

Chapter 19

Stump Closure Techniques for Laparoscopic Appendectomy in Acute Appendicitis: A Review

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Abstract

Appendectomy is among the most frequently performed emergency surgical procedures globally. A pivotal aspect of laparoscopic appendectomy is the secure closure of the appendicular stump, which is essential to prevent postoperative complications such as stump leak, intra-abdominal abscess, and stump appendicitis. Over recent decades, various techniques for stump closure have been developed, ranging from simple ligature methods to advanced mechanical devices, including staplers, clips, and endo loops. Each technique presents unique advantages concerning safety, cost-effectiveness, operative time, and ease of use. The widespread adoption of minimally invasive surgery has introduced additional modalities in laparoscopic appendectomy, such as clips, energy devices, and intracorporeal suturing. This chapter seeks to critically assess the different appendicular stump closure techniques within the context of acute appendicitis, focusing on clinical outcomes, complication rates, and cost implications. Although no single technique is universally superior, current evidence indicates that secure closure, tailored to intraoperative findings and resource availability, remains crucial.

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

Introduction

Acute appendicitis is a prevalent surgical emergency that frequently leads to emergency department visits due to abdominal pain. It primarily affects pediatric and young adult populations, with peak incidence occurring in the second and third decades of life. In most Western countries, the incidence of acute appendicitis is approximately 90-100 cases per 100,000 individuals, although it is higher in Asia and the Middle East. Clinically, it presents as right lower abdominal pain accompanied by fever, nausea, and vomiting. Abdominal examination typically reveals guarding and rigidity in the right iliac fossa, with tenderness at McBurney's point (Bhangu, 2015). Acute appendicitis is categorized into uncomplicated appendicitis, characterized by inflammation of the appendix, and complicated appendicitis, which involves perforation, abscess formation, or mass formation. Diagnosis involves clinical examination, assessment of inflammatory markers such as leukocytosis and elevated C-Reactive Protein (CRP), and imaging techniques like ultrasound and computed (Moris, 2021; Bom, 2021). Management typically involves an appendectomy, which can be performed using either open or laparoscopic methods. Laparoscopic appendectomy is regarded as the gold standard for treating acute appendicitis. Non-operative treatment may be considered for patients who are not suitable candidates for surgery (Weledji, 2023; Diaz, 2025; Sohn, 2017).

Various methods exist for the closure of the appendicular stump following laparoscopic appendectomy. These methods include the use of a stapler, clips, and sutures. Clips can be further categorized into non-absorbable types, such as titanium or Hem-o-Lok, and absorbable types. Sutures, such as the endo-loop, are also employed. Each closure method presents distinct advantages and disadvantages (Ekestubbe, 2026)). According to the 2020 guidelines by the World Society of Emergency Surgeons (WSES) for the diagnosis and management of acute appendicitis, it is recommended that appendicular stumps be closed using 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 advised for patients with complicated appendicitis, contingent upon their availability (Di Saverio, 2020)).

This chapter seeks to evaluate the different methods for closing the appendicular stump after laparoscopic appendectomy, specifically examining the Endo stapler, Endo loop, and Endo clip techniques. The advantages and disadvantages of each method will be analyzed, and a

comparison of the various stump closure techniques will be provided. A comprehensive literature review was conducted using PubMed, the Cochrane Database of Clinical Reviews, Semantic Scholar, and Google Scholar. The chapter focused on original articles, clinical trials, observational studies, cohort studies, review articles, systematic reviews, and meta-analyses published between 1990 and 2026. The search utilized 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. The studies included adults, the elderly, and children, while pregnant patients were excluded.

Discussion

Endo stapler closure of the appendicular stump

The application of the Endo stapler for the closure of the appendicular stump eliminates the need for meso-appendix dissection, thereby reducing operative time. Albuz et al. conducted a study involving 24 patients with acute appendicitis who underwent laparoscopic appendectomy, reporting a mean operative time of 13 minutes with no conversions to open appendectomy. The wound infection rate was 4%; however, the use of the Endo stapler was associated with increased costs (Albuz, (2018)). In a retrospective study by Swank et al., the Endo stapler was compared with the Endo loop for appendicular stump closure following laparoscopic appendectomy. This study included 1036 patients, with 571 undergoing Endo stapler stump closure and 465 undergoing Endo loop closure. The study found no significant differences in intra-operative and post-operative complications between the two procedures. Additionally, there were no differences in the rates of intra-abdominal abscess and wound infection between the procedures (Swank, 2014).

A meta-analysis conducted by Kazemier et al. compared the Endo stapler and the Endo loop for appendicular stump closure in laparoscopic appendectomy. This study included four studies with a total of 427 patients. The findings indicated a reduction in 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) in the Endo stapler group. Additionally, the operative time was shorter for the Endo stapler group, while the hospital stay and intra-abdominal abscess rate were similar between the groups (Kazemier, 2006). Ihnat et al. conducted a randomized clinical trial on appendicular stump closure during laparoscopic appendectomy for acute, uncomplicated appendicitis. The study involved 180 patients, divided into three groups: 60 patients underwent Endo loop application, 60 patients underwent Hem-o-Lok application, and 60 patients underwent Endo-stapler application. The incidence of surgical site infection was comparable across the groups, although the Endo stapler application was identified as the most expensive procedure (Ihnát, 2021). Beldi et al. compared the Endo stapler and the Endo loop for appendicular stump closure in cases of acute appendicitis. The study included 6486 patients, with 3921 patients receiving Endo stapler application and 2565 patients receiving Endo loop application. The intra-abdominal infection rate was lower in the Endo stapler group (0.7% vs. 1.7%), and the readmission rate 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 advantageous due to its ease of application, which consequently reduces operative time. Endo clips are categorized into non-absorbable clips, such as titanium, and absorbable clips, like Hem-O-Lok. However, clip application may be challenging if the base of the appendix is inflamed, potentially hindering its use (Mayir, 2015). Reinke et al. evaluated the safety and efficacy of polymeric clips for appendicular stump closure, reporting that the procedure was rapid and free of complications (Reinke, 2016). Cimen et al. conducted a study comparing polymeric clips with staplers for appendicular stump closure in acute appendicitis, involving 692 patients—606 underwent polymeric clip closure, while 86 underwent stapler closure. The overall complication rates were similar between the two methods, but clip application was more cost-effective than stapler closure (Çimen, 2026). A comparable study by Vuille-dit-Bille also reached the same conclusion when comparing polymeric clips with Endo staplers (Vuille-Dit-Bille, 2020). Srikanthgowda et al. compared polymeric clips with Endo Loop ligatures for appendicular stump closure in a study of 70 patients, with 35 receiving polymeric clip application and 35 receiving Endo Loop ligature. The use of polymeric clips was associated with shorter operative times and reduced hospital stays, with no significant difference in complication rates between the groups (Srikanthgowda, 2025)..

Colak et al. conducted a prospective randomized study comparing non-absorbable polymeric clips with the Endo loop for appendicular stump closure in cases of acute appendicitis. The study included 53 patients and found no significant differences in complications or hospital stay duration between the two procedures (Colak, 2013). Rickert et al. performed a prospective multicenter observational study, known as the TICAP study, on the use of titanium clips for appendicular stump closure. Out of 502 patients, titanium clips were successfully applied in 390 cases, with a superficial wound infection rate of 2.31%, an intra-abdominal abscess rate of 1.28%, and an adverse event rate of 5.64%. The study concluded that titanium clips are safe and effective for managing the appendicular stump (Rickert, 2015)). Strzalka et al. compared titanium clip application with the Endo stapler and invaginating sutures for appendicular stump closure. The study involved 307 patients, divided into 102 who underwent Endo staple closure, 160 who received titanium clip application, and 45 who had invaginating suture closure. No differences in operative time were observed, but the titanium clip group exhibited the lowest complication rate and shortest hospital stay (Strzalka, 2016). Kliuchanok et al. retrospectively evaluated non-absorbable polymeric clips and Endo staplers for appendicular stump closure in 618 patients, finding that non-absorbable clips were associated with reduced costs compared to the Endo stapler (Kliuchanok, 2019).

Almeida et al. conducted a systematic review and meta-analysis to compare metallic clips and Endo loop for closing the appendicular stump in cases of acute appendicitis. This study included five studies with a total of 344 patients, of whom 181 underwent clip application and 164 underwent Endo loop application. The findings indicated that the operating time was shorter for the metal clip group (STD 0.81, 95% CI, 1.13 to 0.49), while the wound infection rate was similar between the two groups (RR 0.87, 95% CI, 0.24 to 3.13). The study concluded that metallic clip application was faster (Almeida, 2025). Shaikh et al. conducted another systematic review and meta-analysis on managing the appendicular stump following laparoscopic appendectomy. This study included seven studies with 487 patients, with 245 undergoing endo clip application and 242 undergoing Endo loop application. The results showed that endo clip application was associated with a shorter operative time (SD 0.90, 95% CI, 1.26 to 0.54), with no significant differences in postoperative complications or length of

hospital stay (Shaikh, 2015). Makaram et al. conducted a systematic review on the closure of the appendicular stump for acute appendicitis, including 19 studies. The review found that Endo clips provided clinical outcomes equivalent to those of Endo loop, but with the shortest surgery duration (Makaram, 2020). Poon et al. conducted a systematic review and meta-analysis comparing clip closure with Endo loop closure for the appendicular stump. This review included 18 studies and found that clip application was associated with a shorter operative time, while the length of hospital stays and postoperative complications were comparable to those of Endo loop closure. (Poon, 2023).

Ucar et al. conducted a comparative study on the use of Hem-o Lok clips versus titanium clips for the closure of the appendicular stump in laparoscopic appendectomy for acute appendicitis. The study included 179 patients, with 82 receiving Hem-o Lok clips and 97 receiving titanium clips. The findings indicated no significant differences between the two groups in terms of postoperative complications, operative time, or length of hospital stay. The study concluded that both Hem-o Lok and titanium clips are safe options for appendicular stump closure (Uçar, 2024)..

Endo Loop closure of the appendicular stump

An analysis by Sahm et al. examined the application of the Endo loop for closing the appendicular stump in cases of acute appendicitis. In this study, 1,790 patients with acute appendicitis underwent laparoscopic appendectomy, with 1,670 patients receiving Endo loop closure and 46 patients receiving Endo stapler closure. The study found no significant differences in complications, operative time, or length of hospital stay between the two procedures (Sahm, 2011). Caglia et al. conducted a retrospective study on the use of the Endo loop for appendicular stump closure following laparoscopic appendectomy, involving 35 patients. The study reported a 0% mortality rate and an average hospital stay of 2 days (Caglià, 2014). Elshoura et al. conducted a prospective study comparing Endo loop and Endo stapler closures of the appendicular stump in acute appendicitis. This study included 45 patients who underwent Endo stapler closure and 47 patients who underwent Endo loop closure. The findings indicated that while the Endo loop was associated with a longer operative time, it was more cost-effective than the Endo stapler (Elshoura, Hassan, & Saber, 2017).

An observational retrospective study by Guldogan et al. compared the use of Hem-o-Lok and endo-loop for closing the appendicular stump in patients with acute appendicitis. The study included 123 patients, with 73 undergoing endo-loop closure and 50 undergoing Hem-o-Lok closure. The results indicated that postoperative complication rates, length of hospital stay, and duration of the operative procedure were comparable between the two groups (Guldogan, 2024). Antoniou et al. conducted a meta-analysis on optimal stump management in laparoscopic appendectomy, incorporating 43 studies. This analysis found that the endo-loop was associated with improved outcomes in terms of intra-abdominal abscess formation and superficial infection rates (OR 0.56, 95% CI 0.32-0.96). The study concluded that sutured ligation of the appendicular stump yielded the best outcomes (Antoniou, 2017)). Additionally, a meta-analysis by Zorzetti et al. compared stump closure methods and the endo-loop, including seven studies. This analysis revealed no significant differences in postoperative complications, intra-abdominal abscess rates, or length of hospital stay between the procedures (Zorzetti, 2022).

Harmonic scalpel for closure of the appendicular stump

The harmonic scalpel is an energy device employed to close the appendicular stump during laparoscopic appendectomy. Gupta et al. conducted a retrospective study involving 310 patients with acute appendicitis, wherein 102 patients underwent Endo loop closure, and 108 patients underwent harmonic scalpel closure. The study found that the mean operative time was shorter in the harmonic scalpel group, while the complication rate was comparable between the two groups. This study demonstrated that the use of the harmonic scalpel for closure is both safe and effective (Gupta, 2020). Mathur et al. conducted a randomized controlled trial comparing the harmonic scalpel and sutured ligation of the appendicular base. In this trial, 60 patients were randomized, with 30 patients receiving harmonic scalpel application to the stump and 30 patients undergoing sutured ligation. The harmonic scalpel was associated with reduced operative time, shorter hospital stays, and fewer postoperative complications compared to sutured ligation (Mathur, 2025).

A systematic review and meta-analysis conducted by Borkar et al. evaluated the efficacy of the harmonic scalpel compared to other techniques for appendicular stump closure following laparoscopic appendectomy in cases of acute appendicitis. This study incorporated data from four studies, encompassing a total of 642 patients, with 283 patients undergoing harmonic scalpel closure and 359 patients receiving conventional appendicular stump closure. The findings indicated that the use of the harmonic scalpel was associated with a reduction in operative time (MD -12.96, 95% CI, 15.42 to 10.50). Additionally, the harmonic scalpel demonstrated comparable outcomes to other closure techniques in terms of postoperative complications, length of hospital stay, and intra-abdominal abscess formation (Borkar, 2022). In a separate systematic review and meta-analysis by Singh et al., the safety and efficacy of energy devices for appendicular stump closure were assessed. This analysis included six studies with a total of 3025 patients. The results revealed a shorter operative time when energy devices were employed for appendicular stump closure (MD 12.34, 95% CI, 16.57 to 8.11), although no significant differences were observed in the postoperative infection rate (Singh, 2022).

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

The closure of the appendicular stump is a crucial aspect of appendectomy, with several effective techniques available. No single method has demonstrated universal superiority; rather, the selection is contingent upon the surgeon's expertise, intraoperative observations, and available resources. Endo loops are a dependable and cost-effective choice for uncomplicated appendicitis, whereas staplers offer increased safety in more complex cases. Clips and energy devices are also viable alternatives, though they necessitate careful patient selection. Ultimately, the surgeon's ability to tailor the technique to the clinical scenario is essential for achieving optimal outcomes.

Article Information

Conflict of Interest Disclosure: No potential conflict of interest was declared by the authors.

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