Evaluation of closure of appendicular stump in laparoscopic appendectomy using LT400 clips

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Introduction
Closure of the appendicular stump in laparoscopic appendectomy is a crucial step owing to its importance in preventing postoperative infectious complications. The best method is still debatable. In this study, we used a titanium LT400 clip; the aim was to investigate the safety and feasibility of the clip as an alternative for stump closure.

Patients and methods
A prospective randomized study was conducted for all patients presented with acute appendicitis and had laparoscopic appendectomy using LT400 clips for stump closure. Hospital records over 2 years for intraoperative and postoperative complications, operation time, duration of hospital stay, rehospitalization, reoperation, and incidence of using different methods to close the stump of the appendix other than the LT400 clips among patients were analyzed.

Results
This study included 102 patients who presented with acute appendicitis including 29 cases complicated by abscess, mass, and gangrene. All participants were operated on by laparoscopic appendectomy, with one case converted to open surgery. Median lengths of operative time and hospital stays were 29.11 min and 1 day, respectively. The clips used ranged from three to eight LT400 clips in each case. In addition, we used Hem-O-Lok clips for the closure of the appendix stump in 10 (9.8%) patients. Postoperative complications occurred in seven cases; all were superficial wound infection. There was no intestinal leakage or need for readmission to hospital.

Conclusions
LT400 clips are a safe, feasible, easy to apply, and cheap alternative for stump closure in laparoscopic appendectomy.

Keywords:
appendicitis, appendix stump closure, laparoscopic appendectomy, LT400 clips

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Introduction

Acute appendicitis is one of the most common surgical emergencies requiring urgent hospital admission [1] and is the most common presentation of the acute abdomen [2].

Laparoscopic appendectomy has challenged open appendectomy as the preferred surgical treatment for acute appendicitis with advantages of decreasing postoperative pain, a lower rate of wound infection, faster recovery, and shorter hospital stay when compared with the open procedure. As time and experience has progressed, laparoscopy has been used to treat even more complex cases of acute appendicitis to include perforation, abscess, and gangrene [3,4].

However, the laparoscopic approach is associated with longer procedure times, increased cost, and a higher risk of postoperative intra-abdominal abscess formation [5–7].

Closure of the appendicular stump (AS) is an essential step performed during laparoscopic appendectomy. Several methods of stump closure have been described, and there is still no agreement on the best way. Inadequate management of the AS has the potential to cause significant morbidity. Stump leakage secondary to inadequate stump closure is a known complication following the laparoscopic approach [8].

Aim

The aim was to investigate and evaluate the safety and feasibility of LT400 clips as a safe, feasible, cheap,

available alternative in AS closure in different severities of acute appendicitis.

Patients and methods

A prospective randomized study was conducted on all patients admitted to the emergency department in Fayoum University Hospital and Misr International Hospital diagnosed with acute appendicitis between March 2019 and December 2021.

Our university's ethical committee approved the study. Informed consent was obtained from all patients.

We included 102 patients who presented with the picture of acute appendicitis. All cases had an adequate clinical examination and were aided by abdominal-pelvic ultrasound, complete blood count, and C-reactive protein for diagnosis.

Inclusion criteria

The following were the inclusion criteria:

(1) Age: 16 years and above.
(2) Acute noncomplicated appendicitis.
(3) Acute complicated appendicitis like appendicular abscess, perforated, or even gangrenous appendix.

Exclusion criteria

The following were the exclusion criteria:

(1) Previous history of upper abdominal open surgery to avoid the effect on operation time.
(2) High risk cardiopulmonary patients to prevent the effect of pneumoperitoneum.
(3) Cases were found to have other pathologies rather than appendicitis during laparoscopic exploration of the peritoneal cavity.
(4) Patients with high risk for general anesthesia.
(5) Patients missed during postoperative follow-up.

All operations were done by the authors (MD certified surgeons) with at least 7 years of experience in laparoscopic surgery. All operations were done under general anesthesia. The patient was placed in a supine position. Standard three-port approach, peri-umbilical left lower quadrant, and lower midline were used for all procedures.

Pneumoperitoneum was established by direct trocar entry using a 5.5-mm safety blunt trocar, and then, an 11-mm safety trocar was introduced for the telescope. Under direct vision, a 5.5-mm port was placed midline in a suprapubic position. A third 11-mm port was placed in the left lower quadrant of the abdomen.

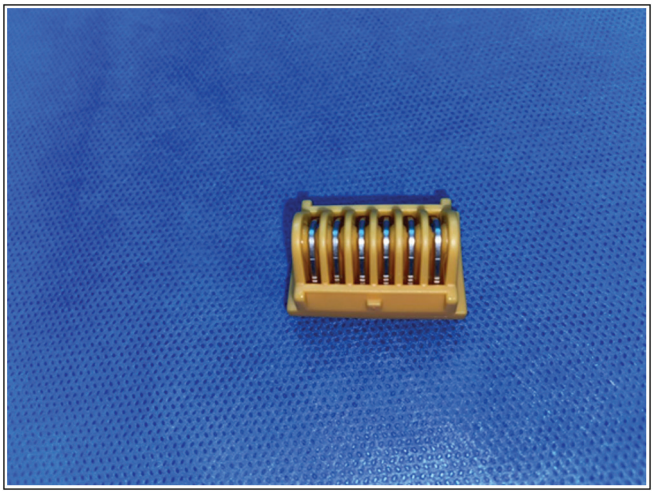
After exploring the abdominal cavity and confirming the diagnosis, the appendix was mobilized by dissecting the mesoappendix with electrocautery close to the appendix; this facilitated the delivery of the appendix through the left 11-mm port. In some cases, LT400 clips were applied over the mesoappendix.

LT400, a pure titanium clip, comes in a cartridge of six clips. The clip aperture is 7.5 mm, and the closed clip length is 12.26 mm.

On average, the price of each cartridge is 120 L.E. It has been available in Egypt for more than 10 years, and it is manufactured by ETHICON (Somerville, NJ, USA) (Fig. 1). The clips were applied by reusable and autoclavable clip applier (Fig. 2).

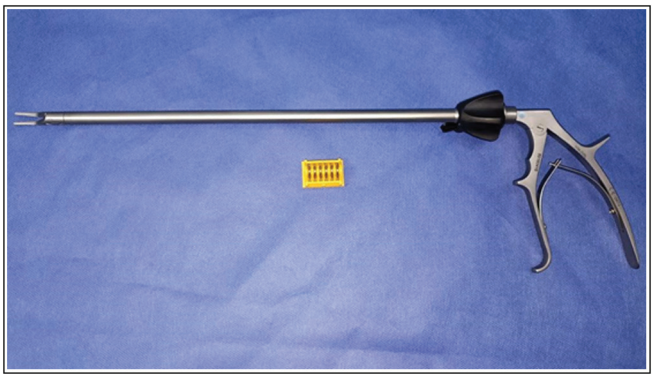
Two LT400 clips were placed on the base of the appendix just distal to the caeco-appendiceal junction by the clip applier introduced through the 11-mm

Figure 1



LT400 clips.

Figure 2



Clip applier for LT400 clips.

left iliac port. A third clip was positioned distal to the previously applied two clips.

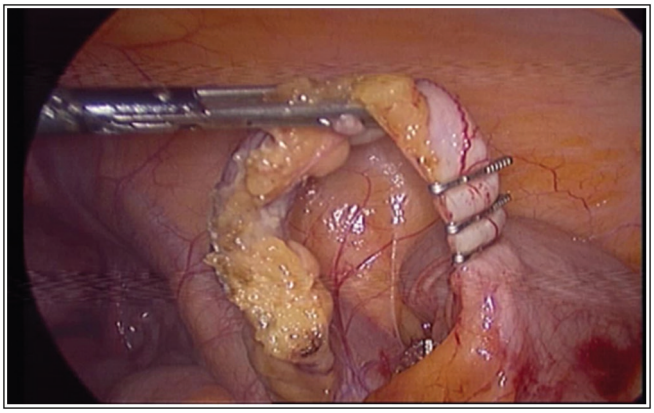
LT400 clips were used to close the AS in most cases included in this study (92 patients); two proximal clips and a distal clip were enough to close the AS adequately, and the tip of the clips was closed beyond the stump edge (Fig. 3).

In a few cases when the AS outer diameter was larger than 12 mm, a third clip was applied in the most distal position over the stump (Fig. 4).

In 10 of 102 patients included in this study, we preferred to close the AS with Hem-O-Lok; a polymeric clip was selected in those 10 patients because the AS was severely inflamed, friable, and even gangrenous (Figs 5,6).

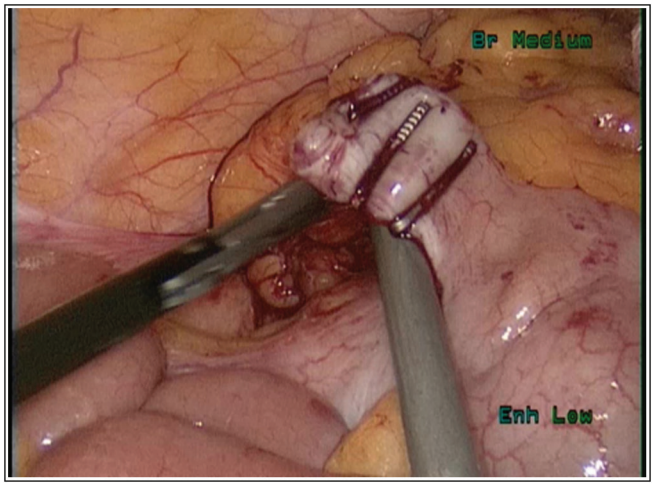
The closure force of the Hem-O-Lok clips is lower than the titanium LT400, and its removal is much easier if we decide to remove it.

Figure 3



Appendicular stump closed by two clips and one distal clip.

Figure 4



Appendicular stump closed by three LT400 clips.

Cutting the appendix was done between the proximal clips and the distal clip by a scissor just proximal to the most distal clip.

The appendix was removed through the 11-mm left-side port. The stump and mesoappendix were inspected for security and hemostasis. In cases of peritoneal abscess, evacuation of collection and peritoneal wash by 0.9 saline was done with a tube drain insertion through the suprapubic port.

Analysis

The collected data were organized, tabulated, and statistically analyzed using SPSS software statistical computer version 18 (SPSS Inc., Chicago, Illinois, USA).

Descriptive statistics were presented as mean and SD for normally distributed numerical variables and median and interquartile range (IQR) for nonnormally distributed variables. At the same time, numbers and percentages are used for categorical variables.

Mann–Whitney test was used to compare operative time, hospital length of stay, and the number of clips with the status of the appendix. In addition, the χ^2 test or Fisher exact test was used to compare operative and postoperative characteristics with the status of the appendix.

IBM SPSS 28 for Windows software was used for the analysis, and a *P* value less than 0.05 was considered statistically significant.

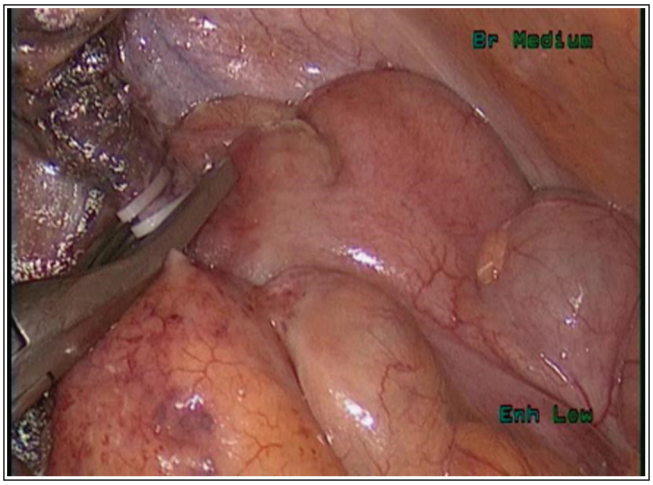
Results

A total of 102 patients presented a picture of acute appendicitis were included in this study. All of them were operated upon laparoscopically after confirming the diagnosis by pelvi-abdominal ultrasonography and laboratory test in the form of CRP-CBC.

The following is the analysis for patients' age, sex, incidence of complicated appendicitis, perioperative events, and outcome variables.

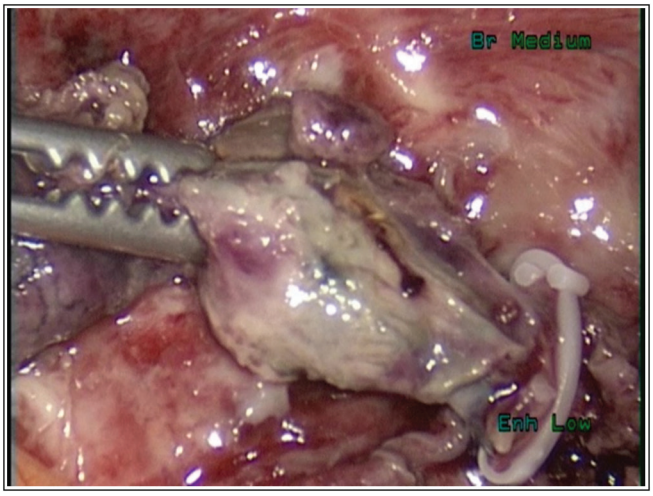
Table 1 presents the age and sex distribution in our patients and also the incidence of complicated appendicitis (abscess, gangrene, and mass). The mean age of patients was 29.50 ± 10.45 years. Overall, 42.2% of the patients were males, whereas 57.8% were females (Fig. 7). In addition, 28.4% of the patients had complicated appendicitis, whereas 71.6% had no complicated appendix (Fig. 8). Moreover, 13.7% of the patients had mass as a complication, 3.9% of the patients

Figure 5



Appendicular stump closed by Hem-O-Lok clips.

Figure 6



Extensive gangrene of the appendix reaching to the base closed by Hem-O-Lok.

Table 1 Age, sex, and complications

	n (%)
Age	
Mean (SD)	29.50 (10.45)
Sex	
Male	43 (42.2)
Female	59 (57.8)
Complicated appendix	
No	73 (71.6)
Yes	29 (28.4)
Type of complication	
Mass	14 (13.7)
Abscess	4 (3.9)
Abscess and gangrene	4 (3.9)
Mass and gangrene	4 (3.9)
Abscess and mass	2 (2.0)
Gangrene	1 (1.0)

had abscess as a complication, 3.9% of the patients had abscess and gangrene as complications, 3.9% of the patients had mass and gangrene as complications, 2% of the patients had abscess and mass as complications, and 1% of the patients had gangrene as a complication (Table 1).

The median operative time was 29.11 min (IQR=21), whereas the median hospital length of stay was 1 day (IQR=0). Hem-O-Lok was used in 9.8% of the patients.

Regarding the number of clips excluding cases when Hem-O-Lok were used to close (AS), three clips were used in 63% of the patients, four clips were used in 19.6% of the patients, five clips were used in 10.9% of the patients, six clips were used in 4.3% of the patients, seven clips were used in 1.1% of the patients, and eight clips were used in 1.1% of the patients (Fig. 9). Conversion to open surgery occurred with one patient, whereas no cases required hospital readmission (Table 2).

The drains were used in 26% of the patients [95% confidence interval (CI): 19%, 36%]. Overall, 10% of the patients had mild bleeding as an operative complication (95% CI: 5%, 17%), and 7% of the patients had surgical site infection as a postoperative complication (95% CI: 3%, 14%).

Hem-O-Lok was used in 9.8% of the patients (95% CI: 5%, 17%) (Table 3).

Mann–Whitney test was used to compare operative time, hospital length of stay, and the number of clips with the status of the appendix.

It showed a statistically significant difference in operative time as patients with complicated appendix took longer operative time (median=44.5, IQR=24) than patients with no complicated appendix (median=19, IQR=10), with *P* value less than 0.001.

There was a statistically significant difference in hospital length of stay as patients with complicated appendix stayed in the hospital for a longer duration (median=2, IQR=1) than patients with no complicated appendix (median=1, IQR=0), with *P* value less than 0.001.

There was no statistically significant difference in the number of clips.

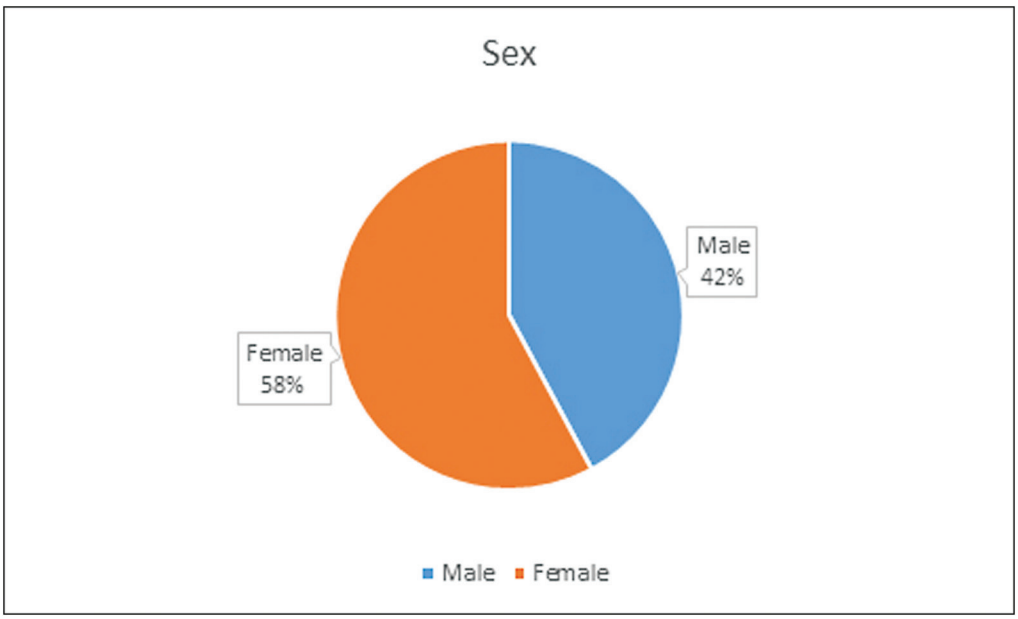
χ^2 test or Fisher exact test was used to compare operative and postoperative characteristics with the status of the appendix.

Hem-O-Lok clip usage showed a statistically significant difference with the status of the appendix as the percentage of Hem-O-Lok used in patients with complicated appendix was 24.1%, which is less than the group without complicated appendix, which was 4.1%, with *P* value of 0.005.

Use of drains showed a statistically significant difference as the percentage of patients who had a drain in the complicated appendicitis group was higher than the percentage of patients who had a drain in the noncomplicated appendicitis group (65.5 and 11%, respectively; *P*<0.001).

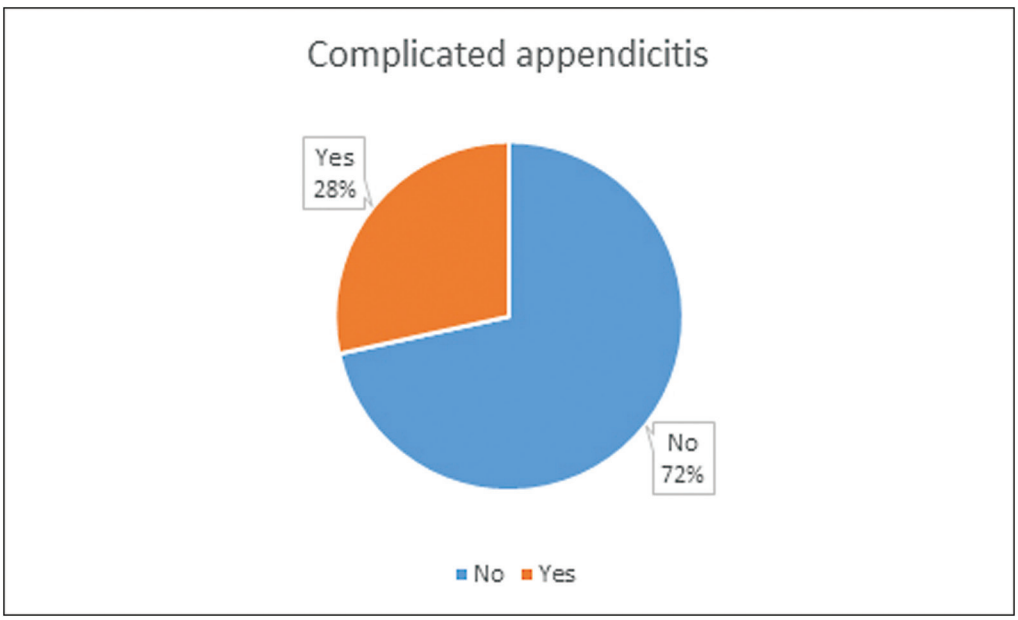
Postoperative complications showed a statistically significant difference. The percentage of patients who had surgical site infection in the complicated appendicitis group was higher than that in the noncomplicated appendicitis group (17.2 and 2.7%; *P*=0.019).

Figure 7



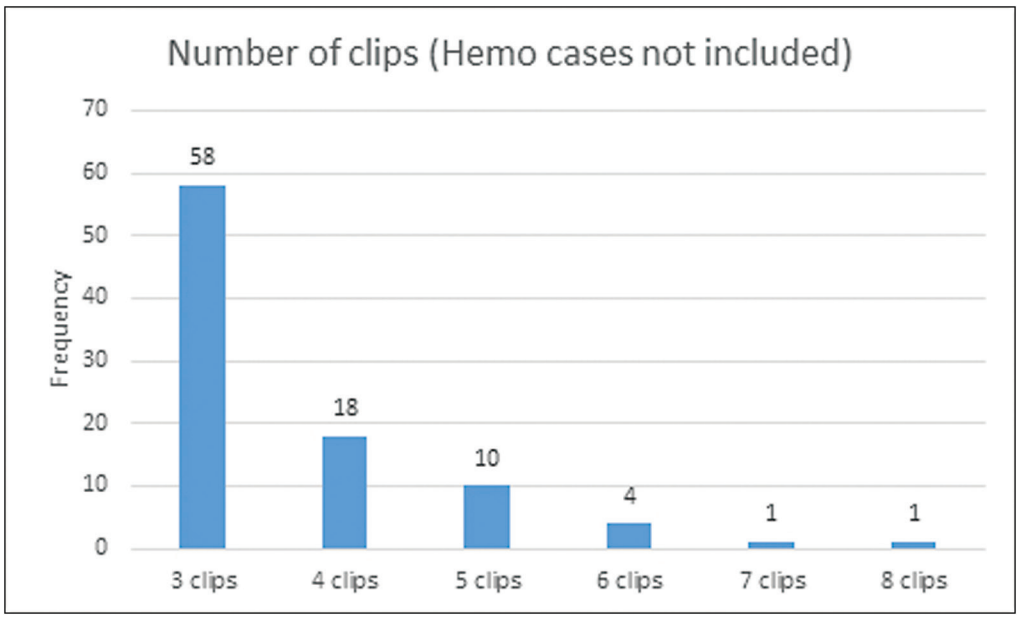
Pie chart of sex distribution among patients.

Figure 8



Pie chart of complicated appendicitis.

Figure 9



Bar chart of the number of LT400 clips used.

Table 2 Characteristics of operative and postoperative outcomes

	Median (IQR)
Operative time	29.11 (21)
Hospital stay	1 (0)
	n (%)
Use of other techniques	
Hem-O-Lok	10 (9.8)
Number of clips (HEMO cases not included)	
3 clips	58 (63.0)
4 clips	18 (19.6)
5 clips	10 (10.9)
6 clips	4 (4.3)
7 clips	1 (1.1)
8 clips	1 (1.1)
Conversion to open surgery	1 (1.0)
Use of drain	27 (26.5)
Readmission	0 (0)
Operative complication	
Mild bleeding	10 (9.8)
Postoperative complication	
Surgical site infection	7 (6.9)

IQR, interquartile range.

There was no statistically significant difference between the two groups regarding the occurrence of minimal bleeding (Table 4).

Discussion

Laparoscopic appendectomy is the current recommended surgical approach for treating uncomplicated appendicitis, as this has been found to reduce hospital stay, postoperative pain, and risk of infection [1]. During this procedure, closure of the AS is believed to be the most crucial step. Complications from incomplete closure include postoperative fistula, peritonitis, and sepsis [2].

The question of the optimal technique for AS closure is not settled. The data, however, have been conflicting, especially when assessing the effect of the method on complications [3].

The LT400 clip is made from titanium which is a biocompatible implant material that leads to high tissue adaptation as well as a constant and high closing force [5].

Several methods and devices are available to close the AS during a laparoscopic appendectomy, such as the endoloop, linear stapler, metal or polymer clips, and open purse-string suture. The best among them, however, remains controversial [4,5].

The laparoscopic linear stapler is frequently used outside Egypt to close the AS. One study reported that this method is the safest and most expensive option [6]. Meanwhile, an endoloop is less expensive than a stapler but more technically demanding and requires laparoscopic sewing experience [7].

In recent years, clips have been suggested as an alternative for closing the AS during laparoscopy. Some reports have presented the results of nonabsorbable polymeric clips, called Hem-O-Lok, showing that polymeric clips reduced costs and produced comparable complication rates. However, the use of this polymeric clip is limited and depends on inflammatory severity and appendicular base diameter [2,5,9].

Table 3 Results of operative outcomes

			95% CI of the percentage	
	N	Proportion	Lower	Upper
Use of drain	27	26%	19%	36%
Operative complication (mild bleeding)	10	10%	5%	17%
Postoperative complication (surgical site infection)	7	7%	3%	14%
Use of Hem-O-Lok	10	9.8%	5%	17%

Table 4 Comparison of patients with and without complicated appendicitis

	Complicated appendix		
	No	Yes	*P* value
Operative time [median (IQR)]	19 (10)	44.5 (24)	<0.001
Hospital stays [median (IQR)]	1 (0)	2 (1)	<0.001
Number of clips [median (IQR)]	3 (1)	3.5 (2)	0.122
Hem-O-Lok usage [*n* (%)]			
Hemo usage	3 (4.1)	7 (24.1)	0.005
Clips only used	70 (95.9)	22 (75.9)	
Use of drain [*n* (%)]			
No	65 (89.0)	10 (34.5)	<0.001
Yes	8 (11.0)	19 (65.5)	
Operative complication (minimal bleeding) [*n* (%)]			
No	68 (93.2)	24 (82.8)	0.221
Mild bleeding	5 (6.8)	5 (17.2)	
Postoperative complication (surgical site infection) [*n* (%)]			
No	71 (97.3)	24 (82.8)	0.019
Surgical site infection	2 (2.7)	5 (17.2)	

IQR, interquartile range.

Rickert *et al*. [10] recommended double shanked clips for AS closure owing to the safety and effectiveness of the titanium used in its design. Still, to our knowledge, this device is expensive and not available in Egypt.

The LT400 clip is made from titanium, which is a biocompatible implant material that leads to high tissue adaptation and a constant and high closing force. Some studies have reported the safety of using the Hem-O-Lok clip for the closure of ASs up to 10-mm stump diameter [11].

Many studies comparing different methods of stump closure regarding safety, operative time, rate of complications, cost, hospital stay, and readmission rate were reported [8].

In our study, 102 patients were included, where 43 were males and 59 were females. All of them were operated laparoscopically with conversion to open surgery in only one case.

Stump closure was performed in all of them with LT400 clip, which was very easily applied using a special clip applier. No special experience was needed to use this device, and the clip was applied easily on the stump. The price of this clip is almost cheaper than the price of the sutures.

In only 10 cases with the severely inflamed and gangrenous appendix, we preferred to apply a Hem-O-Lok clip, which is more expensive, with an average cost of 800 L.E. for the cartridge containing six clips.

The median operative time in this study was 29.11 min, and the reported operative time when a suture was used to close the stump was 68.2 min [12]. In comparison, Lucchi *et al*. [13] reported an operative time of about 36 min, and they compared in their series the use of Hem-O-Lok versus endoloops.

The median hospital stay in our study was 1 day. This reported hospital stay was in agreement with the study designed by Kim and Weireter. [14].

In 325 patients who underwent a laparoscopic appendectomy, the majority [250 (77%)] underwent stump closure with a stapler. The reported median hospital stay was 1.1 days, whereas Rickert *et al*. [15] reported a median of 4 days of hospital stay, and they used a Titanium clip for stump closure.

Many studies compared the cost-effectiveness of the equipment and materials that were used during stump closure. In our study, the cost of an average of 6 titanium clips that were used to close the stump and secure the mesoappendix

was about 120L.E. This was in agreement with Collak and his colleagues, and they also used endo clips during stump closure, whereas Kim and Weireter [14] reported a cost of 2005 euros, and they used an endostapler for stump closure.

The overall complications in our study were 7% (mainly port site infection), and our reported incidence of complications was the same when end loops were used to close the stump [16], whereas the overall complication rate was 14.4% with suture closure. This represented the highest incidence of complications among all methods of closure [12].

Conclusion

Using the titanium LT400 clips as a choice for stump closure during laparoscopic appendectomy had many advantages in comparison with other methods. The selected clips were readily available in Egypt, cheap, and easily applied; we reported neither slipping, migration of the clips, nor stump leakage in our cases; no special surgical skills were needed; and the overall operative time and hospital stay were shorter than those reported in the literature, with the complication rate almost the same as endostaplers and much lower than suture technique for (AS) closure.

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Nil.

Conflicts of interest

No conflict of interest.

References

1 Wei HB, Huang JL, Zheng ZH, Wei B, Zheng F, Qiu W-S. Laparoscopic versus open appendectomy: a prospective randomized comparison. Surg Endosc 2010; 24:266–269.

2 Gomes CA, Junior CS, de Peixoto RO, Netto JM, Gomes CC, Gomes FC. Appendiceal stump closure by metal endoclip in the management of complicated acute appendicitis. World J Emerg Surg 2013; 8:35.

3 White C. Determining the appropriate technique for appendix stump closure. Dayton, OH: Wright State University; 2021.

4 Gorter RR, Heij HA, Eker HH, Kazemier G. Laparoscopic appendectomy: state of the art. Tailored approach to the application of laparoscopic appendectomy? Best Pract Res Clin Gastroenterol 2014; 28:211–224.

5 Imaoka K, Fujisaki S, Fuk Uhara S, Ono K, Sawada H, Shishida M, *et al*. Effective appendix stump closure using the double-shanked titanium ligation clip (D.S. clip): a case report. HJMS J 2018; 67: 31–34.

6 Kazemier G, in't Hof KH, Saad S, Bonjer HJ, Sauerland S. Securing the appendiceal stump in laparoscopic appendectomy: evidence for routine stapling?. Surg Endosc 2006; 20:1473–1476.

7 osta-Navarro D, Jiménez-Fuertes M, IllánRiquelme A. Laparoscopic appendectomy: quality care and cost-effectiveness for today's economy. World J Emerg Surg 2013; 8:45.

8 Makaram N, Knight SR, Ibrahim A, Patil P, Wilson MSJ. Closure of the appendiceal stump in laparoscopic appendectomy: a systematic review of the literature. Ann Med Surg (Lond) 2020; 57:228–235.

9 Di Saverio S, Mandrioli M, Sibilio A, Smerieri N, Lombardi R, Catena F, *et al*. A cost-effective technique for laparoscopic appendectomy: outcomes and costs of a case–control prospective single-operator study of 112 unselected consecutive cases of complicated acute appendicitis. J Am Coll Surg 2014; 218:e51–e65.

10 Rickert A, Krüger CM, Runkel N, Kuthe A, Köninger J, Jansen-Winkeln B, Gutt CN, *et al*. The TICAP-Study (titanium clips for appendicular stump closure): a prospective multicentre observational study on appendicular stump closure with an innovative titanium clip. BMC Surg 2015; 15:85.

11 Delibegovic S. The use of a single Hem-o-lok clip in securix during laparoscopic appendectomy. J Laparoendosc Adv Surg Tech A 2012; 22:85–87.

12 Ates M, Dirican A, Ince V, Ara C, Isik B, Yilmaz S. Comparison of intracorporeal knot-tying suture (polyglactin) and titanium endoclips in laparoscopic appendiceal stump closure: a prospective randomized study. Surg Laparosc Endosc Percutaneous Tech 2012; 22:226–231.

13 Lucchi A, Berti P, Grassia M, Siani L, Gabbianelli C, Garulli G. Laparoscopic appendectomy: hem-o-lok versus Endoloop in stump closure. Updat Surg 2017; 69:61–65.

14 Kim S, Weireter L. Cost effectiveness of different methods of appendiceal stump closure during laparoscopic appendectomy. Am Surg 2018; 84:1329–1332.

15 Rickert A, Bonninghoff R, Post S, *et al*. Appendix stump closure with titanium clips in laparoscopic appendectomy. Langenbeck's Arch Surg 2012; 397:327–331.

16 Swank HA, van Rossem CC, van Geloven AA, Hof K, Kazemier G, Meijerink W. Endostapler or endoloops for securing the appendiceal stump in laparoscopic appendectomy: a retrospective cohort study. Surg Endosc 2014; 28:576–583.