Turkish Journal of Clinical Research

Turk J Clin Res. 2025;1(3):181-186
https://doi.org/10.63909/1453029

RESEARCH ARTICLE

Comparison of the extracorporeal knot technique and hem-o-lok polymeric clip application for appendiceal stump closure in laparoscopic appendectomy: A retrospective study

Laparoskopik apandisitte apendiks güdüğünün kapatılmasında ekstrakorporeal düğüm tekniği ile hem-o-lok polimerik klips uygulamasının karşılaştırılması: Retrospektif bir çalışma

Erkan KARACAN[1], Halil Berkay UZUNCU[1]

[1]Karabük Training and Research Hospital, Department of General Surgery, Karabük, Türkiye

Abstract

Aim: To compare the efficacy of the extracorporeal knot technique versus Hem-o-Lok polymer clips for appendiceal stump closure during laparoscopic appendectomy (LA) for uncomplicated acute appendicitis, assessing operative time, postoperative clinical outcomes, and cost-effectiveness.

Methods: This single-center retrospective cohort included 40 patients who underwent LA between January 2024 and June 2025. Patients were stratified by stump closure method into an Extracorporeal Knot group (Group 1, n=22) and a Hem-o-Lok Clip group (Group 2, n=18). Demographics, operative duration, hospital length of stay, 12- and 24-hour visual analog scale (VAS) pain scores, postoperative complication rates, and direct cost parameters were compared. Statistical analyses employed the Mann–Whitney U test for continuous variables and the Chi-square test for categorical variables.

Results: There were no significant differences between groups in age or sex distribution, operation time, length of hospital stay, 12- and 24-hour VAS pain scores, or overall postoperative complication rates (all p>0.05). Hovewer, a significant difference was observed in cost (p<0.001). The mean expenditure for the extracorporeal knot method was 40.22±4.21 TL, while Hem-o-Lok clip application averaged 650.0±59.4 TL.

Conclusion: Extracorporeal knotting provides clinical efficacy and safety comparable to Hem-o-Lok clips for appendiceal stump closure during LA, with a markedly lower cost. Given equivalent short-term outcomes and a substantial cost advantage, the knot technique emerges as a reliable, economical, and sustainable alternative—particularly suitable for healthcare settings with limited resources and for systems emphasizing value-based surgical care.

Keywords: Laparoscopic appendectomy, hem-o-lok, surgical clips, extracorporeal knot, cost–benefit analysis.

Özet

Amaç: Bu çalışmanın amacı, komplike olmayan akut apandisit tanısıyla laparoskopik apendektomi (LA) uygulanan hastalarda, apendiks güdüğünün kapatılması için kullanılan ekstrakorporeal düğüm tekniği ile Hem-o-lok polimerik klips uygulamasını; operasyon süresi, postoperatif klinik sonuçlar ve maliyet etkinlik açısından karşılaştırmaktır.

Yöntemler: Ocak 2024 ile Haziran 2025 tarihleri arasında komplike olmayan akut apandisit nedeniyle LA uygulanan 40 hasta, tek merkezli retrospektif kohort çalışmasına dahil edildi. Hastalar, apendiks güdüğünün kapatılma yöntemine göre iki gruba ayrıldı: Grup 1 (Ekstrakorporeal Düğüm, n=22) ve Grup 2 (Hem-o-lok Klips, n=18). Gruplar arasında demografik veriler, ameliyat süresi, hastanede kalış süresi, postoperatif komplikasyon oranları, Vizüel Analog Skala (VAS) ağrı skorları ve maliyet parametreleri karşılaştırıldı. Verilerin istatistiksel olarak değerlendirilmesinde Mann-Whitney U testi ile Ki-kare testinden yararlanıldı.

Bulgular: Her iki grup; yaş, cinsiyet, operasyon süresi, hastanede yatış süresi, ameliyat sonrası 12. ve 24. saat VAS ağrı skorları ve postoperatif komplikasyon oranları bakımından karşılaştırıldığında istatistiksel olarak anlamlı bir farklılık tespit edilmedi (p>0,05). Ancak, iki teknik arasında maliyet yönünden ileri derecede anlamlı bir fark gözlendi (p<0,001). Ortalama maliyet, ekstrakorporeal düğüm grubunda 40,22±4,21 TL olarak saptanırken, Hem-o-lok klips grubunda bu değer 650,0±59,4 TL olarak belirlendi.

Sonuç: Ekstrakorporeal düğüm tekniği, LA sırasında apendiks güdüğünün kapatılmasında Hem-o-lok klips uygulamasına eşdeğer klinik etkinlik ve güvenlik profili sunmaktadır. Klinik sonuçlar benzerken, düğüm tekniğinin maliyet açısından sağladığı belirgin avantaj, bu yöntemi özellikle kaynakların kısıtlı olduğu sağlık merkezlerinde güvenilir, ekonomik ve sürdürülebilir bir alternatif olarak öne çıkarmaktadır.

Anahtar Kelimeler: Laparoskopik apandektomi, hem-o-lok, cerrahi klipsler, ekstracorporeal düğüm, maliyet-yarar analizi.

Corresponding Author: Erkan KARACAN erkan8806@gmail.com

Cite as: Karacan E, Uzuncu HB. Comparison of the extracorporeal knot technique and hem-o-lok polymeric clip application for appendiceal stump closure in laparoscopic appendectomy: A retrospective study. Turk J Clin Res. 2025;1(3):181-186

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial-NonDerivatives 4.0 International License

Received: 2 November 2025 | **Accepted:** 30 November 2025 | **Published:** 31 December 2025

Turk J Clin Res. 2025;1(3):181-186
https://doi.org/10.63909/1453029

INTRODUCTION

Acute appendicitis stands as one of the most frequent abdominal conditions necessitating urgent surgical intervention globally and accounts for a substantial percentage of surgical emergencies (1). At present, laparoscopic appendectomy (LA) is considered the standard of care for non-complex cases because of its documented benefits compared to open surgery, including reduced postoperative pain, briefer hospitalization, a lower incidence of surgical site infections, and superior cosmetic outcomes (2,3).

Achieving a secure and leak-proof closure of the appendiceal stump is a crucial component for the success of an LA procedure. Failure to properly seal the stump may result in severe, life-threatening complications like stump leakage, the formation of an intra-abdominal abscess, or peritonitis, all of which can lead to significant morbidity and mortality (4).

The literature describes a wide array of methods for sealing the appendiceal stump, including endoloops (pre-tied knots), endostaplers, metal clips, polymeric clips (e.g., Hem-o-lok), and various suture ligation techniques (intracorporeal and extracorporeal knotting) (4,5). Despite this variety of methods, there is still no universal consensus on which technique is optimal (4,6). An ideal stump closure method is expected to be safe, effective, easy to apply, and cost-effective (7). The balance between these factors directly influences the choice of method in surgical practice.

The applications of the Hem-o-lok polymeric clip and the extracorporeal knot (handmade Roeder knot), as compared in this study, are two standard techniques with distinct advantages and disadvantages. As a non-absorbable polymer clip equipped with a locking mechanism, the Hem-o-lok clip may decrease surgical duration owing to its rapid and straightforward application (8). However, the main argument against its use is its cost, which is significantly higher than that of traditional sutures (7,8). In contrast, the extracorporeal knot technique is a highly cost-effective method as it uses standard surgical sutures (8). The application of this technique, however, depends on the surgeon's laparoscopic knot-tying skills and experience, and it may prolong the operation time, especially for inexperienced surgeons (9).

Although both methods are reported to be clinically safe, the balance between their operation time and cost-effectiveness remains a critical topic of debate, especially in healthcare systems where the efficient use of resources is increasingly important (10).

This retrospective study was designed to compare the extracorporeal knot technique against the Hem-o-lok polymeric clip application for appendiceal stump closure. The analysis included patients undergoing LA for uncomplicated acute appendicitis and evaluated operation time, postoperative complications, length of hospital stay, and cost-effectiveness.

METHODS

This single-institution, retrospective cohort study was performed in alignment with the Declaration of Helsinki's principles, having first secured approval from the local Clinical Research Ethics Committee. We retrospectively analyzed data from patients treated with LA for acute appendicitis within the General Surgery Clinic of a regional training and research hospital. The data, spanning from January 2024 to June 2025, were extracted from the hospital's automation system and existing surgical records.

The study population included patients aged 18 years or older who had undergone LA for uncomplicated appendicitis (defined as non-perforated or non-gangrenous). A further criterion for inclusion was the use of either the extracorporeal knot technique or a Hem-o-lok clip for appendiceal stump closure. Exclusion criteria were: conversion to open surgery, use of an alternative stump closure method (e.g., stapler, intracorporeal knot), intraoperative findings of complicated appendicitis (i.e., perforation, abscess, or plastron), or incomplete file data.

After applying these criteria, a total of 40 patients were deemed eligible for inclusion. These participants were subsequently allocated into two groups according to the closure method used: Group 1 (Extracorporeal Knot, n=22) and Group 2 (Hem-o-lok Clip, n=18).

All surgeries were performed using the standard LA technique. Under general anesthesia and in the supine position, the abdomen was entered via an infra-umbilical

Turk J Clin Res. 2025;1(3):181-186
https://doi.org/10.63909/1453029

incision, and pneumoperitoneum was established. Subsequently, two 5-mm working trocars were placed in the left lower quadrant and suprapubic region. After the appendiceal meso-artery was divided using an energy device, the appendiceal stump in Group 1 patients was closed by advancing a Roeder-type sliding knot, prepared outside the body using standard suture material, into the abdomen with a knot pusher (extracorporeal knot). In Group 2 patients, the stump was closed by placing a polymeric, locking clip (Hem-o-lok) at the base of the appendix.

Patient demographic, intraoperative, and postoperative data were obtained retrospectively. The variables assessed included: age, gender, comorbid status, estimated intraoperative blood loss (calculated by subtracting the irrigation volume from the total aspirated fluid), total operative duration (minutes), intraoperative perforation, postoperative fever, duration of hospitalization (days), surgical site infection, postoperative intra-abdominal abscess, requirement for reoperation, and postoperative VAS pain scores at 12 and 24 hours, as well as cost. The cost comparison was derived from the unit prices of the specific materials (suture and clip) utilized in each technique.

Statistical Analysis

Data were statistically analyzed utilizing the JASP program (Version 0.16.3). Since continuous variables (age, operation time, length of stay, VAS scores) failed to show a normal distribution, the Mann-Whitney U test was employed for intergroup comparison. For the analysis of categorical variables (gender, presence of comorbidity, complication rates), the Chi-square test or, where applicable, Fisher's exact test was used. Statistical significance was defined as a p-value <0.05.

RESULTS

A comparison of the demographic, intraoperative, and postoperative data for all 40 patients was conducted. The Extracorporeal Knot group (Group 1) and the Hem-o-lok Clip group (Group 2) were found to be homogenous, as no statistically significant differences were noted in age, gender distribution, or the presence of comorbidities. Regarding clinical outcomes, the analysis revealed no significant differences between the two groups in total operation time, intraoperative bleeding, VAS pain scores at 12 and 24 hours post-surgery, or duration of hospital stay (p>0.05). Moreover, postoperative complication rates (including wound site infection, intra-abdominal abscess, and reoperation) were not significantly different. A single minor complication occurred in each cohort (4.5% vs. 5.5%).

A highly statistically significant variation in cost was identified when comparing the two methods (p<0.001). In cases where ligation was performed with a Hem-o-lok clip (Group 2), the mean cost was 650.000±59.440 TL, whereas in the group using the extracorporeal knot technique (Group 1), this value was calculated as 40.22±4.21 TL. The comparative data of the groups are summarized in Table 1, Table 2 and Figure 1.

Table 1. Differences between group 1 and group 2

	Group 1	Group 2	p
Operation time (minutes)	39.16±7.17	38.4±7.77	0.686
Estimated blood loss (ml)	3.88±9.16	8.63±18.07	0.559
Age	29.66±12.29	31.22±11.61	0.531
Hospitalization (day)	2.05±1.76	2.27±3.38	0.951
VAS (postop 12th hour)	5.5±1.04	5.36±1.36	0.497
VAS (postop 24th hour)	3.22±0.94	3.13±1.08	0.678
Cost (Tl)	650±59.40	40.22±4.21	<0.001

Table 2. Preoperative and postoperative complications between group 1 and group 2

	Group 1	Group 2	p
Perforation	3 (16.66%)	4 (18.18%)	0.900
Postop fever	4 (22.22%)	4 (18.18%)	0.751
Postop infection	4 (22.22%)	5 (22.72%)	0.900
Reoperation	1 (5.55%)	0	0.263
Gender Male Female	 12 (66.66%) 6 (33.33%)	 12 (54.54%) 10 (45.45%)	0.430

Turk J Clin Res. 2025;1(3):181-186
https://doi.org/10.63909/1453029

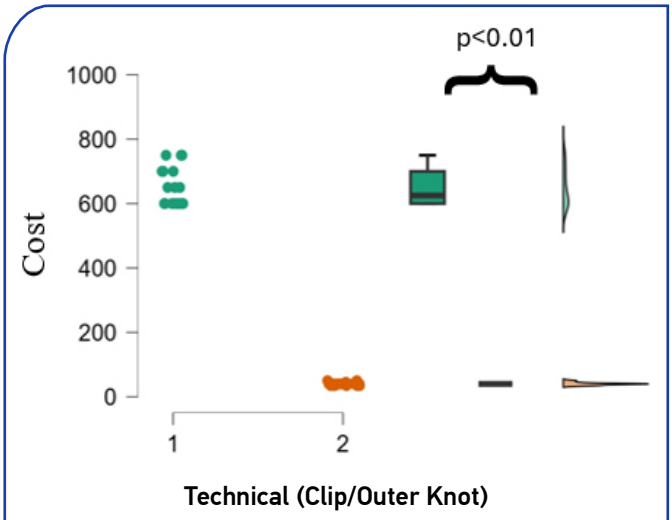

Figure 1. Association between ligation technique and cost in laparoscopic appendectomy.

DISCUSSION

In this study, the extracorporeal knot and Hem-o-lok clip methods used for appendiceal stump closure in laparoscopic appendectomy were compared. While no significant difference was identified between the methods regarding clinical efficacy and safety, the knot technique was determined to hold a substantial advantage in terms of cost. When our findings are evaluated together with data from the literature, they emphasize the importance of factors such as cost and surgeon experience in the choice of stump closure technique.

The primary finding of our study is that both techniques can be applied with similar surgical efficacy and safety. The groups were comparable regarding major complications, showing no significant difference in the rates of wound site infection, intra-abdominal abscess, or stump leakage. This finding is in agreement with a large body of literature, including numerous studies and systematic reviews that have evaluated knot/loop techniques against polymeric clips (4,11,12). A systematic review conducted by Makaram et al. reported that endoloops and endoclips offer equivalent clinical outcomes (4). Similarly, prospective randomized studies by Akbıyık et al. and Ureyen et al. found no statistical difference in postoperative complication rates between the handmade knot and the Hem-o-lok clip (13,14). These data indicate that the safety debate between stump closure methods in uncomplicated appendicitis cases has been largely resolved, and both methods have acceptably low complication rates (15). Thus, it is understood that the decisive factors in method selection are parameters other than safety.

Operation time is the parameter with the most contradictory results reported in the literature. Some studies argue that ready-to-use materials like the Hem-o-lok clip significantly shorten the operation time due to their ease of application (4,8). As an example, a study by Yılmaz et al. reported that the clip application group had an operation time roughly 12 minutes shorter than that of the intracorporeal knot group (8). This time-saving advantage is typically explained by the technique's rapid learning curve and its requirement for less advanced technical skill. In opposition to this, our study, as well as others, found no statistically significant difference in surgical duration between the two techniques (13,14,16). This situation suggests that operation time is a variable determined by the experience of the operating surgeon rather than an intrinsic feature of the technique itself. Extracorporeal knot tying is a skill that takes time to learn and master (9). An experienced surgeon can prepare and apply a Roeder knot in less than a minute, whereas this time can be much longer for an inexperienced surgeon. Therefore, as surgical experience increases, the knot-tying time shortens, and the potential time advantage of the clip disappears. The similar operation times found in our study indicate that the surgeons who performed the operations were proficient in the extracorporeal knot technique.

The most straightforward and clinically significant finding of our study is the cost difference between the two methods. The cost of the extracorporeal knot technique consists only of the cost of one standard surgical suture, whereas the cost of the Hem-o-lok clip is approximately 16 times higher. This finding aligns perfectly with data in the literature. Yılmaz et al. reported the suture cost as 35 TL and the clip cost as 280 TL (8). In a study on pediatric patients, Elgendy et al. reported the handmade loop cost as 4 USD and the Hem-o-lok clip cost as 14 USD (17). In high-volume surgeries like appendectomy, this cost difference cumulatively places a severe economic burden on healthcare systems. In a situation where clinical outcomes are equivalent, the routine use of a more expensive technology means an inefficient use of resources. Therefore, especially in public hospitals and

Turk J Clin Res. 2025;1(3):181-186
https://doi.org/10.63909/1453029

healthcare systems with limited resources, preferring low-cost techniques like the extracorporeal knot makes it possible to both provide treatment without compromising patient safety and contribute significantly to the health economy.

Another critical point to consider in method selection is the specific limitations of each technique. Hem-o-lok clips are technically inapplicable or not regarded as safe when the appendiceal base is broad (>10 mm), highly edematous, or necrotic (18). In such complicated cases, the surgeon must be proficient in an alternative method, such as suture ligation or an endostapler. This situation reveals the potential risks of a surgeon becoming dependent on a single technology. A surgeon accustomed only to using clips may face difficulties when encountering a challenging case where the clip cannot be applied. In this context, the routine use of the extracorporeal knot technique not only provides a cost advantage but also allows surgeons to maintain and develop their basic laparoscopic suturing and knot-tying skills. Yılmaz et al. also support this view, emphasizing that intracorporeal knotting enhances the laparoscopic skills of young surgeons and should therefore be encouraged (8). Consequently, the extracorporeal knot technique is both a versatile method applicable to a broader range of cases and an essential part of surgical training and skill sustainability.

Another critical point to consider in method selection is the specific limitations of each technique. Hem-o-lok clips are technically inapplicable or not regarded as safe when the appendiceal base is broad (>10 mm), highly edematous, or necrotic (18). Therefore, many centers in the literature emphasize the low safety of clips in wide or edematous bases and recommend alternative methods. In such complicated cases, the surgeon must be proficient in an alternative method, such as suture ligation or an endostapler. This situation reveals the potential risks of a surgeon becoming dependent on a single technology. Recent systematic reviews and meta-analyses published between 2023 and 2024 have further consolidated this consensus, demonstrating that while clip techniques are faster, suture techniques yield equivalent clinical safety profiles with no significant increase in complications (19,20). In this context, the routine use of the extracorporeal knot technique not only provides a cost advantage but also allows surgeons to maintain and develop their basic laparoscopic suturing and knot-tying skills. Mastery of these fundamental skills is crucial for navigating the steep learning curve of laparoscopic surgery and has been directly linked to improved clinical adaptability in complex scenarios (21). Consequently, the extracorporeal knot technique is both a versatile method applicable to a broader range of cases and an essential part of surgical training and skill sustainability.

Study Limitations

Several limitations should be acknowledged in this study. The retrospective design is a key weakness, carrying an inherent risk of selection bias. Surgeons may have preferentially chosen a specific technique based on the anticipated difficulty of the appendectomy. This lack of randomization introduces potential confounding bias, as unmeasured factors influencing the surgeon's decision could have affected the outcomes. Additionally, the study's statistical power is constrained by the small sample size (n=40), making it difficult to draw conclusions about infrequent complications. As a single-center investigation, the findings may also lack generalizability. To confirm these results at a higher evidence level, future large-scale, multi-center, prospective, randomized controlled trials are warranted (4).

CONCLUSION

The extracorporeal Roeder knot technique provides surgical efficacy and safety equivalent to the Hem-o-lok polymeric clip in uncomplicated acute appendicitis. While no superiority was found in clinical outcomes, its significant cost-effectiveness makes the extracorporeal knot technique a practical, economical, and sustainable alternative, especially in surgical units with limited resources. Moreover, this technique's contribution to preserving and developing the surgeon's basic laparoscopic skills offers additional value in terms of long-term patient safety and surgical training. Our findings strongly support that extracorporeal knotting, which provides similar clinical results while offering an economic advantage, should be considered a reliable primary option in laparoscopic appendectomy.

Acknowledgement: None.

Turk J Clin Res. 2025;1(3):181-186
https://doi.org/10.63909/1453029

Ethical Approval: Ethical approval for this study was obtained from Karabük University Non-Interventional Clinical Research Ethics Committee (Decision Date/ Number: 2025/2480, Protocol No: E-77192459-050.99-467220).

Author Contributions: Concept/Idea: E.K.; Design: E.K.; Supervision: E.K.; Resources: H.B.U.; Materials: H.B.U.; Data Collection and/or Processing: E.K.; Analysis and/or Interpretation: E.K.; Literature Review: H.B.U.; Writing: H.B.U.; Critical Review: E.K.

Conflict of Interest: There is no conflict of interest between authors.

Financial Disclosure: This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Guan L, Liu Z, Pan G, Zhang B, Wu Y, Gan T, et al. The global, regional, and national burden of appendicitis in 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019. BMC Gastroenterol. 2023;23(1):44.
2. Sauerland S, Jaschinski T, Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database Syst Rev. 2010;6(10): CD001546.
3. Athanasiou C, Lockwood S, Markides GA. Systematic review and meta-analysis of laparoscopic versus open appendicectomy in adults with complicated appendicitis: an update of the literature. World J Surg. 2017;41(12):3083-99.
4. 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;57:228-35.
5. Strzałka M, Matyja M, Rembiasz K. Comparison of the results of laparoscopic appendectomies with application of different techniques for closure of the appendicular stump. World J Emerg Surg. 2016;11:4.
6. Yeni M, Kalaycı T, Kartal M. Apendiks güdüğünün kapatılmasında kullanılan Hem-o-lok klips ile intrakorporeal sütürün erken ve geç dönem sonuçlarının karşılaştırılması. Celal Bayar Univ Saglik Bilim Enstit Derg. 2022;9(1):120-5.
7. Mayir B, Ensari CÖ, Bilecik T, Aslaner A, Oruç MT. Laparoskopik apendektomide apendiks güdük kapatma yöntemleri. Turk J Surg. 2015;31(4):229-31.
8. Yılmaz M, Altunpak B. Laparoskopik apendektomide güdük kapama yöntemlerinden hem-o-lok klip ve intrakorporeal sütürün retrospektif karşılaştırması. Anadolu Klin Tıp Bilim Derg. 2025;30(3):390-5.
9. Najah Q, Makhlouf HA, Abusalah MA, Aboelkhier MM, Rashed MA, Kashbour M, et al. Effectiveness of different appendiceal stump closure methods in laparoscopic appendectomy: a network meta-analysis. Langenbeck's Arch Surg. 2024;409(1):270.
10. Bessa S, Katri K, Elasys I, Darwish N. Hem-o-lok versus Roeder's knot for closure of the appendicular stump during laparoscopic appendectomy: a randomized clinical trial. ALEXMED ePosters. 2023;5(1):10-11.
11. Kesicioğlu T, Aydın İ, Vural S. Appendiceal stump closure with hem-o-lok clips in laparoscopic appendectomy. J Exp Clin Med. 2022;39(2):459-62.
12. Yeşiltaş M, Alemdar A. While the laparoscopic appendectomy is the gold standard in the treatment of acute appendicitis, what should be the preference for closure of the appendix stump? Duzce Med J. 2022;24(2):147-51.
13. Akbıyık F, Avşar FM, Özin Y, Bostancı EB. Hand-made extracorporeal knotting versus Hem-o-Lok clip for stump closure in laparoscopic appendectomy. J Coll Physicians Surg Pak. 2019;29(12):1203-7.
14. Ureyen O, Tan S, Dadalı E, Yıldırım M, İlhan E. Hem-o-lok clips versus intracorporeal knotting for the closure of the appendix stump in laparoscopic appendectomy: a prospective randomized study. Ulus Travma Acil Cerrahi Derg. 2020;26(3):384-8.
15. Mathur A, Yadav GD, Verma S, Shukla P. A comparative study of harmonic scalpel versus suture ligation for appendix base closure in patients with appendicitis undergoing laparoscopic appendectomy: a randomized controlled trial. Cureus. 2025;17(7):e88560.
16. Özcan C, Alkhatıb M, Benli S, Bozkurt H, Çolak T, Ertaş E. Comparison of hand-made extracorporeal knotting and Hem-o-lok clip in laparoscopic appendectomy. Cukurova Med J. 2025;50(1):56-62.
17. Elgendy A, Khirallah MG. Hem-o-lok clip versus hand-made loop in base closure during laparoscopic appendectomy in children. J Pediatr Endosc Surg. 2019;1(2):59-63.
18. Hue CS, Kim JS, Kim KH, Nam SH, Kim KW. The usefulness and safety of Hem-o-lok clips for the closure of the appendicular stump during laparoscopic appendectomy. J Korean Surg Soc. 2013;84(1):27-32.
19. Li Z, Zhao L, Zhang Y, Teo KA, Liu C, Wang W, et al. Clips closure versus endoloop ligation in laparoscopic appendectomy: a systematic review and meta-analysis of comparative studies. Front Surg. 2023;10:1088765.
20. Ergun S, Ciyiltepe H, Gunduz U, Aydin O, Kantarci A. Comparison of three different methods for stump closure in laparoscopic appendectomy: Endoloop, Hem-o-lok clip, and endostapler. Laparosc Endosc Surg Sci. 2024;31(3):123-8.
21. Zhang Y, Wang X, Zhang J, Li Y. The transition of surgical simulation training and its learning curve: a bibliometric analysis from 2000 to 2023. Front Med (Lausanne). 2024;11:1388658.