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ORIGINAL ARTICLE

Comparison of Endoloop and Polymer Locking Clip in Ligating Appendicular Stump during Laparoscopic Appendectomy in Acute Appendicitis

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ABSTRACT

Background: One of the most frequent causes of acute abdomen is acute appendicitis. Because laparoscopic appendectomy is safer and requires less recovery time, it has become the method of choice. However, the optimal method for appendiceal stump closure remains debatable, with endoloop ligation and clipping being the most frequently used techniques. This study aimed to compare polymeric locking clips and endoloop ligation for appendiceal stump closure during laparoscopic appendectomy in patients presenting with acute appendicitis.

Methods: This prospective comparative study included 26 patients diagnosed with acute appendicitis who underwent laparoscopic appendectomy. The patients were randomly assigned to two equal groups, with 13 patients in each group. In Group A, appendiceal stump closure was performed using polymeric locking clips, whereas in Group B, endoloop ligation was used. Demographic characteristics, clinical findings, operative time, postoperative complications, length of hospital stay, time to return to work, and total treatment cost were recorded, analyzed, and compared between the two groups.

Results: Operative time was significantly shorter in the clipping group (44±9.5 min) compared to endoloop ligation (53.08±10.2min, $p<0.05$). Postoperative complications showed no significant difference between both groups. Hospital stay was shorter in the clipping group (2±0.67days) compared to the endoloop group (2.7±0.72 days, $p>0.05$). Total cost was significantly lower in the clipping group (269±45.1EGP) compared to endoloop ligation (1419±162.3 EGP, $p<0.001$). Return to work duration showed no significant difference.

Conclusion: Polymeric clipping and endoloop ligation are both safe and effective techniques for appendiceal stump closure in laparoscopic appendectomy.

Keywords: Laparoscopic appendectomy; Appendiceal stump closure; Clipping; Endoloop ligation

INTRODUCTION

The most frequent cause of acute abdomen is acute appendicitis, which is most prevalent in those aged 10 to 30 and an estimated lifetime incidence of 7% [1]. The most common abdominal surgery performed globally is still appendectomy. Laparoscopic appendectomy has become more popular than the traditional open method for appendiceal resection in recent decades [2]. The laparoscopic technique is often preferred by both patients and surgeons, as it minimizes complications associated with the open method, such as wound infection, seroma, postoperative pain due to muscle incision, extended hospitalization and a postponed return to regular activities.

During laparoscopic appendectomy, the appendiceal stump is secured to be the most important phase since improper closure could lead to severe intra-abdominal infections after surgery. Several methods have been described for appendiceal stump closure, including stapling devices, polymeric clips, extracorporeal or intracorporeal ligatures, and endoloops. However, these methods vary in terms of technical demand, cost, and availability [3,4].

According to the World Society of Emergency Surgery's (WSES) guidelines, endoloop/suture ligation and polymeric locking clips are recommended for appendiceal stump closure in both adults and children with simple and severe appendicitis [5].

This study aimed to compare polymeric locking clips and endoloop ligation for appendiceal stump closure during laparoscopic appendectomy in patients presenting with acute appendicitis.

METHODS

The General Surgery Department's Emergency Unit at Zagazig University Hospitals served as the site of this prospective comparison study from February 2024 to February 2025. 26 patients who had acute appendicitis were included in the study. By employing the alternate number strategy, patients were randomized into two equal groups of 13 each, with even numbers going to Group B and odd numbers going to Group A. Group B had endoloop ligation for laparoscopic appendectomy with stump closure, while Group A got laparoscopic appendectomy with appendiceal stump closure utilizing polymeric locking clips. Every patient gave written informed consent before surgery and was fully informed about the study protocol. The Zagazig University Faculty of Medicine's Institutional Review Board and Research Ethical Committee gave their approval to the study protocol (IRB#141/27-Feb-2024). In compliance with the World Medical Association's Code of Ethics for research involving human beings and the 1964 Declaration of Helsinki and its subsequent amendments, the study was carried out.

Patients older than 18 years, with a clinical diagnosis of acute appendicitis confirmed by an Alvarado score of ≥7, were eligible for inclusion. Patients deemed unfit for laparoscopic surgery according to the American Society of Anesthesiologists (ASA) classification were excluded, as were those with absolute contraindications to laparoscopy such as end-stage liver disease, coagulation problems, or severe cardiovascular or pulmonary disease. Additionally, the study did not include individuals who declined laparoscopic procedures.

All patients included in the study were subjected to a standardized preoperative assessment protocol. A detailed history was obtained, including personal data (such as age and sex), presenting complaints, past medical and surgical history, history of drug intake, and relevant family history. A thorough clinical examination was performed for all patients. Vital signs (blood pressure, heart rate, temperature, and respiration rate) were evaluated as part of the general examination overall general appearance, and identification of any special positions of comfort such as the right lateral decubitus with slight hip flexion, which is commonly adopted by patients with acute appendicitis. Local abdominal examination comprised inspection, palpation to detect tenderness and rebound tenderness, and evaluation of specific signs including Rovsing's, obturator, and psoas signs, in addition to abdominal wall guarding or rigidity. Percussion and auscultation for bowel sounds were also performed, and digital rectal examination as well as per-vaginal examination were undertaken whenever indicated.

Baseline laboratory investigations were carried out for all patients, including CBC, liver function tests (LFT), kidney function tests (KFT), coagulation profile, and C-reactive protein (CRP). Random blood

sugar (RBS) was measured in diabetic patients, and electrocardiography (ECG) with cardiology consultation was obtained for patients with cardiac history or those above 40 years of age.

Imaging studies were routinely performed for diagnostic confirmation. Abdominal ultrasonography was obtained in all cases to support clinical diagnosis and to evaluate potential complications such as appendicular mass or abscess. In selected cases, computed tomography (CT) with both oral and intravenous contrast was utilized for further diagnostic accuracy

Preoperative:

All patients received prophylactic intravenous antibiotics consisting of 1g of a second-generation cephalosporin and 500 mg of metronidazole, administered 30 minutes prior to the operation after performing a sensitivity test.

Surgical Technique:

The patient was in a supine position during all procedures which were carried out under general anesthesia. Patients were anchored securely to the operating table to allow safe mobilization during surgery. The right arm was extended to permit anesthesiologist access for intravenous lines and blood pressure monitoring, while the left arm was tucked alongside the patient's body with a pulse oximeter in place. A three-port technique was used in all patients. A 30° laparoscope was used, and the first port (10 mm optic port) was placed somewhat above the umbilicus. To facilitate diagnostic laparoscopy and visceral mobilization, a second 10 mm port was positioned in the left iliac fossa for the insertion of a non-traumatic grasper. The third working port (5 mm) was placed in the suprapubic region **(Figure 1a).** The patient was placed in the Trendelenburg position with a small leftward tilt to allow the appendix and cecum to be seen. The appendix was then identified after aspirating any free fluid or collections that were seen.

In every case, bipolar diathermy was used to devascularize the mesoappendix as the initial surgical procedure. This was achieved by grasping the mesoappendix near the appendiceal tip and applying traction towards the abdominal wall to allow full stretching of the appendix **(Figure 1b).** The appendiceal stump was then secured using one of the two techniques according to group allocation: polymeric locking clips in Group A **(Figures 1c, 1d),** or endoloop ligation with vicryl in Group B **(Figure 2).** Following stump closure, the appendix was divided using scissors. The peritoneal cavity was carefully inspected for bleeding or residual collections. Drains were not routinely inserted except in indicated cases, and when necessary, they were placed in the dependent pelvic spaces and exteriorized through either the left iliac fossa or suprapubic port site. The appendix was retrieved either through the left iliac fossa port or the optic port, depending on intraoperative conditions. After ensuring meticulous hemostasis, the abdomen was desufflated, trocars were removed, and skin closure was performed using sutures. Operative time was recorded from skin incision to skin closure in both groups.

Postoperative Care and Follow-up:

Postoperatively, all patients received a standard treatment regimen that included intravenous second-generation cephalosporins (1 g every 12 hours) and metronidazole (500 mg every 8 hours) for 3–5 days, extended only in complicated cases. Pain severity was assessed every 6 hours using the Visual Analogue Scale (VAS), and analgesics were administered accordingly [6]. Oral intake was initiated as soon as it was tolerated, and routine wound care was performed. For patients with intraoperative drain placement, the amount and nature of the drain output were recorded daily; drains were changed every 24 hours and removed once the drainage was less than 30 ml per 24 hours.

Patients were considered fit for discharge once they fulfilled the following criteria: absence of fever, restoration of normal intestinal sounds, and general clinical

stability. After discharge, patients were followed up in the outpatient clinic for three days postoperatively, then after one week for suture removal, weekly thereafter for one month, and subsequently on a monthly basis for six months. At each visit, general condition, wound status, and any complications were carefully assessed and managed as appropriate.

The main outcome measures included operative time, hospital stay, intraoperative complications (bleeding, clip or endoloop slippage, injury to other organs, conversion to open appendectomy), and postoperative complications (wound infection, intra-abdominal abscess, intestinal fistula, and adhesive intestinal obstruction).

Statistical analysis

The collected data was evaluated using the Statistical Package for the Social Sciences (SPSS), version 24 (IBM Corp., Armonk, NY, USA). Continuous quantitative data, including age, were expressed as mean ± standard deviation (SD) and median (range), whereas categorical qualitative variables were expressed as absolute frequencies (n) and relative frequencies (%). The normality of the data distribution was assessed prior to analysis. The appropriate statistical tests of significance were applied. A P-value < 0.05 was considered statistically significant, while a P-value < 0.001 was considered high significance (HS). Values with a P < 0.05 threshold were deemed non-significant (NS).

RESULTS

Based on baseline demographic and clinical parameters, Table 1 revealed no statistically significant difference between the two groups. The endoloop group's mean age was 27 ± 8.2 years, while the polymeric clipping groups was 25 ± 5.5 years (p=0.099). Comorbidities (DM, HTN, and heart disease) and the distribution of sexes were similar (p>0.05). Table 2 demonstrated that there was no significant difference (p>0.05) in the intraoperative conditions of the appendix (catarrhal, suppurative, gangrenous, or perforated) between the two groups. One patient from each group underwent conversion to an open appendectomy; intraoperative consequences including hemorrhage or organ damage did not differ significantly. With high statistical significance (p<0.001), the clipping group's mean operational duration was significantly shorter (44 ± 9.5 minutes, range 30–65) than the endoloop group's (53.1 ± 10.2 minutes, range 40–75).

Ileus, wound infection, peritonitis, and stump leakage were among the postoperative problems that did not differ substantially between the two groups (p>0.05). There were no documented incidences of intestinal damage, intestinal fistula, port site hernia, pelvic abscess, or sticky intestinal obstruction. The clipping group's average length of hospital stay was 2±0.67 days, while the endoloop groups was 2.7±0.72 days (p=0.145). According to table 3, the clipping group's mean return to work was 5.2 ± 0.89 days, while the endoloop groups was 5.7 ± 1.04 days (p=0.145).

Table 4 showed the total cost was significantly lower in the polymeric clipping group compared with the endoloop ligation group. The mean cost in the clipping group was 269 ± 45.1 Egyptian pounds, whereas in the endoloop group it was 1419±162.3 Egyptian pounds (p=0.002).

Table (1): Demographic characteristics of the studied groups

item	Polymeric clipping group A (N=13)		Endo loop ligation group B (N=13)		P value
Age (years)					
Mean ± SD	**25 ± 5.5**		**27 ± 8.2**		**0.099 (NS)**
Median (range)	**24 (19 – 40)**		**25 (19 - 50**		
Sex	**NO**	**%**	**NO**	**%**	
Male	**5**	**38.5%**	**3**	**23.1%**	**0.789 (NS)**
Female	**8**	**61.5%**	**10**	**76.9%**	
Comorbidities	**NO**	**%**	**NO**	**%**	
DM	**1**	**7.7%**	**0**	**0%**	**0.641 (NS)**
HTN	**1**	**7.7%**	**1**	**7.7%**	**0.554 (NS)**
Cardiac diseases	**0**	**0%**	**1**	**7.7%**	**0.313 (NS)**

Mann Whitney U test. Chi-Square test $P < 0.05$ is significant. NS: Not significant

Table (2): Intraoperative findings and operative outcomes in the studied groups

item	Polymeric clipping group A (N=13)		Endo loop ligation group B (N=13)		P value
Condition of appendix	**NO**	**%**	**NO**	**%**	
Suppurative	1	7.7	3	23	0.939 (NS)
Catarrhal	9	69.2	9	69.2	
Gangrenous	1	7.7	0	0	
Perforated at the tip	2	15.4	1	7.7	
Time of operation (min)					
Mean ± SD (range)	44 ± 9.5 (30 – 65)		53.08 ± 10.2 (40 – 75)		0.000* (HS)

Chi-square test. #Mann Whitney U test. $P < 0.05$ is significant.
NS: Not significant HS: highly significant.

Table (3): Postoperative outcomes of the studied groups

item	Polymeric clipping group A (N=13)		Endo loop ligation group B (N=13)		P value
	NO	**%**	**NO**	**%**	
Ileus	**0**	**0.0**	**2**	**15.4**	**0.075 (NS)**
Port site infection	**0**	**0.0**	**1**	**7.7**	**0.075 (NS)**
Peritonitis	**1**	**7.7**	**1**	**7.7**	**1.00**
Conversion	**1**	**7.7**	**1**	**7.7**	**1.00**
Stump leakage	**1**	**7.7**	**3**	**23**	**0.64 (NS)**
Hospital stay duration (Days)					
Mean ± SD (range)	**2 ± 0.67 (1 – 3)**		**2.7 ± 0.72 (2 – 4)**		**0.145 (NS)**

#Mann Whitney U test Fisher exact test. $P < 0.05$ is significant.
NS: Not significant

Table (4): Total cost comparison between the two studied groups

items	Polymeric clipping group A (N=13)	Endo loop ligation group B (N=13)	P value
Return to work (Days)			
Mean ± SD (range)	**5.2 ± 0.89 (4 – 7)**	**5.7 ± 1.04 (4 – 8)**	**0.145 (NS)**

#Mann Whitney U test. P < 0.05 is significant. NS: Not significant

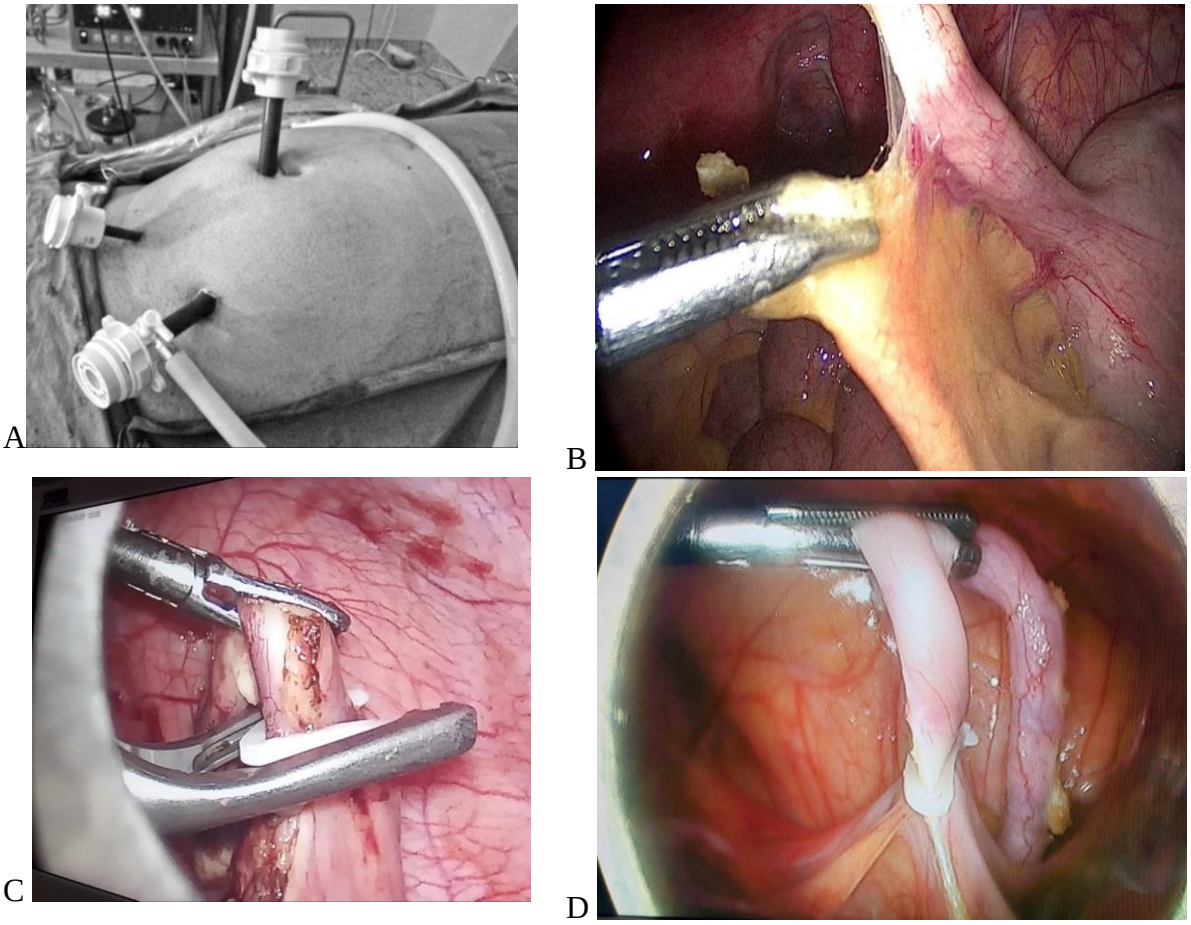

Figure (1): a) Port sites of LA. *b)* Cauterization of mesoappendix using bipolar diathermy. *c)* Hemo-lock clip before its placement on the base. *d)* Hemo-lock clips close the appendicular base

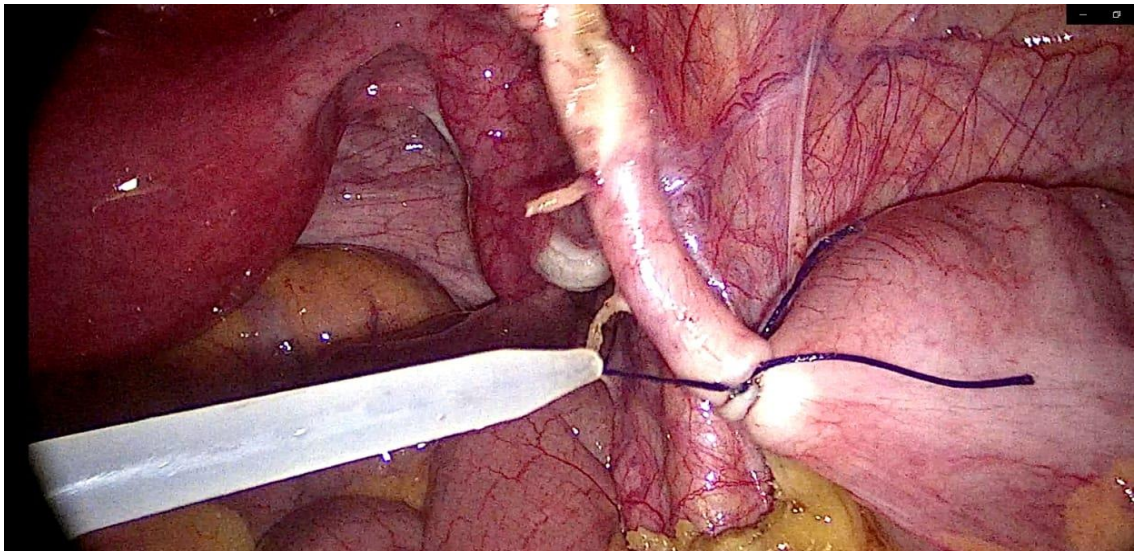

Figure (2): Endoloop Ligation of the appendiceal base with vicryl.

DISCUSSION

In the current study we found that the age of the studied clipping group ranging from 19-40 years old with a mean of 25 ± 5.5 years old, and (38.5%) of them were male, while in the endoloop ligation group, their age ranged from 19-50 years old with mean 27 ± 8.2 and (23.1%) of them were male, were no discernible age or sex differences between the two groups. Regarding related comorbidities, the two study groups did not differ in any noticeable way.

This agrees with IBRAHIM et al. [7] who conducted a study in Ain Shams University Hospitals. The study comprised forty participants who had acute appendicitis. They claimed that neither the age nor the sex of the two groups differed statistically significantly.

Abbas and Seleem, [8] who included 150 individuals in a randomized prospective clinical trial study with acute appendicitis. Patients were randomly assigned to one of two primary groups (A, B). The 75 patients in Group A had their appendix bases secured by ligation, while the 75 patients in Group B had their appendix bases secured by clip application.

There was no statistically significant difference in the two groups' perioperative appendix conditions.

These results were consistent with those of Ibrahim et al. [7], who did not identify any statistically significant difference in the gross pathology or condition of the appendix base between the two groups.

In terms of operational time, our analysis revealed a very statistically significant difference between the groups under investigation. Endoloop Ligation took 53.08 ± 10.2 minutes, while clipping took 44 ± 9.5 minutes.

This is aligned with the results of Ibrahim et al. [7], who discovered a highly significant difference in operational time between the two groups. The clipping and ligation groups had respective durations of 46.44 ± 6.83 and 55.62 ± 6.04 minutes.

Abbas et al. [8] shown that the ligation group had a longer operative duration, indicating a substantial statistical difference between the two groups. It took 20 ± 8.2 minutes for the clipping group and 40 ± 11.5 minutes for the ligation group.

The clipping group's mean operational time was 44.7 minutes, while the ligation groups was 54.6 minutes, according to a different study by Abou-Sheishaa et al. [9]. The average operational time clipped in the Reinke et al. [10] trial was forty-five minutes.

According to surgeons, the polymer clip is a more practical method for closing

appendicular stumps than endoloop, and this finding is statistically significant in the Bhabhor et al. [11] study (p value is 0.032). The operating surgeon provided his judgment on the ease of application, considering the amount of time required for stump closure, covering the appendicular stump appropriately and managing endoloop or polymer clips intraoperatively.

Regarding post-operative complications (intestinal injury, ileus, pelvic abscess, port site infection, port site hernia, intestinal fistula, pertonitis, adhesive intestinal obstruction, conversion, and Stump leakage), the current study revealed no statistically significant difference between the groups under investigation.

Abbas and Seleem [8] showed that the prevalence of surgical complications, including fever, postoperative collection, bleeding, intestinal blockage, and port site infection, did not differ statistically significantly.

Additionally, Omar et al. [12] found no statistically significant difference (p-value 0.05) in postoperative complications between the groups that were assessed. Ileus and port site infection were present in only three instances (15 percent) in the ligation group.

Furthermore, Vinod et al. [13] showed that there were no intraoperative or immediate postoperative problems in either group. None of the patients experienced any post-operative problems throughout the 12-week follow-up period.

Furthermore, neither group experienced any intraoperative or postoperative problems, according to Hue et al. [14].

A prospective randomized clinical trial was designed by Delibegović et al. [15] to evaluate the cost-effectiveness, intraoperative time, and safety of various approaches. Three groups of 90 acute appendicitis patients were randomly assigned: In the first group, the base of the appendix was secured with a single Endoloop ligature; in the second, a 45-mm stapler; and in the third, a single nonabsorbable Hem-o-lok clip. They determined that a single Hem-o-lok clip is as safe to use as a stapler or Endoloop. Nonetheless, the Hem-o-lok laparoscopic procedure was the least expensive and took less time than an Endoloop.

Our latest findings showed that the length of hospital stay did not differ statistically significantly between the groups. Clipping took 2 ± 0.67 days, while endoloop ligation took 2.7 ± 0.72 days.

Abbas et al. [8] demonstrated that there was a statistically insignificant difference between the two approaches with respect to hospital stay, which is consistent with our findings. It took 1.11 ± 0.15 days to clip. The duration of endo loop ligation was 1.32 ± 0.2 days.

Ibrahim et al. [7] found a highly significant difference between the two groups in the length of hospital stay after surgery, which contrasts with our findings. Endo loop grouping lasted longer than clipping in terms of the length of hospital stay after surgery.

According to Je et al. [16], hospital stay is directly linked to postoperative problems; as a result, Bhabhor et al. [11] found comparable outcomes in these two parameters. Although the polymer clip group had reduced rates of hospital stays and postoperative complications, neither of these outcomes was statistically significant (p values for hospital stays and postoperative complications were 0.144 and 0.45, respectively).

40 patients were split into two equal groups for the Elmeligy et al. study [17]: group I underwent clipping, whereas group II underwent intra-corporeal ligation. There were no appreciable differences between the two groups' hospital stays (p >0.05).

Our results demonstrated that the endoloop ligation group's overall cost was statistically higher than that of the clipping group, with the mean cost in the clipping group being 269 ± 45.1 Egyptian pounds and the mean cost in the endoloop ligation

group being 1419 ± 162.3 Egyptian pounds.

Our research supports the findings of Kiudelis et al. [18], who found that intra-corporeal ligation is a less expensive and safer method than end loops, but it requires more training for novices. End loops offer an advantage over laparoscopic staplers since they are less expensive than stapling equipment.

The tools used to secure the base are one of the main reasons for the increased cost. Several techniques, like the costly Endo-GIA and the Endo loop, which are not readily available in many institutions in our nation, were employed to anchor the base during laparoscopic appendectomy. Other, less expensive techniques include intracorporeal suture ligation, metallic clips, and polymeric clips. Sahm and his colleagues' study confirmed that intra-corporeal ligation is a safe alternative to the more expensive linear stapler or less expensive endoloop, with no appreciable difference in terms of efficacy or safety. [19].

The perfect suture material should also be less reactive to tissue and biocompatible. In a laparoscopy, the optimal technique for appendix stump closure should be technically simple, safe, easily accessible, and dependable, with a shorter operating time and lower expenses [3].

LIMITATIONS

There are several restrictions on this study. First, it was only done in one center with a small sample size, which might have limited how broadly the findings can be applied. Second, because of the brief follow-up time, it was not possible to adequately evaluate long-term outcomes like recurrence or late complications. Third, although operative time and cost were evaluated, surgeon experience and learning curve may have influenced the results, particularly regarding the ease of clip versus endoloop application. Finally, cost analysis was based on local pricing, which may vary across institutions and countries.

CONCLUSION

Both ligation and clipping techniques, which were safe, effective, and had few major consequences, were used to hold the appendicular stump in place. Compared to ligation techniques, which need prior experience with a broad, hard, and friable appendicular stump, the use of clips saves time during surgery, is quicker to apply, and is easier for trainees to understand.

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