



# Closure of the Appendiceal Stump in Laparoscopic Appendectomy: A Comparison of Approaches to Complicated Appendicitis

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## Abstract

**Background:** Various techniques can be used for the closure of the appendiceal stump in laparoscopic appendectomy, although no consensus exists on the optimum approach.

**Objectives:** The present study was conducted to compare three different stump closure techniques in cases of complicated appendicitis.

**Methods:** A total of 172 patients who underwent laparoscopic appendectomy for complicated appendicitis were selected for conducting the present retrospective cohort study. The patients were divided into three groups according to the appendiceal stump closure technique: Hem-o-lok clips; extracorporeal knots which were pushed into the abdomen; and laparoscopic knots which were tied manually within the abdomen. The three groups of patients were compared for demographic and clinical characteristics as well as follow-up data.

**Results:** A total of 85 patients were in Group 1, 43 patients in Group 2, and 44 patients in Group 3. The most common surgical finding was a necrotic appendix in all three groups (67.1% vs. 81.4% vs. 68.2%;  $p: 0.448$ ). The rate of drain use (42.4% vs. 34.9% vs. 31.8%;  $p: 0.455$ ) and the readmission rates (10.6% vs. 14% vs. 11.4%;  $p: 0.178$ ) were also similar in all groups. The median postoperative hospital stay was 2 days in all groups.

**Conclusion:** No superiority was identified in any of the approaches to stump closure for the laparoscopic treatment of complicated appendicitis cases. All three techniques can be used safely. Accordingly, the technique should be selected based on the assessment of the surgeon, patient's characteristics, and cost.

**Keywords:** Appendiceal stump, Complicated appendicitis, Laparoscopic appendectomy

## 1. Background

Acute appendicitis (AA) is one of the most common surgical emergencies which requires acute hospitalization. In recent years, laparoscopic surgery has replaced open surgery in appendectomy as many other surgical interventions. Previous studies have determined advantages of laparoscopic appendectomy (LA) over open procedures such as less postoperative pain, lower rate of wound infection, faster recovery, and shorter length of hospital stay (1,2).

Several methods have been described for the laparoscopic closure of the appendiceal stump, including endoloops (handmade or ready-made endoloops), endoclips (metal or polymeric clips), staplers, manual suture ligation, and endocoagulation devices; however, no consensus exists on the optimum approach. Previous studies have detailed the advantages and disadvantages of each method in preserving the appendiceal stump, with the most effective factors in ensuring stump safety reported to be ease of application and severity of stump inflammation (2-4). Data on LA is insufficient in complicated appendicitis while numerous studies have been performed on LA, especially in uncomplicated appendicitis (4,5).

## 2. Objectives

The present study contributes to the literature by

comparing the stump closure methods used in LA in complicated appendicitis.

## 3. Methods

This single-center retrospective study was planned after approval by the local Ethics Committee of Basaksehir Cam and Sakura City Hospital (No: 123 07/2021). Patients over 18 years with a diagnosis of acute appendicitis who underwent LA in the general surgery clinic (01.06.2020-01.06.2021) were reviewed, and those with surgical findings of complicated appendicitis and complete data were included in the study. Cases of complicated appendicitis in the surgical findings were classified as having perforated, plastron, and necrotic appendicitis, or a periappendicular abscess. Exclusion criteria included patients who underwent open surgery with a diagnosis of acute appendicitis, those who underwent open surgery converted from laparoscopic surgery, patients without complicated appendicitis based on surgical findings, and those with malignancies of the appendix which were diagnosed with pathology.

Acute appendicitis was diagnosed in patients who presented to the emergency department or outpatient clinic with abdominal pain based on the medical history, physical examination, laboratory tests, and abdominal ultrasonography and/or computed tomography. All patients received pre-

incision antibiotic prophylaxis, and all operations were performed under general anesthesia. Three trocars – an 11-mm infra-umbilical, a 5-mm suprapubic, and an 11-mm left lateral – were used after urinary catheterization. Extra Large (XL) 7mm-16mm Hem-o-lok clips were used for all patients.

The patients were divided into three groups based on the appendiceal stump closure technique selected by the surgeon: "Group 1: Hem-o-lok clips", "Group 2: extracorporeal knots which were pushed into the abdomen" and "Group 3: laparoscopic knots which were manually tied within the abdomen". The three groups were compared for demographic characteristics, laboratory parameters, surgical findings, appendiceal stump closure techniques, drain use, length of hospital stay, and unplanned 30-day hospital readmission rate.

### 3.1. Statistical Analysis

Quantitative data were summarized based on median (minimum-maximum) values and qualitative variables using numbers and percentages. Shapiro-Wilk test was used to analyze the normality of the data. The presence of statistically significant differences in the input variables and the relationship between the categories of the output variable were

examined using a Kruskal-Wallis test and Chi-squared test. A p-value less than 0.05 was considered statistically significant. IBM SPSS Statistics for Windows (Version 26.0. Armonk, NY: IBM Corp.) was used for all analyses.

## 4. Results

A total of 172 patients were included in the study, with 85,43 and 44 patients were divided into groups 1, 2, and 3, respectively. The mean age was similar ( $p > 0.05$ ), and males were the predominant gender in all groups. The neutrophil ( $p: 0.01$ ) and lymphocyte counts ( $p: 0.002$ ) were different in the groups. The demographic and laboratory data are presented in Table 1.

The most common surgical finding was a necrotic appendix in all three groups (67.1% vs. 81.4% vs. 68.2%;  $p: 0.448$ ). The rate of drain use (42.4% vs. 34.9 vs. 31.8;  $p: 0.455$ ) and readmission (10.6% vs. 14 vs. 11.4;  $p: 0.178$ ) was similar in all groups. The most common reason for re-admission in the groups was wound complications. The mean postoperative length of hospital stay was 2 days in the three groups. The clinical follow-up data are presented in Table 2.

**Table 1.** Demographic and laboratory findings

Variables	Group (Stump)			p-value*
	Hem-o-lok Number (%)	Extracorporeal Number (%)	Intracorporeal Count	
Age	31 (18-71)	30 (18-58)	29.5 (18-74)	0.46498
Gender	Male	47 (55.3)	30 (69.8)	0.286
	Female	38 (44.7)	13 (30.2)	
White blood cells	12.98 (4.53-28.24)	11.56 (5.12-20.32)	12.9 (4.49-17.8)	0.07614
Neutrophils	10.27 <sup>a</sup> (2.28-27)	8.62 (2.86-16.68)	10.11 (3.09-14.65)	0.01154
Lymphocytes	1.7 <sup>a</sup> (0.82-11.93)	2.14 <sup>b</sup> (0.9-5.16)	1.83 (0.25-4.93)	0.00221
C-reactive protein	25.6 (0.8-355)	35.4 (0.3-187)	22.9 (0.15-333.1)	0.93242

\*: a: different from the extracorporeal group; b: different from the intracorporeal group.\*\*: Variables are summarized as 'median (min-max.)'.

**Table 2.** Clinical data

Variables	Group (Stump)			p-value*
	Hem-o-lok Number (%)	Extracorporeal Number (%)	Intracorporeal Number	
Surgical Findings	Necrotic	57 (67.1)	35 (81.4)	0.448
	Perforated, without abscess	10 (11.8)	1 (2.3)	
	Perforated, with abscess	9 (10.6)	5 (11.6)	
	Peritonitis	3 (3.5)	1 (2.3)	
Drain	Plastron	6 (7.1)	1 (2.3)	0.455
	No	49 (57.6)	28 (65.1)	
Readmission	Yes	36 (42.4)	15 (34.9)	0.853
	No	76 (89.4)	37 (86.0)	
Readmission Reasons	Yes	9 (10.6)	6 (14.0)	0.853
	Local wound complications (Infection, hematoma, seroma)	7 (8.2)	5 (11.7)	
	Subileus	1 (1.2)	0	
	Intraabdominal abscess	1(1.2)	0	
Length of hospital stay	Intraabdominal hematoma	0	1 (2.3)	0.17863
	2 (1-10)	2 (1-5)	2 (1-12)	
Length of follow-up	192 (54-425)	240 (55-384)	207.5 (62-394)	0.2811

\*: Pearson's Chi-squared test

## 5. Discussion

The present study which compared the stump closure techniques in patients with complicated appendicitis treated with the laparoscopic approach established similar results in quality indicators such as length of hospital stay and unplanned readmission for the three stump closure techniques examined in a patient population with similar demographic and clinical characteristics.

The optimum stump closure technique during laparoscopic appendectomy remains a controversial issue. Ensuring safe stump closure is a key factor in dealing with complicated appendicitis due to the potential for local inflammation and infection at the surgical site, which can involve the cecum and the base of the appendix. Stump closure can sometimes become acute, leading to serious postoperative, and life-threatening complications such as stercoral fistulas, postoperative peritonitis, and sepsis. Choosing a technique for the closure of the appendiceal stump usually depends on several factors, including the surgeon's confidence in various available techniques, the macroscopic aspect of the appendix and the degree of inflammation, the availability of the technique, and the cost of the procedure (6, 7).

Several studies were conducted on stump closure techniques in the literature. Soll et al. compared Hem-o-lok clips with the endoloop technique in their 813 cases and reported postoperative intra-abdominal abscesses in 1% of the Hem-o-lok group and 4% of the endoloop group (8). Similarly, Üreyen et al. established no significant difference in complications between the intracorporeal knotting and Hem-o-lok clip (3). In contrast, the rate of postoperative intra-abdominal abscess, length of hospital stay, and readmission and reoperation rates in a systematic review of 5934 patients with complicated appendicitis were found to be similar to all stump closure techniques. No difference was observed in the primary outcomes of patients with complicated appendicitis (6).

While numerous studies in the literature reported similar results from different stump closure techniques, a study of 43 randomized controlled trials found suture ligation to be the most effective treatment approach in intra-abdominal and superficial infections at the surgical site (9). However, no significant difference was established in postoperative quality indicators of the three stump closure techniques in the present study.

Although the potential for postoperative complications and stump leak should be considered when choosing a ligation technique, a systematic review of Cochrane established no significant difference in postoperative complications between the endoscopic clip and ligation techniques (endoloops and intracorporeal knots) used to close

the appendiceal stump (10). Delibegović et al. selected 120 patients with acute appendicitis into endoloop, stapler, metal, and plastic locking clip (Hem-o-lok) groups in their recently published randomized controlled trial to compare four different approaches to the closure of the appendiceal stump, however, they reported no perioperative complications in their study. The summarized study findings reported only a longer operative time associated with endoloops and a similar length of hospital stay in the treatment arms (11).

Despite the numerous studies conducted to date, no consensus exists on the optimum approach to appendiceal stump closure in LA, and no specific method is recommended in the literature. Based on the findings of prospective randomized studies with large sample sizes comparing different methods, staplers should be considered when the base of the appendix is severely inflamed or necrotic. Stapler and endoloop approaches are known to be more expensive than others, while cheaper alternatives include suture ligations and handmade loops, which are also safe options (7, 12-14).

Research limitations included selecting retrospective design and closure techniques based on the decision of the treating surgeon. A surgeon's experience can affect the outcome of a technique.

## 6. Conclusion

In conclusion, the three techniques which were examined in the present study are all accepted techniques for stump closure in complicated appendicitis and can be safely performed with similar outcomes. The surgeon's experience and the patient's characteristics should be considered in choosing the appropriate method.

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