



# A review of reports on single-incision laparoscopic surgery for Crohn's disease

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## Abstract

The aim of this review was to analyze the currently available literature on single-incision laparoscopic surgery (SILS) for Crohn's disease (CD) with respect to surgical indications, surgical techniques, feasibility, and possible benefits of SILS for CD. A systematic query of articles published from January 2010 to July 2018 was performed. The studies were assessed for patient's age, gender, body mass index, disease type, SILS procedure, surgical procedure, incision length, operation time, rates of conversion to open surgery, postoperative complications, mortality, length of hospital stay, and rates of reoperation. After an initial review, 11 reports were selected. The surgical techniques and instruments showed wide variation. The mean operation time for SILS tended to be shorter than that for multiport laparoscopic surgery (MLS). The reported rates of conversion to open surgery and postoperative complications were not very different from those reported for MLS. In conclusion, the present review suggests that the SILS technique may be feasible and safe for select patients with CD. However, because we reviewed only a few studies with small sample sizes, prospectively designed trials with a large number of patients are required to clarify the true benefits of SILS for CD.

**Keywords** Crohn's disease · Single-incision laparoscopic surgery · Minimally invasive surgery

## Introduction

The safety and feasibility of laparoscopic surgery for Crohn's disease (CD) have been described in several studies, such that this approach is now thought to be acceptable for select patients with CD [1–7]. Recent technological advancements and increasing experience among surgeons have resulted in the development of single-incision laparoscopic surgery (SILS). This technique has been applied in cholecystectomy [8], appendectomy [9, 10], and colectomy for colon cancer [11–16].

SILS aims to minimize the surgical access trauma by reducing the number of abdominal incisions to a single incision site. SILS is performed entirely through the umbilicus, potentially offering better cosmetic results, decreased

postoperative pain, and a faster recovery than conventional multiport laparoscopic surgery (MLS) [17–19]. Furthermore, reducing the number of intraabdominal adhesions as a result of adopting a laparoscopic approach may facilitate the performance of repeat surgeries often needed in patients with CD.

Although only a few studies regarding SILS for CD have been done, their reports suggest that SILS may be safe and feasible [20, 21]. However, most of these reports were limited to small sample sizes. Therefore, the true value of SILS for CD remains unclear.

In the present systematic review, we analyzed the currently available literature on SILS for CD with respect to surgical indications, surgical techniques, feasibility, and possible benefits of SILS in patients with CD.

## Materials and methods

### Article identification and selection

A systematic query was performed using the PubMed and Medline databases. Articles published from January

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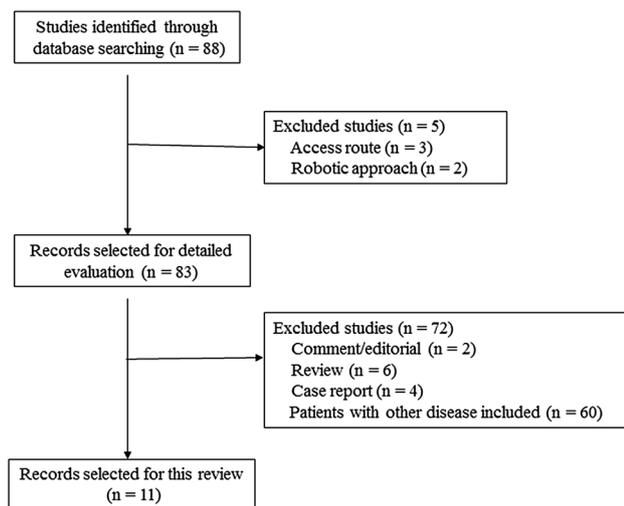
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2010 to July 2018 were considered. Search terms included “single-incision laparoscopic surgery”, “single-port laparoscopic surgery”, “single-site”, “single-access”, “SILS”, “colectomy”, and “Crohn’s disease”. Studies combining SILS with other access routes or using a robot approach were excluded. Studies reporting the use of SILS in colorectal surgery in other diseases except CD (malignant colorectal disease, appendicitis, or diverticulitis) were also excluded. In addition, letters to the editor, reviews, and case reports were also excluded.

## Article analyses

Data were extracted by one surgeon (KM) experienced in both SILS and standard laparoscopic colorectal surgery. Suitable articles were divided into different study types, such as case series and case–control studies. The studies were assessed for the following criteria: mean and/or median patient’s age, gender, body mass index (BMI), initial surgery or redo surgery, disease type, SILS procedure, surgical procedure, incision length, operation time, rates of conversion to open surgery, postoperative complications, mortality, length of hospital stay, and rates of reoperation. The disease types were divided into complex or simple CD. Complex CD was defined as CD with fistula formation, intraabdominal abscess formation, or recurrent CD, and simple CD was defined as primary non-penetrating CD, in accordance with previous reports [22–25].

After an initial review of these studies, 11 reports [20–30] seemed to match our criteria; a review of these reports was conducted, and the full text was reviewed (Fig. 1).



**Fig. 1** The flow chart of the selection of the analyzed studies

## Results

### Study characteristics

Of the 11 studies evaluated, 2 were case series, and 9 were case–control studies (Fig. 1). All studies except one were from a single institution. All nine case–control studies were retrospective studies. The selected studies were published in the years 2012 ( $n=3$ ), 2013 ( $n=1$ ), 2014 ( $n=2$ ), 2016 ( $n=2$ ), 2017 ( $n=2$ ), and 2018 ( $n=1$ ).

### Patient characteristics

Duplicated cases were analyzed in two studies [21, 30], so the total number of patients enrolled in these studies was 369 (Table 1). The mean and/or median patient age ranged from 15.5 to 41 years. The mean body mass index (BMI) ranged from 18.1 to 22.0 kg/m<sup>2</sup>. In all cases, informed consent for SILS was obtained preoperatively. Regarding the disease types, 161 patients were classified as complex type, and the other 208 patients were classified as simple type.

### Surgical procedures

The reported procedures included 321 ileocolic resections, 46 small bowel resections, four right hemicolectomies, and four sigmoid colon resections (Table 2). Furthermore, strictureplasty was performed as an additional procedure in several studies.

### SILS technique

All of the studies specified the type of port applied, with one study reporting the application of two different types of port (Table 2). The applied ports were the SILS port™ (Covidien, Norwalk, CT, USA) in five studies, the SSL Access™ (Ethicon Endosurgery, Cincinnati, OH, USA) in two studies, the Gel Point™ (Applied Medical, Rancho Santa Margarita, CA, USA) in two studies, the EZ access™ (Hakko Medical, Nagano, Japan) in one study, and the Free Access™ (Top Corporation, Tokyo, Japan) in one study. The optical systems used were a flexible tip camera in four studies and straight 30° optics in three studies. The optical systems used in the other four studies were not described.

The predominant technique was a posterior approach involving the mobilization of the colon prior to mesenteric dissection. After mobilization, the diseased bowel was extracted through the incision site. This posterior approach was used in nine studies, while a medial to lateral approach was performed in the remaining two studies. In these two studies, both mesenteric dissection and

**Table 1** The 11 selected studies and the patient characteristics

Author, year	Total number of patients	Mean or median age (years)	BMI	Male:female	Number of patients		Number of patients subdivided by disease type	
					Initial surgery	Redo surgery	Simple	Complex
Rijcken et al. (2012)	20	31.6	21.5	6:14	20	0	20	0
Maeda et al. (2012)	11	31	20.7	10:1	11	0	11	0
Stewart et al. (2012)	6	25.5	20.7	3:3	NR		0	6
Gardenbroek et al. (2013)	21	26	21.5	7:14	21	0	21	0
Moftah et al. (2014)	33	31	21.3	12:21	27	6	31	2
Sharp et al. (2014)	28	15.5	18.9	9:19	NR		11	17
Mizushima et al. (2016)	24	41	18.1	17:7	16	8	12	12
Huntington et al. (2016)	41	15.7	19.6	21:20	NR		27	14
Leo et al. (2017)	45	41	NR	19:26	27	18	0	45
Carvello et al. (2017)	101	28	22.0	47:64	NR		73	28
Maeda et al. (2018)	50	36	19.9	39:11	44	6	25	25

*BMI* body mass index

**Table 2** Surgical procedures, applied instruments and techniques

Author, year	Total number of patients	Number of surgical procedures			Type of port applied	Optical system	Approach
		Ileocolic resection or right hemicolectomy	Small bowel resection	Sigmoid colon resection			
Rijcken et al. (2012)	20	20	0	0	SILS port	30° straight	Posterior approach
Maeda et al. (2012)	11	11	0	0	SILS port	Flexible	Posterior approach
Stewart et al. (2012)	6	6	0	0	SSL access	Flexible	Posterior approach
Gardenbroek et al. (2013)	21	21	0	0	SSL access	NR	Posterior approach
Moftah et al. (2014)	33	31	0	0	Surgical glove	30° straight	Medial to lateral approach
Sharp et al. (2014)	28	28	0	0	SILS port	Flexible	Posterior approach
Mizushima et al. (2016)	24	15	15	0	EZ access	NR	Posterior approach
Huntington et al. (2016)	41	38	5	0	SILS port	NR	Posterior approach
Leo et al. (2017)	45	39	6	0	Gel point	30° straight	Medial to lateral approach
Carvello et al. (2017)	101	101	3	2	Gel point	NR	Posterior approach
Maeda et al. (2018)	50	26	20	2	SILS port or free access	Flexible	Posterior approach

*NR* not reported

mesenteric vessel ligation were performed intracorporeally using laparoscopic coagulating shears or a vessel sealing device. Bowel resection and anastomosis were performed extracorporeally in all studies. Almost all authors used straight laparoscopic graspers and dissectors, which are the standard laparoscopic instruments.

## Surgical indications

The most common surgical indications were stricture and/or obstruction of the terminal ileum or ascending colon (Table 3). Fistula, abdominal abscess, or mass were indications for SILS in nine studies. SILS was also performed

**Table 3** Surgical indications and exclusion criteria

Author, year	Total number of patients	Surgical indication (number)(including overlapping cases)					Exclusion criteria
		Stricture and/or obstruction	Fistula, abdominal abscess, or mass	Recurrent CD	Urgent surgery	Other	
Rijcken et al. (2012)	20	20	0	0	0	0	NR
Maeda et al. (2012)	11	11	0	0	0	0	Complex type
Stewart et al. (2012)	6	0	6	0	0	0	Hemodynamic instability BMI of $\geq 50$
Gardenbroek et al. (2013)	21	NR	NR	NR	NR	NR	Enterovesical fistula Entero-sigmoidal fistula Large inflammatory mass
Moftah et al. (2014)	33	7	16	6	15	0	NR
Sharp et al. (2014)	28	11	1	0	2	15	NR
Mizushima et al. (2016)	24	10	12	0	0	2	Patients who need an extensive surgical procedure with multiple-organ resection or extensive colectomy
Huntington et al. (2016)	41	32	11	0	0	2	NR
Leo et al. (2017)	45	0	13	18	8	11	NR
Carvello et al. (2017)	101	73	3	0	3	25	NR
Maeda et al. (2018)	50	30	20	6	0	0	Patients who need proctectomy or extensive cystectomy

CD Crohn's disease, NR not reported

in patients with recurrent CD (three studies) and in those needing urgent surgery (four studies). Five studies described the exclusion criteria, which included patients with hemodynamic instability, BMI of  $\geq 50$ , the presence of an enterovesical fistula or an entero-sigmoidal fistula, a large inflammatory mass, and the need for extensive surgical procedures with multiple-organ resection or proctectomy.

### Surgical outcomes

Although Stewart et al. [22] placed the incision site at the right-sided abdomen considering the future need for diverting loop ileostomy, the umbilicus has been the most frequent site of abdominal access in SILS procedures (Table 4). The reported mean incision lengths ranged from 2 to 4.5 cm. Several authors reported widening of the initial incision for extraction of the specimen with thickened mesentery peculiar to Crohn's disease. The mean or median operation times ranged from 86 to 171 min.

Conversions to open surgery were reported in seven studies. The rates of conversion to open surgery ranged from 0 to 15.1%. A vast majority of conversion was due to technical difficulties, including severe adhesion, fistulizing diseases, bulky inflammatory mass, thickened mesentery, and inadequate visualization, as well as difficulties regarding

pneumoperitoneum due to a previous surgery. Conversions to multiport laparoscopic surgery or hand-assisted laparoscopic surgery were reported in three studies. Stewart et al. [22] reported that an additional port was needed in one patient (16.6%) to complete the laparoscopic procedure. We also reported that four patients (8%) required the addition of one port due to severe adhesions or a bulky inflammatory tumor [30]. In addition, Gardenbroek et al. [23] reported that a hand-assisted laparoscopic procedure was needed in one patient with a large inflammatory tumor.

The reported rates of postoperative complications ranged from 4.1 to 18.8% (Table 5). Although severe complications, such as anastomotic leakages, ileus, intraabdominal abscesses, and surgical site infection, were reported in eight studies, the reoperation rates due to complications were relatively low, ranging from 0 to 5.9%. No mortalities were reported in these studies. The mean or median hospital stays ranged from 4 to 11 days.

### Discussion

Although current literature about laparoscopic surgery for CD still suffers from a low level of evidence, due to the limited number of randomized trials, the safety and feasibility

**Table 4** Intraoperative outcomes

Author, year	Total number of patients	Incision site	Mean, median or range of incision length (cm)	Mean or median operative time (min)	Conversion rates to open surgery	Reasons for conversion
Rijcken et al. (2012)	20	Umbilicus	3.3	137	5% (1/20)	Firm adhesion fistula
Maeda et al. (2012)	11	Umbilicus	3	144	0	–
Stewart et al. (2012)	6	Right-sided abdomen	3.5	160	0	–
Gardenbroek et al. (2013)	21	Umbilicus	4–5	103	0	–
Moftah et al. (2014)	33	Umbilicus	3	120	15.1% (5/33)	Dense adhesions, fistula, previous laparotomy
Sharp et al. (2014)	28	Umbilicus	NR	87	0	–
Mizushima et al. (2016)	24	Umbilicus	4.5	171	4.2% (1/24)	Fistula
Huntington et al. (2016)	41	Umbilicus	NR	135	2.4% (1/41)	Foreshortened mesentery
Leo et al. (2017)	45	Umbilicus	3–4	120	11.1% (5/45)	Mesenteric bleeding, dense adhesions
Carvello et al. (2017)	101	Umbilicus	3.45	121	3% (3/101)	NR
Maeda et al. (2018)	50	Umbilicus	3.5	160	4% (2/50)	Adhesions, bulky mass

NR not reported

**Table 5** Postoperative outcomes

Author, year	Total number of patients	Rates of postoperative complications	Rates of reoperations	Mean or median hospital stay (day)
Rijcken et al. (2012)	20	20% (4/20)	5% (1/20)	9
Maeda et al. (2012)	11	9% (1/11)	0	9.7
Stewart et al. (2012)	6	17% (1/6)	0	4.8
Gardenbroek et al. (2013)	21	23.8% (5/21)	0	4
Moftah et al. (2014)	33	39% (13/33)	0	5
Sharp et al. (2014)	28	39% (11/28)	10.7% (3/28)	6
Mizushima et al. (2016)	24	4% (1/24)	4% (1/24)	NR
Huntington et al. (2016)	41	19% (8/41)	4.9% (2/41)****	6.5
Leo et al. (2017)	45	36% (16/45)	0	8
Carvello et al. (2017)	101	27% (27/101)	6% (6/101)	6
Maeda et al. (2018)	50	12% (6/50)	4% (2/50)	11

NR not reported

of MLS has rendered it an acceptable procedure for simple-type CD [1–5]. Regarding complex-type CD, Goyer et al. [6] and Okabayashi et al. [7] reported that although the conversion rate to open surgery tended to be higher than with simple-type CD, the postoperative morbidity was similar between both types, prompting them to conclude that MLS is feasible and safe, even for the complex type.

Since the first case reports of SILS for CD were published in 2010 [31], larger case studies or comparative studies from specialized centers have been reported. From a technical

point of view, compared to conventional laparoscopic surgery, SILS has some technical limitations, such as the risk of clashing of instruments and difficulty achieving access through such a small incision. Therefore, SILS requires an experienced surgeon to overcome the difficulties of triangulation and instrument crowding. Although some investigators have recommended using articulating instruments [31] or a laparoscope with a flexible tip [21, 22, 25, 30] to avoid clashing of instruments, most operators use standard straight laparoscopic instruments. We previously reported that the

addition of one more port made it easy to complete the SILS procedure in some cases with complex disease [30]. However, it is important to keep in mind that the addition of ports or adoption of specialized instruments is not a failure of SILS. Several studies have noted that the addition of one port reduced the technical difficulty and that single-incision-plus-one-port laparoscopic surgery was feasible in patients with colorectal disease [32–34]. This technique is expected to result in cosmetic outcomes similar to those with SILS and improved ergonomics with laparoscopic instruments.

Concerning the surgical techniques, 9 of the 11 authors whose reports were evaluated here applied a posterior approach involving the mobilization of the bowel prior to mesenteric dissection. Because the diseased bowel has a thickened and/or vulnerable mesentery that may bleed easily, intracorporeal mesenteric dissection is considered difficult. Most authors, therefore, performed mesenteric dissection, bowel resection, and/or anastomosis extracorporeally.

Although the indications and contraindications for SILS for CD have yet to be clearly defined, Rijcken et al. [20] reported that SILS is a safe procedure for stricturing disease of the terminal ileum. de Groof et al. [35] also reported that SILS may be feasible for ileocecal resection and/or segmental colectomy for localized simple disease. However, SILS has not been widely accepted for treating the complex disease type, including penetrating disease and recurrent CD, because the anatomical alterations and adhesions caused by fistula formation or previous surgery are thought to make laparoscopic surgery difficult. In this review, although 9 of the 11 authors performed SILS not only for stricturing disease but also for complex disease [22–30], it was apparent that most authors applied SILS predominantly in select cases. A detailed examination of these papers showed that these authors excluded patients with complicated fistulas (especially in the pelvis) from the indications for SILS. Indeed, most of the reported procedures were ileocecal resection or segment colectomy, with no cases of proctectomy or cystectomy reported [20–30]. Pelvic fistulas often penetrate other pelvic organs, thus necessitating an extensive surgical procedure with multiple-organ resection. Therefore, at our institution, the indications for SILS are now restricted to the simple disease type or complex disease type not needing proctectomy, extensive cystectomy, or multiple-organ resection.

Regarding the intraoperative outcomes, four comparative studies showed that the mean operation time for SILS tended to be shorter than that for MLS [20, 21, 23, 28]. Because these studies were retrospective studies and not randomized prospectively, the patients who underwent SILS and those who underwent MLS received their operation at different points in time. Therefore, the reduction in the operation time may merely reflect improvements in a surgeon's laparoscopic skills.

The rate of conversion to open surgery ranged from 0 to 11%, while previous studies on conventional MLS reported rates ranging from 0 to 37% [1–7]. The reported rates of conversion to open surgery in patients with CD who underwent SILS seemed to be similar to those reported for conventional MLS. Stated reasons for conversion included fistulas, adhesions, pelvic abscess, and recurrent disease, which are also similar to the reasons stated in previous studies on MLS.

The rates of postoperative complications reported ranged from 4 to 39%, and the rates of reoperation ranged from 0 to 10.7%. Neither of these values were markedly different from those reported for MLS [1–7]. No mortalities were observed in any studies. These results suggest that SILS may be safe in patients with CD, similar to conventional MLS. However, it should be noted that all studies were reported from tertiary referral centers experienced in surgery for CD where laparoscopic surgery was well established. At present, SILS remains a challenging procedure for surgeons insufficiently experienced in managing CD or performing laparoscopic surgery.

SILS may have potential benefits over conventional multiport laparoscopic surgery. Several previous studies have cited benefits such as a shorter hospital stay, reduced time to bowel movement, and better cosmetic outcomes [23, 27–29]. Because the majority of patients with CD who need surgical treatment are young and socially active, good cosmetic outcomes and a rapid recovery are beneficial. The potential cosmetic benefits of SILS should be assessed using a cosmetic scale or body image scale; however, no such reports have yet been published.

Other expected benefits of SILS include reduced postoperative pain and a reduced rate of long-term port site complications. A single midline fascial incision may minimize trauma to the abdominal muscles, epigastric arteries, and parietal nerves that might otherwise be inflicted by the use of multiple trocars in conventional multiport surgery. This may lead to less postoperative pain and/or a reduced rate of long-term port site complications, such as incisional hernia. Gardenbroek et al. [23] reported that the postoperative morphine use was decreased in patients who underwent SILS compared with those who underwent multiport surgery. Furthermore, the reduced number of intraabdominal adhesions resulting from the laparoscopic approach may facilitate the repeated operations often needed in patients with CD. However, the results from the present studies appear to be limited to small sample sizes with low statistical power. In the available literature on SILS, potential benefits have yet to be demonstrated.

In conclusion, although the indications and contraindications of SILS for CD have yet to be clearly defined, the present review suggests that the SILS technique may be feasible and safe for select patients with CD if performed at an institution with sufficient experience in performing

laparoscopic surgery and capable of handling prompt conversion to open surgery or the addition of another port. However, because only a few studies with small sample sizes have been performed on this topic, the benefits of SILS for CD have not yet been conclusively proven.

Prospectively designed trials with a large number of patients will be required to clarify the true benefits of SILS for CD.

### Compliance with ethical standards

**Conflict of interest** The authors declare that there are no conflicts of interest or financial ties to disclose.

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