

Stump Closure Techniques for Laparoscopic Appendectomy in Acute Appendicitis: Narrative Review Article

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Abstract: Appendectomy remains one of the most performed emergency surgical procedures worldwide. A critical step in laparoscopic appendectomy is the secure closure of the appendicular stump, which prevents postoperative complications such as stump leak, intra-abdominal abscess, and stump appendicitis. Over the past few decades, numerous techniques for stump closure have evolved, ranging from simple ligature methods to advanced mechanical devices, such as staplers, clips, and endo loops. Each technique offers distinct advantages in terms of safety, cost-effectiveness, operative time, and ease of use. With the widespread adoption of minimally invasive surgery, laparoscopic appendectomy has introduced additional modalities, including clips, energy devices, and intracorporeal suturing. This review aims to critically evaluate various appendicular stump closure techniques in the context of acute appendicitis. Key considerations include clinical outcomes, complication rates, and cost implications. Although no single technique is universally superior, current evidence suggests that secure closure tailored to intraoperative findings and resource availability remains paramount.

Keywords: Acute Appendicitis, Endo Loop, Endo Clip, Endo Stapler, Laparoscopic Appendectomy, Harmonic Scalpel.

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INTRODUCTION

Acute appendicitis is a common general surgical emergency that accounts for presentation to the emergency department with symptoms of abdominal pain. It is predominantly seen in pediatric and young adults, with a peak age incidence in the second and third decades of life. The incidence of acute appendicitis is about 90-100 cases per 100,000 population in most Western countries, but the incidence is higher in Asia and the Middle East. The clinical presentation is right lower abdominal pain with symptoms of fever, nausea, and vomiting. On abdominal examination, there is guarding and rigidity over the right iliac fossa, with tenderness at McBurney's point (Bhangu, 2015). Acute appendicitis can be classified into uncomplicated appendicitis, which is characterized by inflammation of the appendix, and complicated appendicitis, where appendicitis is associated with perforation, abscess formation, or mass formation. The diagnosis of acute appendicitis involves a clinical examination and assessment of inflammatory markers, such as leukocytosis and elevated C-Reactive

Protein (CRP), as well as imaging modalities like ultrasound and computed tomography (Moris, 2021; Bom, 2021). The management of acute appendicitis is by performing an appendectomy, which can be done as an open or laparoscopic method. Laparoscopic appendectomy is considered the gold standard for the management of acute appendicitis. Non-operative treatment can be considered for patients who are not fit for surgery (Weledji, 2023; Diaz, 2025; Sohn, 2017).

There are various methods for closure of the appendicular stump following laparoscopic appendectomy, which include closure with a stapler, closure using clips, which can be divided into non-absorbable clips like titanium or Hem-o-Lok, or absorbable clips, and closure with sutures like endo-loop. Each method of closure has its advantages and disadvantages (Ekestubbe, 2026)). The World Society of Emergency Surgeons (WSES), in their guidelines for the diagnosis and management of acute appendicitis of 2020, have recommended that the appendicular stumps be

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closed with either sutures, in the form of an Endo loop, or suture ligation or polymeric clips for both adults and children with acute appendicitis. Endo staplers are recommended to be used for patients with complicated appendicitis, and depending on their availability (Di Saverio, 2020)).

This review aims to assess the various methods of closure of the appendicular stump following laparoscopic appendectomy. We will look at the Endo stapler, Endo loop, and Endo clip methods of closure, looking at its advantages and disadvantages. We will also compare the various stump closure techniques. A comprehensive literature review was conducted using PubMed, the Cochrane Database of Clinical Reviews, Semantic Scholar, and Google Scholar, targeting original articles, clinical trials, observational studies, cohort studies, review articles, systematic reviews, and meta-analyses from 1990 to 2026. The search employed the following keywords: “Stump closure,” “Acute Appendicitis,” “Endo stapler,” “Endo loop,” “Endo clip,” “laparoscopic appendectomy,” and “Harmonic Scalpel.” All articles were in English, with case reports and commentaries excluded. Studies involving adults, the elderly, and children were included, while pregnant patients were excluded.

DISCUSSION

Endo Stapler Closure of the Appendicular Stump

The use of the Endo stapler for closure of the appendicular stump does not require the dissection of the meso-appendix, and this reduces the operative time. Albuz *et al.*, conducted a study on 24 patients with acute appendicitis who had undergone laparoscopic appendectomy, and the mean operative time was 13 minutes, and there were no conversions to open appendectomy. The wound infection rate was at 4%, but the use of Endo-stapler was associated with an increase in cost (Albuz, 2018). Endo stapler was compared with the Endo loop in the closure of the appendicular stump following laparoscopic appendectomy in a retrospective study by Swank *et al.*, A total of 1036 patients were included in this study, with 571 undergoing Endo stapler stump closure and 465 undergoing Endo loop closure of the appendicular stump. There were no significant differences regarding the intra-operative and post-operative complications between the procedures. There were no differences between the intra-abdominal abscess rate and wound infection between the procedures (Swank, 2014).

A meta-analysis comparing the Endo stapler and the Endo loop for appendicular stump closure in laparoscopic appendectomy was conducted by Kazemier *et al.*, A total of 4 studies with 427 patients were included in this study, and the superficial wound infection rate (OR-0.21,95%CI,0.06-0.71), and postoperative ileus (OR-0.36,95%CI,0.14-0.89) were reduced in the Endo stapler group. The operative time was shorter in the Endo stapler group. The hospital stay and intra-abdominal

abscess rate were similar between the groups (Kazemier, 2006). A randomized clinical trial on the closure of the appendicular stump during laparoscopic appendectomy for acute uncomplicated appendicitis was conducted by Ihnat *et al.*, A total of 180 patients were divided into 60 patients who underwent Endo loop application, 60 patients who underwent Hem-o-Lok application, and 60 patients who underwent Endo-stapler application. The incidence of surgical site infection was comparable between the groups, and the Endo stapler application to the appendicular stump was the most expensive procedure (Ihnát, 2021). Beldi *et al.*, compared the Endo stapler and the Endo loop for appendicular stump closure for acute appendicitis. A total of 6486 patients were included, with 3921 patients undergoing Endo stapler application and 2565 patients undergoing Endo loop application. The Intra-abdominal infection rate was lower in the Endo stapler group (0.7% vs 1.7%), and the readmission was also lower in the Endo stapler group (0.9% vs 2.1%) (Beldi, 2006).

Endo Clip Closure of the Appendicular Stump

Endo clip closure of the Appendicular stump following appendectomy for acute appendicitis is associated with ease at application and hence reduction of the operative time. Endo clips can be divided into non-absorbable clips, such as titanium, and absorbable clips, like Hem-O-Lok. Clip application can be difficult if the base of the appendix is inflamed, to prevent its application (Mayir, 2015). The safety and efficacy of polymeric clips for the closure of the appendicular stump were assessed by Reinke *et al.*, who found the procedure was fast and associated with no complications (Reinke, 2016). Polymeric clips were compared with staplers for the appendicular stump closure for acute appendicitis by Cimen *et al.*, A total of 692 patients were included in this study, with 606 patients undergoing polymeric clip closure and 86 undergoing stapler closure. The overall complication rate between the procedures was similar, but clip application was associated with reduced cost when compared with stapler closure (Çimen, 2026). A similar study comparing polymeric clips with Endo staplers for appendicular stump closure by Vuille-dit-Bille also concluded the same (Vuille-Dit-Bille, 2020). Polymeric clips were compared with Endo Loop ligatures for the closure of the appendicular stump by Srikantgowda *et al.*, A total of 70 patients were included in this study, with 35 patients undergoing polymeric clip application and 35 undergoing Endo Loop ligature. Polymeric clips were associated with shorter operative times and shorter hospital stays. The incidence of complications did not differ between the groups (Srikantgowda, 2025).

Non-absorbable polymeric clips were compared with the Endo loop for the closure of the appendicular stump in acute appendicitis by Colak *et al.*, This prospective randomized study included 53 patients, and there were no differences regarding complications between the procedure, and the length of hospital stay

was similar between the groups (Colak, 2013). A prospective multicenter observational study on the use of titanium clips for the closure of the appendicular stump (TICAP study) was conducted by Rickert *et al.*, Titanium was successfully applied in 390 out of the 502 patients who were included in this study, and the superficial wound infection rate was 2.31%, the intra-abdominal abscess rate was 1.28%, and the adverse event rate was 5.64%. This study showed that titanium clips were safe and effective in the management of the appendicular stump (Rickert, 2015). Titanium clip application was compared with the endo stapler and invaginating sutures in the closure of the appendicular stump by Strzałka *et al.*, A total of 307 patients were divided into 102 patients who underwent Endo staple closure, 160 patients who underwent titanium clip application, and 45 who underwent invaginating suture closure. There were no differences regarding operative time, but the titanium clip group had the lowest complication rate and the shortest hospital stay (Strzałka, 2016). Kliuchanok *et al.*, retrospectively assessed non-absorbable polymeric clips and Endo staplers for the closure of the appendicular stump. A total of 618 patients were included in this study, and non-absorbable clips were associated with a reduced cost when compared with the Endo stapler (Kliuchanok, 2019).

A systematic review and meta-analysis comparing metallic clips and Endo loop for the closure of the appendicular stump for acute appendicitis was conducted by Almeida *et al.*, A total of 5 studies with 344 patients were included in this study, with 181 patients undergoing clip application and 164 patients undergoing Endo loop application. The operating time was shorter in the metal clip group (STD 0.81, 95%CI, 1.13, 0.49), but the wound infection rate was similar between the groups (RR 0.87, 95%CI, 0.24, 3.13). This study showed that the metallic clip application was faster (Almeida, 2025). Another systematic review and meta-analysis on the management of the appendicular stump following laparoscopic appendectomy was conducted by Shaikh *et al.*, A total of 7 studies with 487 patients were included in this study, with 245 patients undergoing endo clip application and 242 undergoing Endo loop application. Endo clip application was associated with a shorter operative time (SD 0.90, 95%CI, 1.26-0.54). There were no differences regarding the postoperative complications and length of hospital stay (Shaikh, 2015). A systematic review on the closure of the appendicular stump for acute appendicitis was conducted by Makaram *et al.*, A total of 19 studies were included in this study, and Endo clips were associated with equivalent clinical outcomes with Endo loop, but it had the shortest duration of surgery (Makaram, 2020). A systematic review and meta-analysis comparing clip closure with endo loop closure for the appendicular stump was conducted by Poon *et al.*, A total of 18 studies were included in this review, and clip application was associated with a shorter operative time, but it had a comparable length of hospital stay and

postoperative complications with endo loop closure (Poon, 2023).

Hem o Lok clips were compared to titanium clips for the closure of the appendicular stump following laparoscopic appendectomy for acute appendicitis by Ucar *et al.*, A total of 179 patients were included in this study, with 82 patients undergoing hem o Lok application and 97 patients undergoing titanium clip application. There were no differences regarding postoperative complications, operative time, and length of hospital stay between the procedures. This study showed that both Hem-o Lok and titanium clips can be safely used for appendicular stump closure (Uçar, 2024).

Endo Loop Closure of the Appendicular Stump

An analysis of the use of the Endo loop for the closure of the appendicular stump for acute appendicitis was conducted by Sahm *et al.*, A total of 1790 patients with acute appendicitis underwent laparoscopic appendectomy, with 1670 patients undergoing Endo loop closure of the stump and 46 patients undergoing Endo stapler closure. There were no differences regarding complications, operative time, and length of stay between the procedures (Sahm, 2011). Caglia *et al.*, conducted a retrospective study on the use of the Endo loop for the closure of the appendicular stump following laparoscopic appendectomy. A total of 35 patients were included in this study, and the mortality rate was 0% and; the mean hospital stay was 2 days (Caglia, 2014). Endo loop closure was compared with Endo stapler closure of the appendicular stump in acute appendicitis by Elshoura *et al.*, This prospective study included 45 patients who underwent Endo stapler closure and 47 patients who underwent Endo loop closure. Endo loop application was associated with a longer operative time, but it was cheaper to use than the Endo stapler (Elshoura, Hassan, & Saber, 2017).

An observational retrospective study comparing Hem-o-Lok and endo-loop for the closure of the appendicular stump in patients with acute appendicitis was conducted by Guldogan *et al.*, A total of 123 patients were included in this study, with 73 patients undergoing endo-loop closure and 50 undergoing Hem-o-Lok closure. The postoperative complication rates, length of hospital stay, and length of operative procedure were similar between the groups (Guldogan, 2024). A meta-analysis on the optimal stump management in laparoscopic appendectomy was conducted by Antoniou *et al.*, A total of 43 studies were included in this analysis, and the endo loop was associated with better outcomes regarding intra-abdominal abscess formation and superficial infection rates (OR 0.56, 95% CI 0.32-0.96). This study showed that sutured ligation of the appendicular stump was associated with the best outcomes (Antoniou, 2017)). A meta-analysis comparing stump closure and endo loop was conducted by Zorzetti *et al.*, A total of 7 studies were included, and there were no differences regarding the

postoperative complication, intra-abdominal abscess rate, and length of hospital stay between the procedures (Zorzetti, 2022).

Harmonic Scalpel for Closure of the Appendicular Stump

The harmonic scalpel is an energy device that is used to close the appendicular stump following laparoscopic appendectomy. Gupta *et al.*, conducted a retrospective study on 310 patients with acute appendicitis, with 102 patients undergoing Endo loop closure and 108 undergoing harmonic scalpel closure. The mean operative time was shorter in the harmonic scalpel group, and the complication rate was similar between the groups. This study showed that closure of the harmonic scalpel was safe and effective (Gupta, 2020). A randomized controlled trial on harmonic scalpel and sutured ligation of the appendicular base was conducted by Mathur *et al.*, A total of 60 patients were randomized to 30 patients who underwent harmonic scalpel application to the stump and 30 patients who underwent sutured ligation to the appendicular stump. Harmonic scalpel was associated with reduced operative time, reduced length of hospital stays, and reduced

postoperative complications when compared with sutured ligation (Mathur, 2025).

A systematic review and meta-analysis comparing the harmonic scalpel with other techniques of appendicular stump closure following laparoscopic appendectomy for acute appendicitis by Borkar *et al.*, A total of 4 studies with 642 patients were included in this study, with 283 patients undergoing harmonic scalpel closure and 359 undergoing conventional appendicular stump closure. Harmonic scalpel closure was associated with reduced operative time (MD-12.96,95%CI,15.42,10.50). Harmonic scalpel was also associated with comparable results with other appendicular stump closure techniques regarding postoperative complications, length of hospital stays, and intra-abdominal abscess formation (Borkar, 2022). A systematic review and meta-analysis on the safety and efficacy of the energy devices on appendicular stump closure was conducted by Singh *et al.*, A total of 6 studies with 3025 patients were included in this study, and there was a shorter operative time with the use of energy devices on the appendicular stump (MD 12.34,95%CI,16.57-8.11), but there were no differences regarding postoperative infection rate (Singh, 2022).

Table 1

Outcomes	Endo Loop	Endo Clip (Hem-O-Lok and Titanium)	Endo Stapler	Harmonic Scalpel
Overall Complication Rate	Low; generally comparable to clips and staplers. In the Ihnát RCT, no significant difference in postoperative complications among the endoloop, clip, and stapler groups. (Inhat,2021)	Low; like endo loop regarding wound infection, readmission, reoperation, and overall complications. (Colak,2013)	Low; no significant difference from Endo loop in modern studies. Earlier meta-analyses suggested fewer superficial wound infections and ileus than the Endo loop. (kazemier,2006)	Borkar's systematic review found no increase in total complications compared with conventional closure methods. (Borkar,2022)
Intra-abdominal Abscess Rate	Comparable to clips and staplers; typically, 1–5% across studies. (Kazemier,2006)	No significant difference compared with the Endo loop. Meta-analyses show equivalent infective outcomes. (Almeida,2025)	Comparable to Endo loop; no consistent reduction in abscess formation demonstrated. (Kazemier,2006)	Limited evidence; available studies show no increase in postoperative abscess formation. (Borkar,2022)
Length of Hospital Stay	Approximately 1–4 days, depending on disease severity, such as clips and staplers. Ihnát reported a mean LOS of 3.6 ± 1.7 days across all groups. (Ihnat, 2021)	Like Endo loop. No significant difference in randomized and observational studies (Colak,2013)	Length of hospital stay was similar. (Beldi 2006)	Like conventional techniques; no significant reduction demonstrated. (Borkar 2022)
Operative time	Longest among commonly used methods. Kazemier reported about 9 minutes longer than stapler closure; Poon and Almeida found longer operative times than clips. (Kaziemer,2006, Poon 2023, Almeida 2025)	Typically shortest operative time. Meta-analysis demonstrated significant reductions versus the Endo loop.(Inhat,2021)	Shorter than the Endo loop and comparable to clips. (Kazemier,2006)	Generally comparable to or shorter than conventional techniques because sealing and division are performed simultaneously (Borkar,2022)

CONCLUSION

Appendicular stump closure remains a critical step in appendectomy, with multiple effective techniques available. No single method has proven universally superior; instead, the choice depends on surgical expertise, intraoperative findings, and resource availability. Endo loops represent a reliable and cost-effective option for uncomplicated appendicitis, while staplers offer enhanced safety in complicated cases. Clips and energy devices provide viable alternatives but require careful patient selection. Ultimately, the surgeon's ability to adapt the technique to the clinical scenario ensures optimal outcomes.

Conflict of Interest: There is no conflict of interest.

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