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Stump Invagination Versus Simple Ligation in Open Appendicectomy: A Systematic Review and Meta-Analysis

Daohai Qian, Zhigang He, Jie Hua, Zhenshun Song

Department of General Surgery, Shanghai Tenth People's Hospital, Tongji University of Medicine, Shanghai, China

The aim of this meta-analysis was to compare the superiority of stump closure between stump invagination (SI) and simple ligation (SL) during open appendicectomy (OA). The literature searching was conducted in MEDLINE, EMBASE, the Cochrane Library, and http://scholar.google.com. Available data was extracted by 3 independent reviewers. The clinical outcomes were analyzed by meta-analytic software to compare the difference between 2 methods during OA. The pooled odds ratios (ORs) and weighted mean differences (WMDs) with 95% confidence intervals (95% CIs) were obtained by using fixed effect model. Eleven randomized controlled trials (RCTs) were finally included in this study involving 2634 patients. Postoperative pyrexia and infections were similar between SL and SI groups, respectively, but the former group had a shorter operative time (WMD: 8.72; 95% CI: 6.87–10.56; $P < 0.00001$); less incidence of postoperative ileus (WMD: 2.02; 95% CI: 1.36–3.01; $P = 0.0005$); and quicker postoperative recovery (WMD: 0.30; 95% CI: 0.11–0.48; $P = 0.002$). The above results were based on 5, 11, 4, 11, and 9 articles, respectively. The clinical results revealed that SL was significantly superior to SI. SL should be suggested during OA.

Key words: Appendicectomy – Appendicitis – Ligation – Invagination – Meta-analysis

Although thousands of patients undergo open appendicectomy (OA) annually worldwide, there is a lack of consensus regarding the management of stump closure. There are mainly 2 techniques for managing the appendicular stump: ligation with stump invagination (SI) and simple ligation (SL). Simple ligation was originally used in OA in 1884,[1] but some authors argued that the exposed appendicular stump was a source of contamination within the peritoneal cavity and

Corresponding author: Zhenshun Song, Department of General Surgery, Shanghai Tenth People's Hospital, Tongji University of Medicine, 301 Yanchang Middle Road, Shanghai 200072, China.
Tel.: +86 137 6120 5962; Fax: +86 21 6630 7365; E-mail: zs_song@hotmail.com

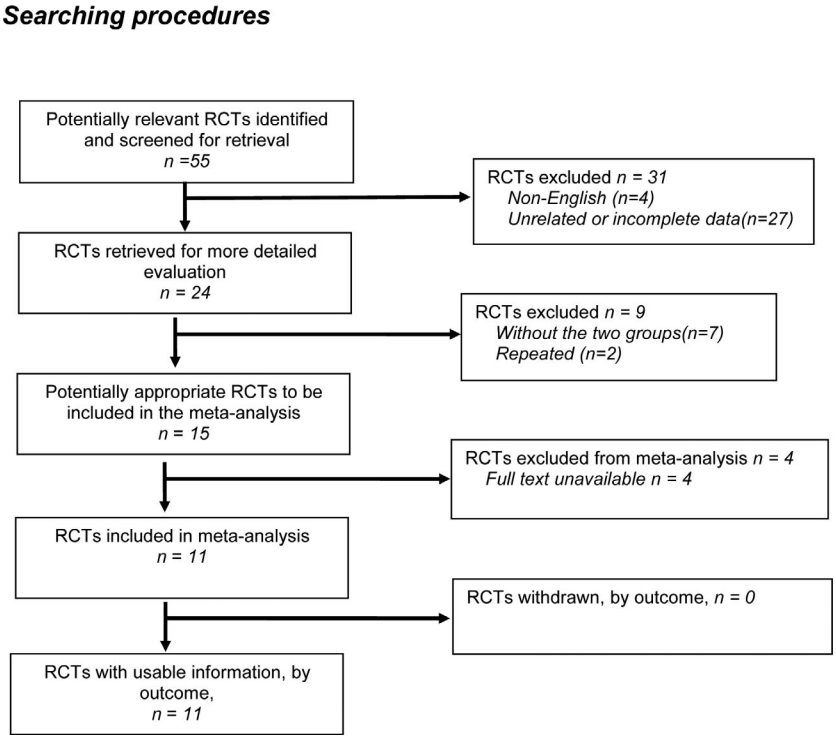

Fig. 1 Searching procedure

Table 1 Study characteristics and patient demographics

			Sex, F/M		Age, y		Study size, n	
Author	Year	Country	SI	SL	SI	SL	SI	SL
Watters DA *et al*[2]	1984	England	30/29	23/21	21.7 (6–46)	18.1 (5–43)	59	44
Chaudhary IA *et al*[3]	2005	Pakistan	157/138	213/169	NA	NA	295	382
Neves L *et al*[6]	2011	Brazil	NA	NA	NA	NA	64	49
Amirian GR *et al*[9]	2011	Iran	53/124	53/124	25.7 ± 13.1	27.8 ± 13.8	177	184
Suvera MS *et al*[10]	2013	India	33/23	30/24	28.4 ± 5.5	27.1 ± 4.9	56	54
Khan S *et al*[5]	2010	Nepal	22/48	27/58	30.0 ± 8.8	30.8 ± 9.8	70	80
Khan N *et al*[11]	2009	Pakistan	18/32	15/35	23.8 (14–45)	24.2 (14–70)	50	50
Chalya PL *et al*[7]	2012	Tanzania	23/21	23/20	26.3 ± 14.6	24.1 ± 12.1	44	43
Jamal A *et al*[8]	2012	Lahore	NA	NA	20.90 ± 6.23	22.92 ± 8.57	40	40
Altin MA *et al*[12]	1993	Turkey	NA	NA	2–15	2–15	73	45
Engström L *et al*[4]	1985	Sweden	187/187	165/196	29 (14–85)	29 (15–91)	374	361

NA, not available.

closure of the intestinal wall was inadequate with SL, which would increase the risk of infection and adhesions around the appendiceal stump. Thus, many surgeons in many centers, including the surgeons in our center, advocate that the appendiceal stump be buried in the cecal wall by a purse-string suture, z-suture, or a tobacco pouch—despite the lack of evidence to justify the routine invagination of the appendiceal stump during appendectomy. There are numerous studies that have compared the advantages and disadvantages between SI and SL.[1–12] Many studies have shown that SL is superior to SI based on the shorter operative time, shorter hospital stay, and lower rate of postoperative ileus.

Based on the above arguments, we conducted this meta-analysis to identify and assess the available literature and compare SI and SL.

Methods

Article search

The analysis of initial studies was performed in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) and meta-analysis of observational studies in epidemiology (MOOSE) guidelines. A comprehensive literature search was conducted involving all randomized controlled trials for comparing the clinical outcomes using SI or SL through January 2014. The key words included (1) "appendiceal stump" OR "appendix stump"; (2) "invagination" OR "simple ligation" OR "embed" OR "bury" OR "inversion"; and (3) "appendectomy" OR "appendicectomy" OR "appendicitis" in the MEDLINE, EMBASE, and Cochrane Library electronic databases, and http://scholar.google.com. The articles were written in English.

Criteria for inclusion and exclusion

In this meta-analysis, data were extracted by 3 independent reviewers (QDH, HZG, HJ) and each study conformed to the following inclusion criteria: (1) prospective randomized controlled trials; (2) use of 2 methods for closure of the appendiceal stump with a comparison of the clinical outcomes between the 2 approaches; (3) inclusion of at least 1 clinical indication for comparison and having the standard deviation of the mean for continuous outcomes; (4) clear presentation of the clinical outcomes in the 2 groups; and (5) unduplicated studies, which should be issued in different institutions and/or by different authors. Abstracts, letters, editorials, expert opinions, reviews without original data, case

Table 1 Extended

Diagnosis, N/A/G/P		Stump closure			
SI	SL	SI	SL	Follow-up	Jadad Score[13]
15/43/1/0	9/32/3/0	Ligation with invagination.	Simple stump ligation	2–3 wk	2
NA	NA	Invagination and purse-string suture or z-stitch by chromic 2/0 suture	Simple ligation	≥9 mo	2
0/15/30/19	0/9/29/11	Making tobacco pouch and burial of the stump	Ligation of the stump	NA	2
177/0/0/0	184/0/0/0	Invaginate and purse-string suture	Simple ligation	NA	2
0/56/0/0	0/54/0/0	Invaginate and purse-string suture by silk 2-0	Simple ligation by silk 1-0	≥6 mo	4
0/56/2/12	0/62/3/14	Invaginate and purse-string suture by 2/0 chromic catgut	Simple ligation by chromic catgut	6 mo	2
0/50/0/0	0/50/0/0	Invaginate and purse-string suture	Simple ligation	≥2 mo	2
0/44/0/0	0/43/0/0	Invaginate and purse-string suture by chromic 2/0 suture	Simple ligation	≥6 mo	6
0/40/0/0	0/40/0/0	Invaginate and purse-string suture	Simple ligation	2 wk	2
0/20/0/53	0/10/0/35	Invaginate and purse-string suture by 3/0 atraumatic silk	Simple ligation by 2/0 silk	3 y	2
91/139/93/51	87/148/92/34	Invagination and purse-string suture or z-stitch by absorbable thread	Simple ligation by nonabsorbable thread	1 y	4

reports, and studies without control groups were excluded (Fig. 1).

Outcomes of interest

The main clinical outcomes refer to postoperative infections (intra-abdominal abscesses and wound infection), and postoperative ileus (early paralytic ileus and adhesive intestinal obstruction). The secondary indicators include operative time, postoperative pyrexia and length of hospital stay. Mortalities and patients with cecal fistulas were excluded due to the extreme low incidence and inadequate data.

Statistical methods

This meta-analysis was conducted using commercial software (Review Manager Software Version 5.0, RevMan 5; The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). Dichotomous variables were estimated using odds ratios (ORs) with a 95% confidence interval (95% CI), and continuous variables were analyzed using the weighted mean difference (WMD) with a 95% CI. If the article only offered the mean of continuous variables, the SD was replaced by the mean. Fixed effects models were applied in the pooled effect due to no difference in heterogeneity ($P > 0.05$, $I^2 < 50\%$). A value of $P < 0.05$ was considered significant.

Results

Eleven randomized controlled trials (RCTs)[2–12] involving 2634 patients were included and satisfied the inclusion criteria (SI: n = 1302; SL: n = 1332). Four RCTs were excluded due to unavailable full text. The study characteristics and patient demographics are summarized in Table 1. There was no statistical difference with respect to the incidence of postoperative infections between the 2 groups (WMD: 1.10; 95% CI: 0.82–1.46; $P = 0.53$; Fig. 2), including wound infections (WMD: 1.09; 95% CI: 0.82–1.45; $P = 0.56$; Fig. 2) and intra-abdominal abscesses (WMD: 2.80; 95% CI: 0.66–11.79; $P = 0.16$; Fig. 2). Similarly, no difference existed in the rate of postoperative pyrexia (WMD: 1.12; 95% CI: 0.69–1.81; $P = 0.65$; Fig. 3). About the operative time, the pooled results showed that the SL group saved 8.8 min (WMD: 8.72; 95% CI: 6.87–10.56; $P < 0.00001$; Fig. 3). In addition, patients in the SL group had a quicker return to activities (WMD: 0.30; 95% CI: 0.11–0.48; $P = 0.002$; Fig. 3); a lower rate of paralytic ileus (WMD: 2.03; 95% CI: 1.28–3.21; $P = 0.003$; Fig. 4); and a lower total incidence of postoperative ileus (WMD: 2.02; 95% CI: 1.36–3.01; $P = 0.0005$; Fig. 4), though the rate of postoperative adhesive intestinal obstruction was similar (WMD: 1.66; 95% CI: 0.63–4.39; $P = 0.31$; Fig. 4). Publication bias was also not observed as measured with funnel plot, Egger's regression intercept method, or Begg-Mazumdar rank correlation method (Figs. 5–9). Of 2634 patients, only 1 was reported to have a postoperative cecal fistula. No deaths were reported in these clinical trials. A total of 6 patients in 2 studies were reported to have postoperative vomiting. Only 1 study reported no use of pre-, intra-, or postoperative antibiotics. Most patients were aged 10 to 50 years in the reviewed studies, and had no underlying diseases. Most of the studies excluded patients with complicated appendicitis. Of 11 studies, 2 explicitly mentioned the placement of abdominal drains, 1 reported no wound drainage, and information was not available for the remaining studies.

Discussion

Based on this meta-analysis, SL was more easily and rapidly applied than SI. Additionally, it could also accelerate the patient's recovery and reduce the incidence of postoperative ileus.

There are 2 routine options for managing the appendiceal stump when performing OA (SL and SI).[14] Simple ligation is suitable for beginners; however, the appendiceal stump is considered contaminated and theoretically might increase the risk for intra-abdominal infections, intestinal adhesions, and even cecal fistulas compared with burial of the stump. Thus, some surgeons recommend double-burying the stump by means of a purse-string suture, z-stitch, or a tobacco pouch after ligation and transfixation of the appendiceal stump as a seromuscular encircling suture about 0.5 to 1 cm distal to the appendix base.[15–17] The reasons given for using SI are safety against ligature slippage from the stump, blowout of the appendiceal stump, decreased risk of peritonitis from spillage of pathogens in the stump, decreased incidence of postoperative wound infections, improved healing by formation of granulation tissue, and collagen from the serosal layer of the cecum.[18]

There are many studies showing that SL is superior to SI.[19,20] Many reports have also indicated that SI could lengthen the operative time and increase the incidence of paralytic ileus.[3,8] In

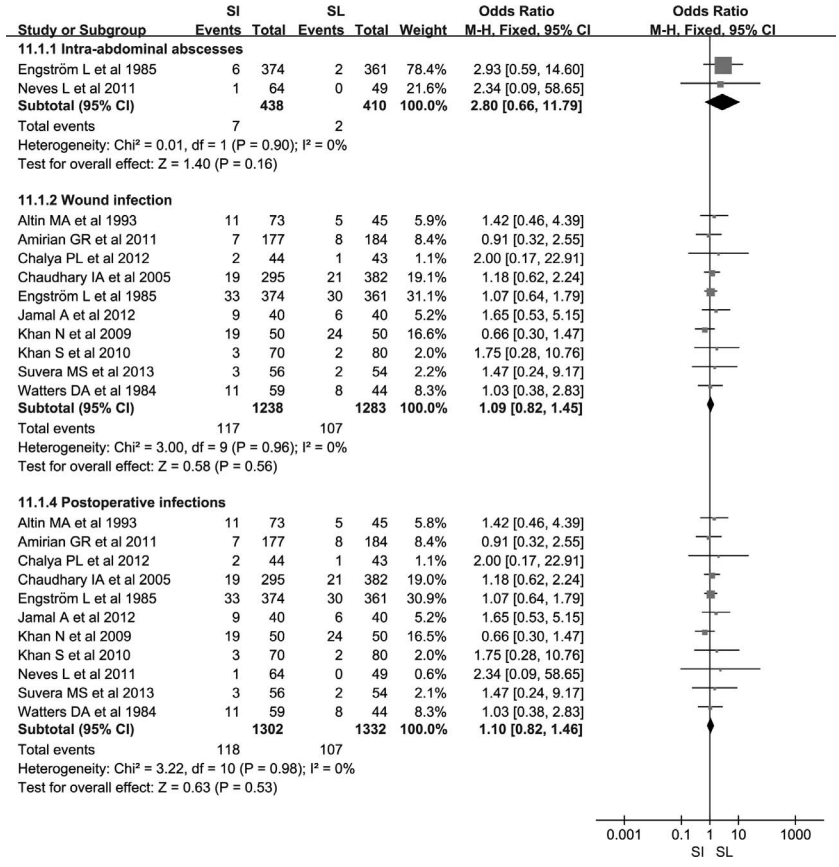

Fig. 2 Postoperative infections, including intra-abdominal abscesses and wound infection. IV, inverse variance; MH, Mantel-Haenszel.

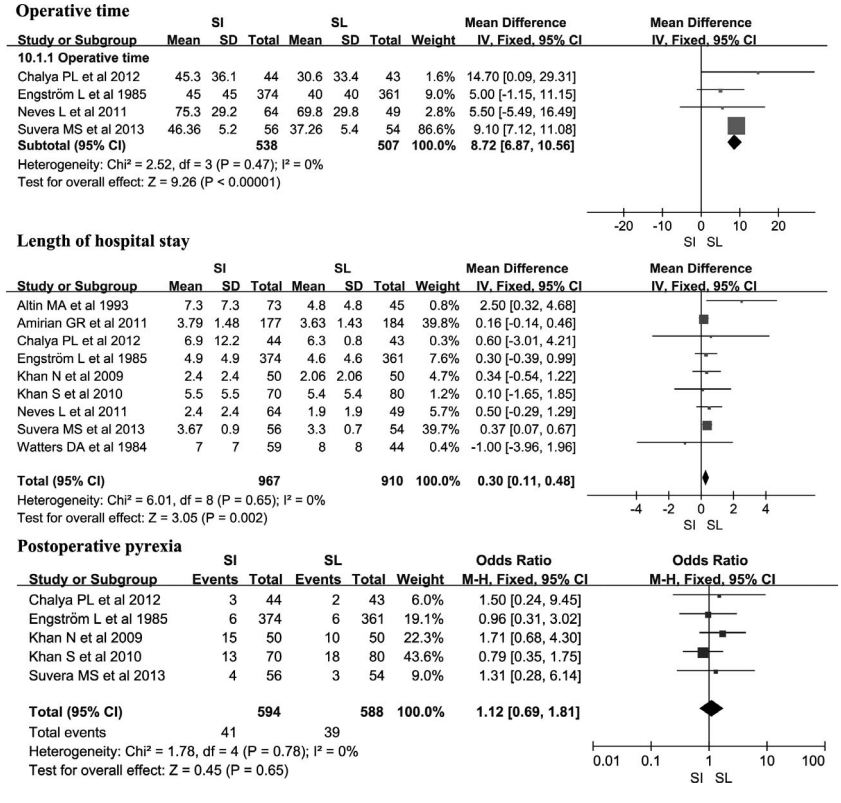

Fig. 3 Operative time (minutes), length of hospital stay (days), and postoperative pyrexia.

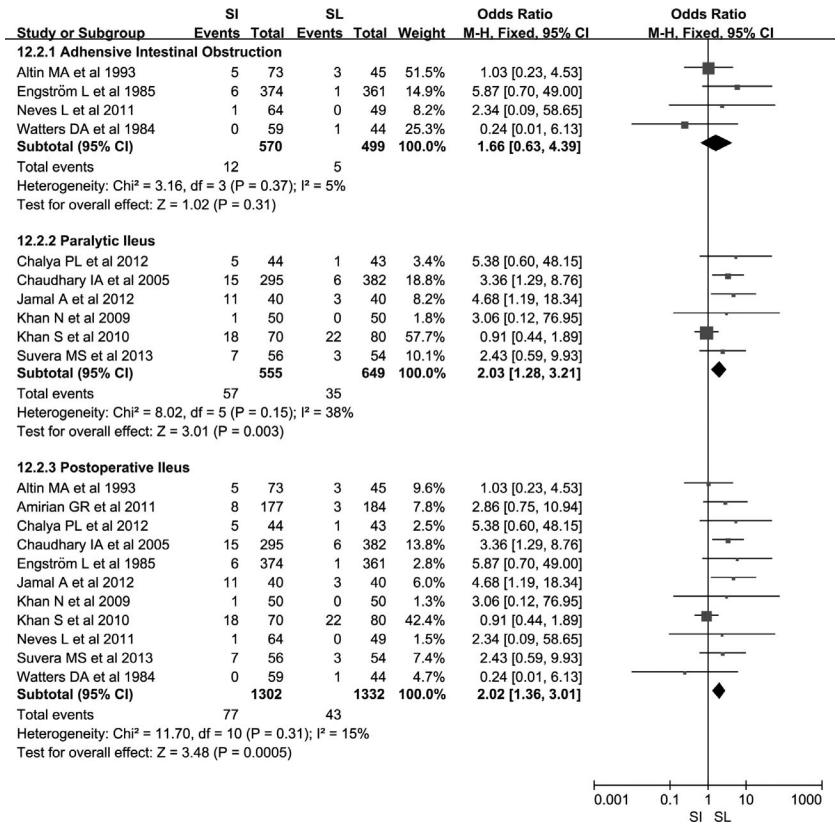

Fig. 4 Postoperative ileus, including paralytic ileus and adhesive intestinal obstruction.

addition, patients in the SI group have more frequent residual abscesses over the wall of the cecum,[21] wound infections,[22] and deformation (filling defect) may be suspected as a neoplasm, possibly leading to unnecessary laparotomy or colonoscopy.[19]

In this meta-analysis, SL could save a mean of 8.8 minutes. The operative time findings, in fact, are based on the weight (86.6%) of 1 study. The explanations for above weight bias include many aspects, such as the experience of surgeons, the severity of diseases, the choice of operative incision, and the number of cases and so on. The overall result is beneficial to a simple ligation approach due to the simplicity of the procedure. Many studies have shown that operative time is correlated with

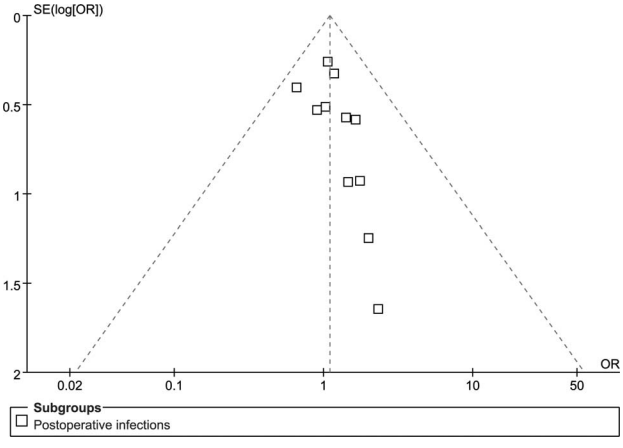

Fig. 5 The postoperative infections funnel plot is demonstrating no significant publication bias.

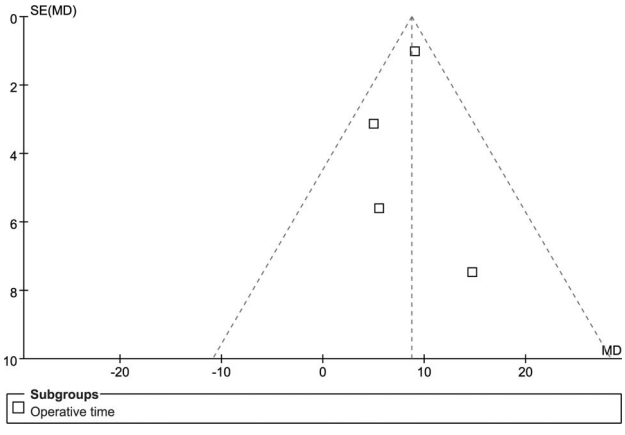

Fig. 6 The operative time funnel plot is demonstrating no significant publication bias.

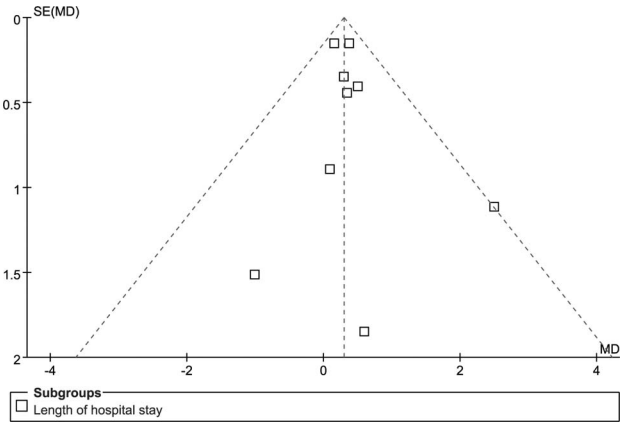

Fig. 7 The length of hospital stay funnel plot is demonstrating no significant publication bias.

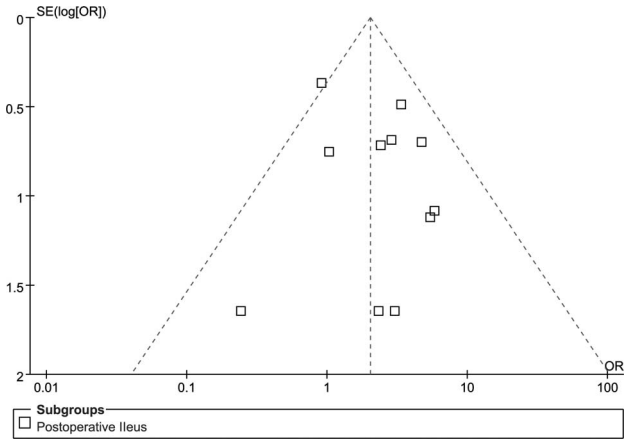

Fig. 9 The postoperative ileus funnel plot is demonstrating no significant publication bias.

prognosis. Furthermore, saved operative time improves work efficiency and reduces cost. There was no difference in the frequency of postoperative infections between the 2 approaches, which was inconsistent with a previous report,[23] and attributed to the use of prophylactic antibiotics,[24,25] postoperative drainage,[24] nonperforated appendices, and good physical health. These factors, combined with advanced surgical sutures, could decrease the occurrence of infection.[26,27]

Postoperative ileus included paralytic ileus and adhesive intestinal obstruction in this meta-analysis. More patients had postoperative or paralytic ileus in the SI group instead of adhesive intestinal obstruction. In the SI group, the appendiceal stump was required to perform burial into the serosa, which led to deformation and ischemia at the distal end of the cecum. The ischemic cecal wall could be aggravated by a small or tight purse-string suture. If the purse string was too large or loose, the stump would not be embedded intact into the serous inner layer of the cecum, which could increase the incidence of infections, abdominal adhesions, and cecal fistulas. A moderate purse ring would be difficult to complete by surgeons, especially beginners. Although the patients in the SL group should be more prone to the occurrence of abdominal adhesions, in theory, the 2 techniques indeed had a similar incidence. Thus, we conclude that an inadequate purse-string suture in the SI group could be the main reason for the occurrence of a higher rate of ileus and a similar rate of adhesions resulting from an impairment of blood supply to the cecal serosa and the anatomic deformation.

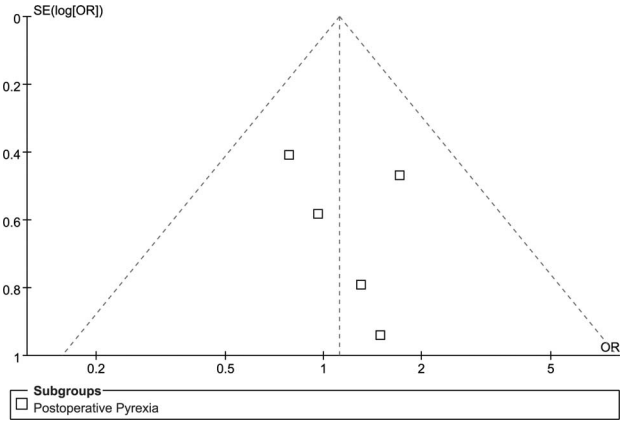

Fig. 8 The postoperative pyrexia funnel plot is demonstrating no significant publication bias.

Through a detailed examination of all studies, we found that high-quality studies were lacking. Second, the diagnoses amongst patients were different [normal (N), acute (A), gangrenous (G), and even perforated appendicitis (P)]. Third, the recording of antibiotic use and intra-abdominal drainage was incomplete. Fourth, the use of sutures was different in these studies, with 3 reporting the use of chromic sutures, 2 using atraumatic silk suture, and 1 using absorbable and nonabsorbable threads. Finally, the observed results were mainly early postoperative indicators.

In conclusion, the clinical evidence favors the application of SL when performing appendicectomies. Simple ligation could simplify the technical procedure, shorten the operative time, decrease the incidence of postoperative ileus, and reduce the length of hospital stay.

Acknowledgments

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