowel resection for deep endometriosis (DE) provides a treatment that is associated with improved quality of life by reduction of pain symptoms and may enhance fertility.^{3–5} However, surgical management of bowel endometriosis is also a point of clinical controversy and there are various approaches including rectal shaving, disc resection and segmental resection techniques;⁶ however, there are no universal guidelines as to which excision technique is optimal.^{7,8}

Segmental resection appears as the most radical approach and is usually chosen for DE lesions exceeding 3 cm in diameter or multifocal disease.^{8,9} Compared with rectal shaving, segmental resection and disc resection have been associated with a higher risk of rectovaginal fistula development and bowel leakage.^{7,10} After the first reports on colorectal resection for the treatment of endometriosis more than a century ago,¹¹ the nerve-sparing technique avoiding possible damage of the inferior hypogastric plexus by dissection and lateralization of nerve bundles was first described in a large series of colorectal cancer patients by Heald et al.¹² in 1982 and was further adopted for the treatment of colorectal DE with segmental resection.^{13,14} This technique involves the limited resection of a bowel segment with preservation of all adjacent structures, mainly the autonomic pelvic nerve plexus and vessel supply. One may expect that preservation of these structures contributes to optimized wound healing and therefore lower severe complication rates such as anastomotic leakage and fistula formation.⁴ Furthermore, some authors advocate additional preservation of the rectal artery supply by preserving the mesenteric inferior and rectal arteries, suggesting a possible benefit regarding the perfusion of the anastomosis.^{4,15,16} However, the relation between these variations of segmental resection techniques and subsequent surgical outcomes have not been systematically evaluated to date. The present systematic review aims to search the literature for surgical outcomes of different segmental resection techniques for bowel endometriosis and to evaluate the associated perioperative morbidity, postoperative early-late complications and recurrence rates.

Key message

There is no proven difference in clinical outcomes of different segmental resection techniques including nerve-vessel sparing, nerve-sparing and classical colorectal segmental resection performed in patients with colorectal deep endometriosis.

2 | MATERIAL AND METHODS

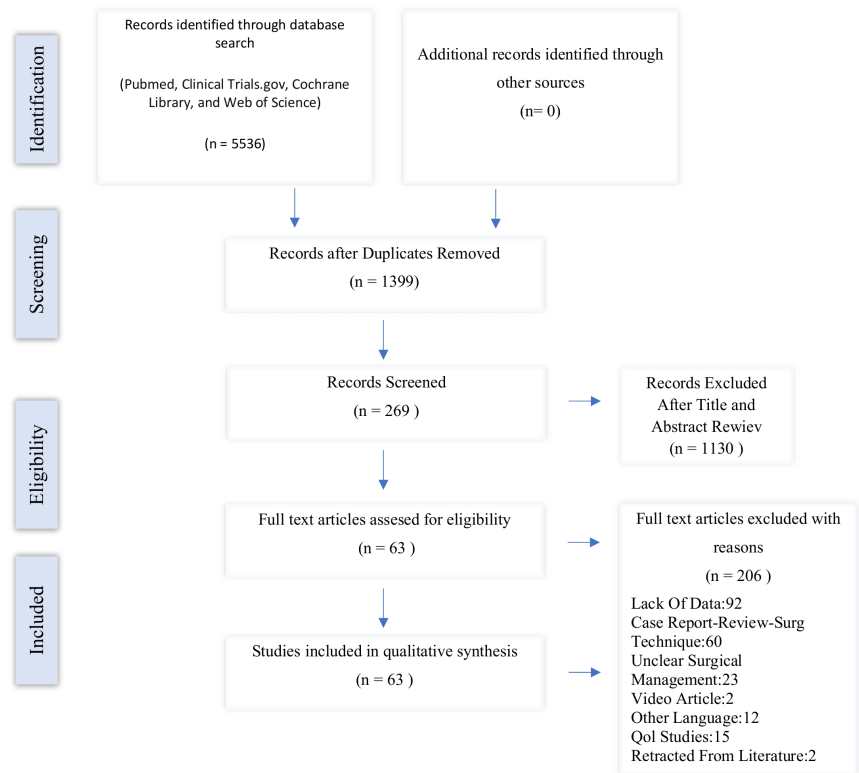
2.1 | Study design

A systematic review was conducted in accordance with the Preferred Reported Items for Systematic Reviews and Meta-analyses guidelines (PRISMA) guidelines (Figure 1)¹⁷ and registered with the International Prospective Register of Systematic Reviews (PROSPERO ID: CRD42021250974).

2.2 | Search strategy and selection criteria

Publications on segmental resection for colorectal endometriosis published between 1997 and 2021 were comprehensively reviewed. The following databases were used to search for relevant keywords: PubMed, Clinical [Trials.gov](https://www.trials.gov/), Cochrane Library, and Web of Science. The MESH (Medical Subject Headings) terms “bowel endometriosis”, “colorectal endometriosis” combined with “segmental resection”, “colorectal resection”, “radical surgery” and “treatment”, “outcomes”, “complications” were utilized, combining terms with the search functions “AND” and “OR”. An independent investigator (ED) screened titles, keywords and abstracts for relevant indicators. The selected data by the author (ED) were then checked by the remaining authors (GH, AB, EO, BD). A second, full-text screening of all identified studies and the included manuscripts was subsequently performed for the qualifying entries according to the criteria below. To be included, studies had to concern patients undergoing segmental resection for colorectal endometriosis and contain an adequate follow-up phase describing data on at least one of the following terms: early and late postoperative complications including anastomotic leakage,

FIGURE 1 PRISMA flow diagram showing the study selection



rectovaginal fistula, anastomotic stenosis and postoperative urogenital function.

A total of 5536 potential records were identified with the electronic-based search. After removing duplicates ($n = 4137$) in Endnote X9 (Clarivate Analytics, Philadelphia, PA, USA), 1399 records were screened by title and abstract. Full text screening for eligibility was done for the remaining 269 records and 63 records were included in the systematic review (Figure 1). Of these, 206 articles were excluded because 23 had an unclear definition of the surgical management, 60 were case reports, reviews or introduced a new surgical technique, 92 had missing data, 2 were video articles, 12 were in languages other than English (French, Chinese, German), 15 were QoL studies and 2 were retracted from the literature.

2.3 | Data collection and analysis

Selected articles were divided into two groups, namely, conventional segmental resection not otherwise specified (SRNOS) and nerve-sparing resection (NSR). Papers reporting on conventional segmental resection, ie segmental resection without dissection and neither preservation nor removal of the hypogastric nerves and/or not explicitly mentioning the nerve-sparing technique, remained and were classified as segmental resection not otherwise classified (SRNOS). Papers containing a clear description of the surgical technique sparing the pelvic splanchnic nerves were listed under the NSR group. The papers included in the NSR group

reporting to spare both pelvic splanchnic nerves and the superior and inferior hypogastric plexus with inferior mesenteric and middle and inferior rectal arteries to sustain an adequate blood flow during the dissection, were classified as a subgroup—artery and nerve-sparing segmental resection (ANSR)—for a further subgroup analysis in which we compared patients undergoing ANSR with women undergoing NSR not otherwise classified, ie not mentioning the preservation of the inferior mesenteric and/or rectal artery supply (NSR not otherwise specified [NSRNOS]), presuming a lack of preservation of these structures.

The following data were extracted: author, publication date, study type, number of the patients, mean size of the nodule (cm), operating time (min), surgery type (laparoscopic, laparotomic or robotic), length of the resected segment (cm), type of the anastomosis, mean distance of anastomosis from anus (cm), low- and ultra-low anterior resection rates, vaginal resection, diverting stoma, estimated blood loss (ml). Cochrane's formula was then used to calculate the combined mean of each parameter. Surgical complications included rectovaginal fistula, anastomotic leakage, pelvic abscess, bowel obstruction, late bowel perforation requiring and non-requiring colostomy, intraoperative and delayed hemorrhage, urinary complications; urinary retention <30 days, long-term bladder catheterization, ureteral leakage, low anterior resection syndrome, anastomotic stenosis, Clavien–Dindo I–II, Clavien–Dindo III–IV, and recurrent rectal endometriosis rates. Complications were reported in all publications as a percentage of the cohort. These data were combined and presented as a percentage of the combined population.

2.4 | Risk of bias

The quality of included studies was assessed by the Study Quality Assessment Tools (<https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>). Studies were rated as “good” when at least 70% of 9, 12 or 14 assessment criteria were fulfilled, “fair” when at least 50% of the criteria were fulfilled and “poor” when less than 50% of the criteria were fulfilled. Conflicts regarding study quality were resolved by the authors.

2.5 | Statistical analyses

Data were represented by descriptive statistics. Meta-analysis could not be performed due to inadequate numbers of high-quality publications comparing the different surgical techniques with each other (NSR vs SRNOS). Data were extracted from the included publications and Cochrane’s formula was used to calculate the combined mean of each parameter.¹⁸ Data are presented as mean \pm SD. Analyses were performed using the SPSS system for Windows, version 21 (SPSS, IBM, Armonk, NY, USA).

3 | RESULTS

3.1 | Study characteristics

A total number of 63 publications were included in this comprehensive review: 26 were prospective,^{4,19–42} 1 was a randomized controlled trial⁴³ and 36 were retrospective studies.^{1,7,16,43–75} A total of 7549 patients presented across the 63 studies underwent segmental resection applying different techniques for colorectal endometriosis. Details of the study characteristics, surgical details and intraoperative interventions are outlined in Table 1. All included studies fulfilled more than 70% of the criteria of the Study Quality Assessment Tools and were rated as good. There were no conflicts between the authors.

3.2 | Surgical technique, patient characteristics and intraoperative findings

In total, 43 publications comprising 5006 patients did not mention the preservation or removal of the hypogastric nerve plexus or main rectal artery supply (SRNOS). The remaining 22 studies comprised 2543 patients listed under the NSR group. Eight studies in the NSR group with 424 patients were reported under ANSR and 2119 patients were reported under the NSRNOS technique. Although two papers^{19,25} of the 63 compared both techniques (NSR and SRNOS), it was not possible to conduct a meta-analysis due to their non-randomized prospective design. Moreover the study group of the latter published paper²⁵ was derived from the previously conducted study and therefore analyzed the same study group.¹⁹

3.3 | Size of the resected nodule and body mass index (BMI)

The mean size of the resected nodules was 3.1 ± 0.8 (95% CI 2.7–3.5) cm in the whole study population, 3.2 ± 0.8 cm (95% CI 2.7–3.7) in SRNOS, 3 ± 0 cm in the NSR group, 3.4 ± 1.2 cm (95% CI 2–34.9) in ANSR, and 2.7 ± 0.6 cm (95% CI 2.1–3.3) in NSRNOS. Moreover, patients’ BMI were 24 ± 3 kg/m² (95% CI 22–25) in SRNOS, 23 ± 1 kg/m² (95% CI 21–26) in NSR and 23 ± 1 kg/m² and 22 ± 1 kg/m² (95% CI 21–24) in ANSR and NSRNOS, respectively.

3.4 | Size of the resected segment

The mean size of the resected segment was 18 ± 19 cm (95% CI 7–30) in all patients. The conventional resection group exhibited a mean size of 19 ± 8 cm (95% CI 1–38). The respective size in the NSR group was 18 ± 22 cm (95% CI 3–34). The ANSR subgroup exhibited a mean size of 10 ± 3 cm (95% CI 4–17) compared with 22 ± 26 cm (95% CI 0–46) in the NSRNOS subgroup.

3.5 | Previous surgery for endometriosis and hospital stay

More than half (54.6%) of the patients, regardless of surgical technique, had a history of previous surgery for endometriosis. However, the length of hospital stay was comparable regardless of surgical technique: 6.9 ± 3 days (95% CI 5.4–8.5) in SRNOS, 7.2 ± 1 days (95% CI 5.2–9.3) in NSR; 7.2 ± 1 days (95% CI 5.2–9.5) in ANSR and 8 ± 1 days (95% CI 6.6–9.4) in NSRNOS.

3.6 | Intraoperative and delayed hemorrhage

Few publications reported data on the amount of intraoperative blood loss, which was comparable regardless of surgical technique. Intraoperative hemorrhage occurred in 0.9% (0–8.4%) in SRNOS, 0.8% (0–4.6%) in NSR, 1.4% (0–2.4%) in ANSR and 0.5% (0–4.6%) in NSRNOS. Delayed hemorrhage was reported as 3.9% (0–16.6%) in SRNOS, 3.8% (0–28%) in NSR, 4.6% (0–10.8%) in ANSR and 3.6% (0–28%) in NSRNOS. Intraoperative hemorrhage and delayed hemorrhage were frequently reported in patients undergoing artery and nerve-sparing techniques as compared with other surgical techniques. (Table 2).

3.7 | Postoperative complications and sequelae

3.7.1 | Rectovaginal fistula and anastomotic leakage rates

As listed in Table 2, rectovaginal fistula rates varied from 0% to 16.6% (mean $3.6 \pm 4\%$, 95% CI 2.3–4.8) in SRNOS compared with

TABLE 1 Study characteristics and intraoperative findings

Authors	Year	Study type	n	Operating time (min)	Surgery type	Length of resected segment (cm)	Type of anastomosis	Mean distance of anastomosis from anus (cm)	LAR %	U-LAR %	Vaginal resection %	Diverting stoma %	Estimated blood loss (ml)
Nerve-sparing resection (NSR)													
Passover et al. ⁴³	2000	Retrospective	34	185.6	LS and LT	NR	NR	4	NR	NR	100	NR	NR
Landi et al. ⁷⁸	2006	Prospective	25	314	LS	NR	NR	NR	NR	NR	NR	NR	328
Mereu et al. ¹⁹	2007	Prospective	192	326.7	LS	NR	NR	NR	NR	NR	31.2	NR	2.5 g
Ferrero et al. ²⁰	2009	Prospective	46	NR	71% LS and 29% LT	NR	EE	NR	NR	NR	NR	2.2	NR
Minelli et al. ²¹	2009	Prospective	357	300	LS	10.2 (6-15)	EE	NR	83.5	7.6	31.7	11.5	250
Douset et al. ²²	2010	Prospective	100	320	LT	18 (14-41)	EE	3.6 ± 1	NR	NR	64	96	NR
Ruffo et al. ²³	2010	Prospective	436	312	LS	NR	EE	NR	78.7	9.4	2	14	250
Meuleman et al. ¹	2011	Retrospective	45	420	LS	13 (8-22)	93% EE	NR	6.6	0	16	2.2	NR
Ceccaroni et al. ²⁴	2012	Prospective	61	301	LS	NR	EE	NR	NR	NR	49.2	29.5	354
Cassini et al. ²⁵	2014	Prospective	19	370	ROBOTIC-HYBRID	13	EE	NR	15.7	0	21	NR	150
Mangler et al. ²⁶	2014	Prospective	71	162	LS	7.5	NR	NR	NR	NR	NR	NR	NR
Aklaidos et al. ⁴⁴	2015	Retrospective	41	210	LS	13 (4-27)	NR	NR	34	9.7	41.4	9.7	NR
Malzoni et al. ⁴⁵	2016	Retrospective	248	169	LS	11.8	NR	NR	71	6	NR	1.6	72.8
Jayot et al. ⁴⁶	2017	Retrospective	31	180	LS	NR	NR	NR	NR	NR	32	29	NR
Erdem et al. ⁴⁷	2018	Retrospective	66	309	94% LS- 6% LT	NR	85% EE	7	NR	NR	9	10.6	280
Hudelist et al. ⁴	2018	Prospective	102	210.5	99% LS and 0.98% LT	NR	EE	<7 (27.4%) and 7-25 (61.8%)	NR	NR	27.5	11.8	1.76 g
Raffaelli et al. ²⁷	2018	Prospective	62	NR	LS	10	EE	8	NR	NR	NR	8.1	NR
Roman et al. ⁴²	2018	RCT	33	270	97% LS	80 (50-150) COLORECTAL, 50 (40-70) RECTAL, 20 (0-60) SIGMOID	EE	NR	NR	NR	60.6	63.7	200
Bokor et al. ¹⁵	2018	Prospective	CO: 60	121	LS	10 (5-29)	EE	NR	52	NR	NR	NR	35
Abrao et al. ⁴⁸	2019	Retrospective	NOSE:30	96	LS	7 (5-17)	EE	NR	57	NR	NR	0.03	15
Bassi et al. ⁴⁹	2019	Retrospective	71	188	LS	NR	NR	10.5	NR	NR	32.4	NR	<500
	2019	Retrospective	413	NR	LS	11.4 (5.2-22)	NR	10.2	NR	NR	NR	0	NR

(Continues)

TABLE 1 (Continued)

Authors	Year	Study type	n	Operating time (min)	Surgery type	Length of resected segment (cm)	Type of anastomosis	Mean distance of anastomosis from anus (cm)	LAR %	U-LAR %	Vaginal resection %	Diverting stoma %	Estimated blood loss (ml)
Bokor et al. ¹⁶	2020	Retrospective	139	225	97.1% LS and 2.9% LT	8 (±6)	EE	NR	NR	NR	79.8	35.2	NR
Segmental resection NOS (SRNOS)													
Verspyck et al. ⁵⁰	1997	Retrospective	6	NR	LT	NR	EE (83%)	NR	NR	NR	NR	NR	NR
Jerby et al. ²⁸	1999	Prospective	7	240	LS	NR	EE	NR	NR	NR	NR	NR	NR
Redwine and Wright ²⁹	2001	Prospective	6	NR	LS	NR	NR	NR	NR	NR	NR	NR	NR
Duepree et al. ⁵¹	2002	Retrospective	18	200	LS	NR	NR	NR	NR	NR	NR	NR	175
Darai et al. ³⁰	2005	Prospective	40	378	LS	8.2 (4–20)	EE	NR	NR	NR	30	0	2.4 g
Fleisch et al. ⁵²	2005	Retrospective	23	343	LT	NR	EE (78.3%) – NR (21.7%)	NR	78.3	0	NR	0	NR
Keckstein and Wiesinger ⁵³	2005	Retrospective	202	180	LS	NR	EE	NR	NR	NR	NR	NR	NR
Mohr et al. ⁵⁴	2005	Retrospective	47	NR	LS	NR	EE	NR	NR	NR	NR	NR	NR
Dubernard et al. ³¹	2006	Prospective	58	NR	LS	NR	EE	NR	NR	NR	21	NR	NR
Jatan et al. ⁵⁵	2006	Retrospective	14	NR	71.4% LT – 28.6% LS	NR	NR	NR	100	0	NR	NR	NR
Landi et al. ⁷⁸	2006	Prospective	45	348	LS	NR	NR	NR	NR	NR	NR	NR	314
Brouwer and Woods et al. ⁵⁶	2007	Retrospective	137	NR	11.6% LS – 56% Pfannenstiel assisted LS and 29.9% LT	NR	NR	NR	82	9	NR	5	NR
Darai et al. ³²	2007	Prospective	71	366	LS	10 (4–20)	NR	NR	NR	NR	29.5	7	2.4 g
Seracchioli et al. ³³	2007	Prospective	22	192.8	LS	NR	EE	NR	NR	NR	NR	NR	290
Ghezzi et al. ³⁴	2008	Prospective	33	290	LS	NR	NR	NR	51.5	33.3	100	0	300
Kössi et al. ³⁵	2008	Prospective	31	259.5	LS	NR	NR	NR	NR	NR	77.4	NR	NR
Juhász-Böss et al. ⁵⁷	2009	Retrospective	6	201	LS	NR	EE	NR	NR	N3	0	0	NR
Tarjanne et al. ³⁶	2009	Retrospective	54	145	LT	NR	NR	NR	NR	NR	NR	7.4	NR

TABLE 1 (Continued)

Authors	Year	Study type	n	Operating time (min)	Surgery type	Length of resected segment (cm)	Type of anastomosis	Mean distance of anastomosis from anus (cm)	LAR %	U-LAR %	Vaginal resection %	Diverting stoma %	Estimated blood loss (ml)
Fanfai et al. ³⁶	2010	Prospective	88	300	LS	NR	EE	NR	NR	NR	34.1	9.1	200
Kondo et al. ⁵⁹	2010	Retrospective	25	371.4	LS	NR	NR	NR	NR	NR	68	NR	NR
Roman et al. ⁶⁰	2010	Retrospective	15	NR	LS	NR	NR	NR	NR	NR	100	80	NR
Ceccaroni et al. ²⁴	2011	Prospective	65	351.8	LS	NR	EE	NR	NR	NR	29.2	13.8	386.9
Moawad et al. ⁶¹	2011	Retrospective	14	426	NR	NR	NR	NR	NR	NR	NR	NR	276.9
Wolthuis et al. ³⁷	2011	Prospective	21	90	LS	21 (17–24)	EE	NR	NR	NR	12	NR	0 (0–10)
Ruffo et al. ³⁸	2012	Prospective	750	255	LS	NR	EE	NR	92.5	7.5	25.5	14.5	150
Belghiti et al. ³⁹	2014	Prospective	198	NR	69% LS – 31% LT	NR	NR	NR	43	NR	32	27	NR
Kondo et al. ⁶²	2014	Retrospective	59	160	LS	NR	NR	NR	NR	NR	33.9	15	100
Ruffo et al. ⁶³	2014	Retrospective	774	NR	LS	NR	EE	NR	NR	NR	NR	21.3	NR
Milone et al. ⁴⁰	2015	Prospective	90	206	85 LS	NR	EE	NR	NR	NR	NR	24	NR
Afors et al. ⁶⁴	2016	Retrospective	30	184.2	NR	NR	NR	NR	NR	NR	59.9	3.3	NR
Michalak et al. ⁶⁵	2016	Retrospective	11	NR	72% LT – 28% LS	NR	NR	NR	NR	NR	NR	18	NR
Bourdel et al. ⁶⁶	2017	Retrospective	23	330	87% LS	8.4	NR	NR	NR	NR	30	NR	NR
Renner et al. ⁶⁷	2017	Retrospective	113	324.5	22.1% LS – 72.6% NR LS+VAJ, 5.3% LT	NR	NR	NR	NR	NR	73.5	13.3	283.1
Roman et al. ⁴²	2017	Retrospective	532	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Abo et al. ⁶⁸	2018	Retrospective	139	263	92.1% LS	3–25	NR	10.1	NR	NR	3.6	48.2	NR
Byrne et al. ⁴¹	2018	Prospective	181	NR	LS	NR	NR	NR	NR	NR	NR	NR	NR
Mabrouk et al. ⁶⁹	2018	Retrospective	62	207	LS	NR	NR	NR	NR	NR	30.6	0	NR
Bonin et al. ⁷⁰	2019	Retrospective	87	293	LS	11.4	NR	NR	NR	NR	6.9	100	NR
Gomes et al. ⁷¹	2019	Retrospective	47	NR	LS+ROB	NR	NR	NR	NR	NR	NR	NR	NR
Gutierrez et al. ⁷⁹	2019	Retrospective	76	309	LS	NR	EE	NR	NR	NR	36.8	NR	NR
Bafort et al. ⁷⁴	2020	Retrospective	171	NR	LS	NR	60.2% EE	NR	NR	NR	61.4	14.1	NR
Braund et al. ⁷²	2020	Retrospective	266	NR	LS	NR	EE	NR	38.3	11.3	62	44.4	NR
Roman et al. ⁷³	2020	Retrospective	394	NR	LS	NR	NR	NR	NR	NR	NR	NR	NR

Abbreviations: CO, conventional; EE, end-to-end; LAR, low anterior resection; LS, laparoscopy; LT, laparotomy; NOSE, natural orifice specimen extraction; NR, not reported; RCT, randomized controlled trial; ROB, robotic; ULAR, ultra-low anterior resection.

Urinary complications, %							
Urinary retention <30 days	Long-term bladder catheterization	Ureteral leakage	LARS, %	Anastomotic stenosis, %	Clavien–Dindo I–II (%)	Clavien–Dindo III–IV (%)	Recurrent rectal endometriosis, %
0	0	0	0	NR	NR	NR	NR
NR	4	0	NR	0	NR	NR	NR
NR	4.7	1.5	NR	2.6	10.4	26	NR
NR	4.3	0	NR	NR	17.3	19.5	NR
11	9.5	0.6	NR	2	NR	NR	NR
NR	16	NR	NR	NR	NR	NR	NR
NR	9.5	0.9	NR	3.7	NR	NR	NR
NR	NR	6.1	NR	NR	NR	NR	NR
0	2.2	0	NR	NR	NR	NR	NR
0	0	0	NR	0	NR	10.5	NR
NR	NR	NR	NR	NR	NR	NR	NR
9.7	0	2.4	NR	NR	12.1	14.4	2.4
0	0	0	NR	NR	NR	8	0
22	22	NR	NR	NR	29	10.3	NR
3	1.9	1.5	NR	1.5	NR	NR	NR
5.9	NR	NR	7.4	1.2	8.8	6.9	NR
NR	NR	NR	NR	NR	96.8	3.2	NR
9.1	3.6	NR	NR	NR	48.5	30.2	NR
3.3	NR	0	NR	NR	NR	NR	1.7
3	NR	0	NR	NR	NR	NR	0
0	NR	NR	NR	0	9.9	4.2	NR
0.5	NR	0.5	NR	1.4	2.7	3.4	NR
6.49	NR	0.7	31.6	0	11.5	9.3	NR
0	NR	0	NR	NR	NR	NR	0
NR	NR	0	NR	NR	NR	NR	NR
0	0	0	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	NR	NR
NR	17.5	0	NR	NR	NR	NR	0
NR	NR	0	NR	NR	NR	NR	NR
NR	NR	0	NR	3	NR	NR	NR
2	0	2	NR	NR	25	12.5	NR
NR	NR	NR	NR	NR	NR	15.5	NR
NR	NR	0	NR	7.1	NR	0	NR
NR	6.6	0	NR	0	NR	NR	
NR	1.4	0	NR	NR	NR	NR	3
NR	NR	0	NR	NR	NR	12.6	0
9	13.6	0	NR	NR	NR	NR	0
3	6	NR	NR	0	NR	NR	NR
NR	NR	0	NR	0	19.2	6.4	NR
0	0	0	NR	0	0	0	NR

TABLE 2 (Continued)

Author	Early complications, %				Hemorrhage, %			
	Rectovaginal fistulas, %	Anastomotic leakage, %	Pelvic Abscess	Bowel obstruction	Late bowel perforation requiring colostomy	Late bowel perforation not requiring colostomy	Intraoperative hemorrhage	Delayed hemorrhage
Tarjanne et al. ⁵⁸	1.9	0	NR	NR	NR	NR	NR	1.9
Fanfai et al. ³⁶	3.4	1.1	2.2	NR	NR	1.1	NR	5.7
Kondo et al. ⁵⁹	8	4	0	0	NR	NR	NR	NR
Roman et al. ⁶⁰	0	6	0	0	NR	NR	NR	NR
Ceccaroni et al. – C ²⁴	7.7	0	0	0	0	0	3.3	NR
Moawad et al. ⁶¹	0	NR	NR	NR	NR	NR	NR	NR
Wolthuis et al. ³⁷	0	0	NR	NR	NR	NR	0	0
Ruffo et al. ³⁸	2	3	0.6	1	NR	NR	NR	0.5
Belghiti et al. ³⁹	4.5	3	NR	NR	NR	NR	NR	0
Kondo et al. ⁶²	3.4	0	0	0	0	0	0	1.6
Ruffo et al. ⁶³	NR	NR	NR	NR	NR	NR	NR	NR
Milone et al. ⁴⁰	0	2	NR	NR	NR	NR	NR	NR
Afors et al. ⁶⁴	3.3	3.3	0	0	NR	NR	NR	NR
Michalak et al. ⁶⁵	NR	NR	NR	NR	NR	NR	NR	NR
Bourdel et al. ⁶⁶	4.3	8.6	12	NR	NR	NR	NR	NR
Renner et al. ⁶⁷	4.4	0	0	0	0	0	0	8
Roman et al. ⁴²	3.9	0.8	NR	NR	NR	NR	NR	NR
Abo et al. ⁶⁸	5.8	NR	10	NR	NR	NR	0	0
Byrne et al. ⁴¹	1.1	2.2	NR	NR	NR	NR	NR	NR
Mabrouk et al. ⁶⁹	1.6	0	0	0	NR	NR	NR	6.4
Bonin et al. ⁷⁰	5.9	0	1.1	0	NR	NR	NR	0
Gornes et al. ⁷¹	NR	NR	NR	NR	NR	NR	NR	NR
Gutierrez et al. ⁷	5.2	3.9	1.3	0	NR	NR	NR	2.6
Braund et al. ⁷²	6	NR	6.8	NR	NR	NR	NR	NR
Roman et al. ⁷³	3.8	NR	NR	NR	NR	NR	NR	NR
Bafort et al. ⁷⁴	1.8	2.9	2.9	NR	NR	NR	NR	2.2

Abbreviations: LARS, low anterior resection syndrome; NR, not reported.

0% to 10.5% (mean $2 \pm 2\%$, 95% CI 0.98–3.1) in patients undergoing NSR. In the subgroup analysis of ANSR and NSRNOS cohorts, the rectovaginal fistula rate varied from 0% to 3.6% (mean $1.5 \pm 1\%$, 95% CI 0.32–2.8) and 0% to 10.5% (mean $2.26 \pm 3\%$, 95% CI 0.7–3.8), respectively. Anastomotic leakage rates varied from 0% to 8.6% (mean $1.7 \pm 2\%$, 95% CI 1–2.5) in SRNOS compared with 0% to 8% (mean $1.7 \pm 2\%$, 95% CI 0.8–2.6) in patients undergoing NSR. In contrast, anastomotic leakage rates in the ANSR and NSRNOS cohorts varied from 0% to 3.2% (mean $1.8 \pm 1\%$, 95% CI 0.9–2.7) and 0% to 8% (mean $1.6 \pm 2\%$, 95% CI 0.3–3), respectively.

3.7.2 | Urinary retention and long-term bladder catheterization

Postoperative urinary retention rates varied from 0% to 20% (mean $4.5 \pm 6\%$, 95% CI 0.8–8.4) in SRNOS compared with 0% to 22% (mean $4.9 \pm 6\%$, 95% CI 1.6–8.3) in patients undergoing NSR. Furthermore, ANSR and NSRNOS cohorts were associated with postoperative

urinary retention rates of 0% to 22% (mean $8.8 \pm 8\%$, 95% CI –1.3 to 19) and 0% to 11% (mean $2.9 \pm 4\%$, 95% CI 0.1–5.9), respectively. Long-term bladder catheterization rates varied from 0% to 17.5% (mean $4.9 \pm 6\%$, 95% CI 1.8–8) in SRNOS compared with 0% to 22% (mean $5.6 \pm 6\%$, 95% CI 1.7–9.4) in patients undergoing NSR. In line with this, ANSR and NSRNOS cohorts showed long-term bladder catheterization rates varying from 0% to 22% (mean $8.8 \pm 11\%$, 95% CI –20 to 37) and 0% to 16% (mean $4.7 \pm 5\%$, 95% CI 1.3–8.1), respectively. Postoperative urinary retention and long-term bladder catheterization were frequently reported in all groups.

3.7.3 | Bowel obstruction and bowel perforation

Bowel obstruction rates varied from 0% to 14% (mean $0.7 \pm 3\%$, 95% CI –0.59 to 1.9) in the SRNOS group as compared with 0% to 0.6% (mean $0.08 \pm 0.2\%$, 95% CI –0.02 to 0.17) in the NSR group. Bowel obstruction was not reported in ANSR, but was reported to be 0% to 0.6% (mean $0.1 \pm 0.2\%$, 95% CI –0.03 to 0.27) in NSRNOS.

Urinary complications, %								
Urinary retention <30 days	Long-term bladder catheterization	Ureteral leakage	LARS, %	Anastomotic stenosis, %	Clavien–Dindo I–II (%)	Clavien–Dindo III–IV (%)	Recurrent rectal endometriosis, %	
NR	NR	NR	NR	NR	NR	3.7	NR	
NR	14.7	1.1	NR	NR	NR	NR	NR	
NR	NR	NR	NR	NR	24	24	NR	
20	NR	0	NR	NR	NR	NR	NR	
NR	NR	4.9	NR	NR	NR	NR	NR	
NR	NR	NR	NR	NR	NR	NR	NR	
0	0	0	NR	NR	NR	NR	NR	
NR	NR	0.4	NR	NR	NR	NR	NR	
NR	NR	0	NR	NR	NR	NR	NR	
0	0	0	NR	NR	1.6	22	NR	
NR	NR	NR	NR	NR	NR	NR	0.2	
NR	NR	NR	NR	NR	NR	NR	NR	
6.7	NR	NR	NR	NR	6.6	6.6	NR	
9	9	NR	NR	NR	18	18	NR	
NR	NR	0	NR	NR	30	26	0	
NR	NR	0	NR	0	15	15.9	NR	
NR	NR	NR	NR	NR	NR	NR	NR	
NR	4.3	NR	NR	5.8	NR	25.2	NR	
NR	NR	NR	NR	NR	NR	NR	NR	
NR	3.2	NR	NR	0	9.6	9.7	0	
NR	NR	NR	NR	13.8	37.9	5.7	NR	
NR	NR	NR	NR	NR	14	16	NR	
NR	5.2	2.6	NR	NR	23.5	7.8	NR	
NR	2.6	0.4	NR	8.6	NR	NR	NR	
NR	NR	NR	NR	NR	NR	NR	NR	
5.3	1.2	0.6	NR	1.8	15.8	12.8	NR	

No patient in the SRNOS group had late bowel perforation requiring colostomy. However, in the NSR group, there was a mean rate of 0.6% (0%–4.5%, 95% CI –0.3 to 1.5) for late bowel perforation not requiring colostomy compared with a mean rate of 0.1% (0%–0.5%, 95% CI –0.1 to 0.3) for late bowel perforation requiring colostomy and 0.1% (0–0.6%, 95% CI –0.2 to 0.4) for late bowel perforation not requiring colostomy.

3.7.4 | Low anterior resection syndrome (LARS) and anastomotic stenosis

There was no information regarding postoperative LARS rates in SRNOS, but LARS rates varied from 0% to 31.6% (mean $13 \pm 16\%$, 95% CI –28 to 54) in NSR. Postoperative LARS rates varied from 7.4% to 31.6% (mean $19.5 \pm 17\%$, 95% CI –134 to 173) in ANSR. No information was available on this, for the NSRNOS group. Anastomotic stenosis rates varied from 0% to 13.8% (mean $3.6 \pm 4\%$, 95% CI 0.5–6.8) in SRNOS compared with 0% to 3.7%

(mean $1.2 \pm 1\%$, 95% CI 0.3–2.2) in patients undergoing NSR. Moreover, ANSR and NSRNOS cohorts had anastomotic stenosis rates that varied from 0% to 1.2% (mean $0.4 \pm 0.7\%$, 95% CI –1.3 to 2.1) and 0% to 3.7% (mean $1.6 \pm 1\%$, 95% CI 0.4–2.8), respectively. Although the mean follow-up time for most of the patients was above 30 months, there was not sufficient information about pain or the recurrence rates.

4 | DISCUSSION

The present work is the first of its kind to systematically review the available literature on the postoperative outcomes of different techniques applied for performing segmental bowel resection in patients with DE. We were unable to perform a meta-analysis due to a lack of high-quality data comparing different techniques head-to-head. Furthermore, we were unable to find prospective studies comparing the variants of segmental resection techniques. The results of this systematic review pooling data from trials either reporting on

various patient cohorts undergoing different techniques for bowel resection, ie shaving and discoid resection, or segmental resection demonstrate that there is no obvious difference in intraoperative or postoperative complications when applying conventional SRNOS or NSR. Mean rates of rectovaginal fistula were lower in NSR groups (ANSR 1.5%, NSRNOS 2.3%) than in the SRNOS group (3.6%). In addition, similar leakage rates were observed in both groups. Furthermore, postoperative voiding dysfunction and bowel function reflected by LARS scores were similar in patients managed with nerve-sparing techniques and the conventional method (SRNOS).

When compared with segmental resection, conservative resection techniques for colorectal DE such as rectal shaving or discoid resection were advocated by several authors based on lower complication rates regarding anastomotic leakage and postoperative bowel stenosis.^{10,76} Segmental resection is the recommended treatment method in extensive, multifocal diseases where conservative approaches are technically difficult to perform.^{5,8} However, the only prospective randomized trial comparing segmental resection with conservative, full-thickness discoid resection was unable to demonstrate significant advantages of omitting segmental resection, although it did demonstrate a higher risk for bowel stenosis leading to repeated surgical interventions in the segmental resection group.⁴³ To decrease the morbidity of segmental resection regarding autonomous nerve function and risk of anastomotic leakage, nerve-sparing techniques and vessel-sparing variants have been suggested by several authors.^{4,19,25}

The results of the present systematic review do not suggest a relevant advantage of these approaches over the conventional method. However, our results have to be interpreted with caution because of the heterogeneity of the studies included, the human factor of surgical experience and possible effects of volume activity and caseloads.⁷⁷

Furthermore, large prospective randomized controlled trials and comparative observational studies are lacking. The only available literature comparing SRNOS and NSR derive from non-randomized retrospective cohort studies from the same group^{19,25} and do not allow sufficient conclusions. In addition, there are several known additional factors with a proven influence on leakage rates and rectovaginal fistula development: the length of the resected segment, height of the surgical anastomosis, vaginal opening and presurgical morbidity of the patient.^{16,78,79} As a consequence, the ideal study setting would comprise patients undergoing different segmental resection techniques with DE lesions situated at the same anatomical height and similar rates of concomitant vaginal involvement. Finally, nerve-sparing techniques are sometimes difficult to apply in surgical reality due to extension of DE into parametrial tissues, application of traction and thermal damage causing nerval damage despite formal use of so-called nerve-sparing approaches. It also has to be stated that we cannot fully exclude that those papers reporting on segmental resection which lacked otherwise specified information on dissection procedures of nerval structures and vessels included in the SRNOS group, did indeed spare autonomous nerve plexuses during resection of DE.

The strength of this work is that we utilized an extensive search strategy including four databases and that this is the first systematic review on the subject of differences in outcomes of various techniques for segmental resection. The results do not suggest a relevant difference of one approach over the other; however, based on the available literature, a possible advantage of NSR techniques cannot be excluded in light of the limitations of the quality of evidence reviewed. In the ideal scenario, future prospective trials are would be needed to increase the level of evidence for or against nerve-sparing resection methods for segmental resection in women with colorectal DE. These studies would need to include patients with similar baseline surgical risk factors (height of lesion from the anal verge, vaginal opening, parametrial involvement, length of resected segment, etc.) and would also have to take into account surgical experience with adequate patient numbers. This could only be achieved in a standardized multicenter setting with strict inclusion and exclusion criteria.

5 | CONCLUSION

Current data describe the outcomes of different segmental resection techniques. However, the data are inhomogeneous and are not sufficient to reach a conclusion regarding a possible advantage of one technique over the other.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

ED: project development, data collection and management. MS: data analysis, manuscript writing/editing. AB and EO: data collection and management, manuscript writing/editing. BD: manuscript writing/editing, data analysis. GH: Project development, manuscript writing/editing.

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