



## RESEARCH

# Comparison of hand-made extracorporeal knotting and Hem-o-lok clip in laparoscopic appendectomy

Laparoskopik apandektomide el yapımı ekstrakorporeal düğüm atma tekniği ile Hem-o-lok klipsin karşılaştırılması

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### Abstract

**Purpose:** This study aims to compare the extracorporeal knotting technique and the Hem-o-lok clip technique among patients who underwent laparoscopic appendectomy.

**Materials and Methods:** This study is a retrospective evaluation of prospectively acquired data from patients in a single-center setting. Patients were divided into two groups: group 1 was hand-made extracorporeal knotting group and group 2 was Hem-o-lok clip group. A total of 150 patients were included in the study. 81 patients were in Group 1 and 69 patients were in Group 2.

**Results:** No significant difference was found between demographic characteristics and clinical features for two groups. The incidence of surgical site infection was similar between the two groups (Grup 1: %3.7, Grup 2: %5.8). Postoperative complications were seen in 2 patients (2.9%) in the Hem-o-lok group and 3 patients (3.7%) in the extracorporeal knotting group. The mean operation time was group 1 54.2±7.9 minutes, group 2 52.3±10.7 minutes. The mean hospital stay of the patients was 1.2±0.7 days in group 2 and 1.3±0.8 days in the group 1. The cost analysis revealed that the Hem-o-lok technique was more expensive than the hand-made extracorporeal knotting method.

**Conclusion:** Both hand-made extracorporeal knotting and Hem-o-lok clips are effective and safe methods for closing the appendix stump in laparoscopic appendectomy.

**Keywords:** Laparoscopic appendectomy, Hem-o-lok clips, Extracorporeal knotting

### Öz

**Amaç:** Bu çalışma, laparoskopik apandektomi uygulanan hastalar arasında ekstrakorporeal düğüm atma tekniği ile Hem-o-lok klips tekniğini karşılaştırmayı amaçlamaktadır.

**Gereç ve Yöntem:** Bu çalışma, tek bir merkezde prospektif olarak toplanan verilerin retrospektif olarak değerlendirilmesidir. Hastalar iki gruba ayrılmıştır: grup 1, el yapımı ekstrakorporeal düğüm atma grubunu ve grup 2, Hem-o-lok klips grubu oluşturmaktadır. Çalışmaya toplamda 150 hasta dahil edilmiştir. 81 hasta grup 1'de, 69 hasta ise grup 2'de yer almıştır.

**Bulgular:** İki grup arasında demografik özellikler ve klinik özellikler açısından anlamlı bir fark bulunmamıştır. Cerrahi alan enfeksiyonu insidansı iki grup arasında benzerdi (Grup 1: %3.7, Grup 2: %5.8). Hem-o-lok grubunda 2 hastada (%2.9), ekstrakorporeal düğüm grubunda ise 3 hastada (%3.7) postoperatif komplikasyonlar görüldü. Ortalama operasyon süresi Grup 1'de 54.2±7.9 dakika, Grup 2'de ise 52.3±10.7 dakika olarak saptanmıştır. Hastaların ortalama hastanede yatış süresi Grup 2'de 1.2±0.7 gün, Grup 1'de ise 1.3±0.8 gündür. Maliyet analizi, Hem-o-lok tekniğinin el yapımı ekstrakorporeal düğüm atma yöntemine göre daha pahalı olduğunu ortaya koymuştur.

**Sonuç:** Elle yapılan ekstrakorporeal düğümleme ve Hem-o-lok klipslerinin laparoskopik apandektomide apandiks güdüğünün kapatılması için her ikisi de etkili ve güvenli yöntemlerdir.

**Anahtar kelimeler:** Laparoskopik apandektomi, Hem-o-lok klips, Ekstrakorporeal düğüm.

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## INTRODUCTION

Although the number of appendectomies performed per year has decreased significantly over the last few years, this procedure is still one of the most frequently performed operations in gastro-intestinal surgery<sup>1</sup>. Traditionally performed via the muscle-splitting incision described by (and named after) McBurney, appendectomy is more often performed laparoscopically today; several trials and meta-analyses have shown decreased pain, less parietal morbidity, shorter hospital stay, quicker return to normal activities, and better cosmesis via this approach<sup>2,3</sup>. However, the laparoscopic approach is associated with longer procedure times, increased cost and a higher risk of post-operative intra-abdominal abscess formation<sup>4,6</sup>. In 1983 with the advent of the first described minimally invasive laparoscopic appendectomy (LA) by Semm, medicine slowly shifted away from the open appendectomy. Laparoscopic appendectomy, though following open appendectomy by nearly a century, has become more popular<sup>7-9</sup>.

Various methods, including extracorporeal knot, endoloop, endoclips (both metallic and polymeric clips), and endostaplers, are used to close the appendix stump during surgery<sup>10,11</sup>. However, there is no consensus on the optimal method for appendiceal stump closure, as the technical properties of hand-made loops, Hem-o-lok, endoloop ligatures, and endostaplers differ considerably, with each technique offering specific advantages.

Similar to the endoloop ligatures, Hem-o-lok clips are frequently applied in uncomplicated appendicitis without inflammation of the base of the appendix, while endostaplers are preferred in complicated appendicitis with perforation or inflammation of the base of the appendix, but it is also the most expensive method<sup>12-14</sup>, and require insertion of a 12-mm or 15-mm trocar. The high cost of materials used for appendiceal stump closure reduces the popularity of the laparoscopic approach, particularly in public hospitals.

The use of Endoloops has been proposed by several authors due to their safety in closing the appendix stump and their lower cost compared to staplers<sup>15</sup>. however, its application requires certain technical skills and a brief training period<sup>16</sup>. On the other hand,

the Hem-o-lok system is recognized for its ease of handling and safe performance in stump closure.

In our center, with more than a seven hundred laparoscopic procedures per year, we have a wide experience in the use of Hem-o-lok clips to close the cystic duct during the cholecystectomy and the large blood vessels in the other operations. As mentioned earlier, various techniques can be used for stump closure; however, considerations regarding their cost-effectiveness and practicality are essential. There is a limited amount of research comparing the hand-made extracorporeal knotting technique with Hem-o-lok clips. The objective of this study was to compare these two methods—hand-made extracorporeal knotting and Hem-o-lok clips—for stump closure in laparoscopic appendectomy, focusing on factors such as operation time, complication rates, and cost-effectiveness, with the goal of determining which technique is safer and more efficient.

## MATERIALS AND METHODS

### Sample

Patients who underwent laparoscopic appendectomy at Mersin University Faculty of Medicine Hospital General Surgery Clinic between January 2022 and January 2024 were included in this study. All procedures were performed by the same surgical team, with surgeries carried out by qualified surgeons. The study protocol was reviewed and approved by The Board of Ethics Committee of Mersin University on 22/05/2024 with approval 2024/481 Written informed consent was obtained from all individual participants. The patients who underwent laparoscopic appendectomy were retrospectively examined and divided into two groups based on the stump closure technique: Group 1 consisted of patients who underwent hand-made extracorporeal knotting, while Group 2 included patients who had the Hem-o-lok clip technique.

Patients above the age of 18 years presenting to the departments of General and Gastrointestinal surgery with a clinical diagnosis of uncomplicated appendicitis and had undergone laparoscopic appendectomy. Exclusion criteria were patients who underwent open appendectomy, those who were converted to open appendectomy during the

procedure, and cases requiring stump closure with a different technique.

The data collected included age, gender, the american society of anesthesiologists (ASA) score, body mass index(BMI) ,comorbidities(hypertension (HT)and diabetes mellitus(DM)) ,laboratory values such as white blood cell count (WBC) and c-reactive protein (CRP) and preoperative appendix diameter in computed tomography. All this Demographic characteristics and clinical features were studied for both groups. Parameters such as surgery duration, hospital stay, surgical site infections and postoperative complications were compared for both groups.

### Technique

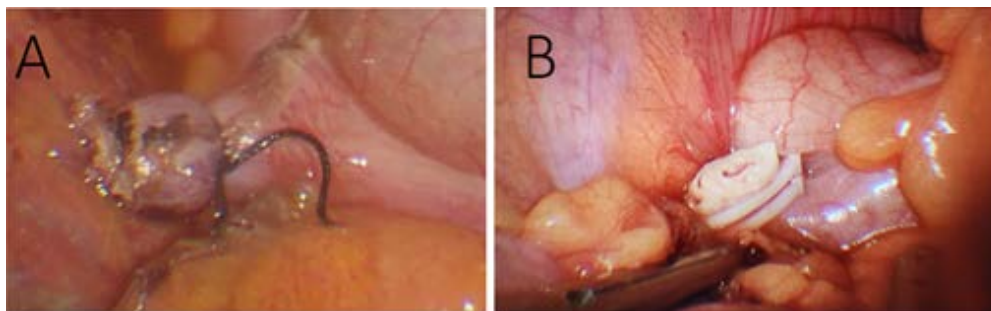
The surgeons have performed 81 appendectomy using Hand-made Extracorporeal Knotting (2–0 polydioxanone) and 69 appendectomy using Hem-o-lok clips (XL size, silver color applier). The stump closure technique was chosen by the operating surgeon. All operations were performed by the same surgical team. All patients received antibiotics

preoperatively. The patient was placed in supine position, combined with Trendelenburg position and left lateral position (10–15°, inclined toward surgeon). The surgeon and an assistant stood on the left side, and the monitor was on the right side of the patient. The bladder was decompressed with Foley catheter to avoid injury during insertion of suprapubic ports.

All operations were performed using 3 conventional laparoscopic trocars. Under direct vision, one 10-mm trocar for the camera (30 degree) was inserted in infraumbilical region. Following the principles of triangulation, Other 10-mm trocar via in left lower quadrant mid-clavicular incision and 5-mm trocar via via suprapubic incision.

The mesoappendix was resected with a 5 mm vessel closure device ligasure (Covidien™ LigaSure™ Maryland Jaw Laparoscopic Sealer/Divider, Unites States)

In Group 2, a two Hem-o-lok clip was placed on the base of the appendix (size XL), and in Group 1, a single polyglactin ligature with extracorporeal knotting to the appendix using knot pushers and cut using a ligasure (Figure 1).



**Figure 1.** Stump closure with Hand-made extracorporeal knotting technique (A). Stump closure with Hemo-lok clip technique (B).

### Statistical analysis

When performing continuous data statistics, mean and standard deviation, minimum and maximum values of features were used; while defining categorical variables, number and percentage values were used. Student's t test statistics were used in the evaluation of mean difference of continuous measurements according to stump slosure method. Chi-Square test statistics were used to evaluate the relationship between stump closure methods and categorical variables. The statistical significance level

of the data was taken as  $p < 0.05$ . IBM SPSS 25 statistical package program was used in the evaluation of the data.

### RESULTS

In the period from January 2022 to January 2024, a total of 632 patients underwent appendectomy at our hospital. Of these, 473 patients underwent open appendectomy, while 7 patients initially planned for laparoscopic appendectomy were converted to open surgery. Additionally, 2 patients had a different stump

closure technique applied, and therefore were excluded from the study. Ultimately, 150 patients met the inclusion criteria and were included in the study. These patients were allocated into two groups, with 81(54% of total cases) patients in the hand-made extracorporeal knotting group (Group 1) and 69 (46% of total cases) patients in the Hem-o-lok clip group (Group 2). 79.3% were male, and 20.7% were female, with ages ranging from a minimum of 18 to a maximum of 83 years. The mean age and standard deviation were  $37.1 \pm 14.5$  years. The BMI ranged from a minimum of 18.7 to a maximum of 30.2, with a mean and standard deviation of  $23.75 \pm 2.91$ . 10% of the patients had a diagnosis of diabetes mellitus (DM), 6.7% had hypertension (HT). The ASA score was 1 in 31.3% of the patients, 2 in 42.7 % of the patients, 3 in 24.7%, and 4 in 1.3% of the patients.

The mean age of patients in Group 1 was  $37.9 \pm 14.1$  years, while in Group 2 it was  $36 \pm 15.1$  years, and the gender distribution was similar in both groups, with males constituting 75.3% of Group 1 and 84.1% of Group 2. The ASA scores did not differ significantly between the groups ( $p=0.12$ ), and the prevalence of diabetes and hypertension was comparable, with diabetes present in 9.9% of Group 1 and 10.1% of Group 2 ( $p=0.99$ ), and hypertension in 7.4% of Group 1 and 5.8% of Group 2 ( $p=0.75$ ). The mean body mass index (BMI) was similar between the groups, with a mean BMI of  $23.66 \pm 2.96$  kg/m<sup>2</sup> in Group 1 and  $23.85 \pm 2.91$  kg/m<sup>2</sup> in Group 2 ( $p=0.70$ ), while the mean white blood cell count (WBC) was  $13.81 \pm 4.75 \times 10^9/L$  in Group 1 and  $13.47 \pm 4.35 \times 10^9/L$  in Group 2 ( $p=0.66$ ). The mean C-reactive protein (CRP) levels were  $48.88 \pm 36.63$  mg/L in Group 1 and  $65.05 \pm 55.41$  mg/L in Group 2 ( $p=0.25$ ).

**Table 1. Patient demographic and clinical characteristics**

Stumpe Closure		Hand-made extracorporeal knotting (Group 1) n=81	Hem-o-lok clips (Group 2) n=69	
		Mean $\pm$ SD	Mean $\pm$ SD	p value
Age		37.9 $\pm$ 14.1	36 $\pm$ 15.1	0.39
		n(%)	n(%)	
Gender	Female	20(24.7)	11(15.9)	0.19
	Male	61(75.3)	58(84.1)	
DM	No	73(90.1)	62(89.9)	0.99
	Yes	8(9.9)	7(10.1)	
HT	No	75(92.6)	65(94.2)	0.75
	Yes	6(7.4)	4(5.8)	
BMI		23.66 $\pm$ 2.96	23.85 $\pm$ 2.91	0.70
White blood cells		13.81 $\pm$ 4.75	13.47 $\pm$ 4.35	0.66
C-reactive proteins		48.88 $\pm$ 36.63	65.05 $\pm$ 55.41	0.25
Preoperative appendix diameter		10.89 $\pm$ 3.06	10.18 $\pm$ 2.32	0.12
ASA Score	1	25(30.9)	22(31.9)	0.12
	2	29(35.8)	35(50.7)	
	3	26(32.1)	11(15.9)	
	4	1(1.2)	1(1.4)	
		Mean $\pm$ SD	Mean $\pm$ SD	p value
Duration of Stay in the Hospital	One day	49(60.5)	46(66.7)	0.43
	Two day	32(39.5)	23(33.3)	
Late complication	No	78(96.3)	67(97.1)	0.99
	Yes	3(3.7)	2(2.9)	
Surgery Duration		54.2 $\pm$ 7.9	52.3 $\pm$ 10.7	0.22
Surgical site infection	Yes	78(96.3)	65(94.2)	0.71
	No	3(3.7)	4(5.8)	

DM: Diabetes Mellitus, HT: Hypertension, SD: standard deviation, BMI: Body mass index ASA: American society of anesthesiologists.

The mean preoperative appendix diameter measured by abdominopelvic computed tomography scan was  $10.89 \pm 3.06$  mm in Group 1 and  $10.18 \pm 2.32$  mm in Group 2 ( $p=0.12$ ). The mean operative duration was comparable between the Hem-o-lok group and the extracorporeal knotting group, with  $52.3 \pm 10.7$  minutes in the Hem-o-lok group and  $54.2 \pm 7.9$  minutes in the extracorporeal knotting group ( $p=0.22$ ). The length of hospital stay was similar between the two groups, with patients in the Hem-o-lok group having a mean stay of  $1.2 \pm 0.7$  days and those in the extracorporeal knotting group having a mean stay of  $1.3 \pm 0.8$  days ( $p=0.43$ ). The incidence of surgical site infection was also comparable between the two groups, with 5.8% in the Hem-o-lok group and 3.7% in the extracorporeal knotting group ( $p=0.71$ ).

Postoperative complications, including intra-abdominal abscess, were observed in 2 patients (2.9%) in the Hem-o-lok group and 3 patients (3.7%) in the extracorporeal knotting group, with no significant difference between the groups ( $p=0.99$ ). The cost analysis revealed that the Hem-o-lok technique was more expensive than the hand-made extracorporeal knotting method. The average cost per patient in the Hem-o-lok group was  $\$100 \pm 30$  ( $3500 \pm 1000$  TL) while in the extracorporeal knotting group, it was  $\$4$  (140TL).

Table 1 provides a clear comparison of the two groups in terms of evaluation of relationship/difference between demographic and clinical characteristics.

## DISCUSSION

Our research aimed to analyze the efficiency, security, and cost-benefits of utilizing hand-tied knots versus Hem-o-lok clips to seal the appendix stump when executing laparoscopic appendectomies. The conclusions indicate that while both procedures are effective and safe, there are noteworthy differences in their financial impacts.

Contrary to a few past studies indicating shorter surgery times with Hem-o-lok clips<sup>17,18</sup>, our findings revealed no significant difference in surgery duration between the two techniques. Both procedures were performed efficiently, with no notable variation in the total operating time. However, recording only the stump closure time would allow for a more accurate evaluation of these procedures. These results suggest

that when surgeons are skilled in either technique, the choice between Hem-o-lok clips and hand-made extracorporeal knots is unlikely to significantly impact the overall efficiency of the surgery. Further research specifically focused on comparing stump closure times between the two methods is warranted to provide more precise insights.

Regarding postoperative recovery, our study demonstrated no significant difference in the length of hospital stays between the two groups. Both hand-made extracorporeal knots and Hem-o-lok clips yielded similar outcomes in terms of recovery times. This suggests that both techniques are equally effective in facilitating postoperative recovery, as patients reached the necessary recovery benchmarks at comparable rates before discharge. Our findings align with those of similar studies (Lucchi A et al, 2017; Erdoğan A et al, 2021) that reported no substantial differences in hospital stay duration between various stump closure techniques<sup>19,20</sup>.

When analyzing surgical site infections and other postoperative complications, both techniques exhibited low complication rates. The incidence of surgical site infections and postoperative complications was similar between the two groups, with no significant difference in the occurrence of adverse events. This finding supports the notion that both hand-made knots and Hem-o-lok clips are safe and reliable methods for appendix stump closure, corroborating previous research (Arer IM et al, 2019; Erdoğan A et al, 2021), which also found low complication rates with both techniques.<sup>20,21</sup> The similar safety profiles further reinforce the idea that either method can be safely employed without increasing the risk of complications.

The most significant difference observed between the two methods was cost. Hem-o-lok clips are considerably more expensive than hand-made extracorporeal knots. The cost analysis revealed that Hem-o-lok clips cost approximately  $\$100$  per patient, whereas hand-tied extracorporeal knotting only cost  $\$4$ . This substantial cost difference raises important considerations, particularly for institutions with limited resources. While Hem-o-lok clips are easier to use and offer standardized application, their higher cost may not always be justified, especially in settings where hand-tied knots can achieve comparable clinical outcomes at a fraction of the expense. This finding is consistent with previous studies, which also

pointed out the significant cost differences between these two techniques <sup>22,23</sup>.

Both techniques have specific advantages. Hand-made extracorporeal knotting, while more cost-effective, requires more skill and practice. Hem-o-lok clips, although more expensive, offer a simpler and more reproducible method for stump closure, potentially reducing variability in surgical outcomes. The choice of technique may thus depend on the available resources and the skill level of the surgical team.

This study has several limitations, including its retrospective design and potential selection bias, as the choice of stump closure technique was made by the operating surgeon. Additionally, the study was conducted at a single center with a specific surgical team, which may limit the generalizability of the results. Power analysis was not conducted in this study. However, considering the sample sizes used in similar studies, it is believed that the study has an adequate sample size.

To further enhance our understanding and refine clinical practices, future studies should focus on evaluating the long-term outcomes and cost-effectiveness of both stump closure methods. Specifically, multicenter prospective trials with larger sample sizes and longer follow-up periods are needed to better assess the durability and impact of each technique on both clinical outcomes and healthcare costs over time. In addition, exploring training programs for surgeons to standardize the skillset required for hand-made extracorporeal knotting could improve the widespread adoption of this technique, especially in low-resource settings. Ultimately, a comprehensive analysis of both the economic and clinical implications of these techniques will provide clearer guidance for decision-making in laparoscopic appendectomy procedures and contribute to the ongoing evolution of surgical practices.

In conclusion, our study demonstrates that both hand-made extracorporeal knotting and Hem-o-lok clips are effective and safe methods for appendiceal stump closure in laparoscopic appendectomy, with no significant difference in operative time, hospital stay, or complication rates. The primary distinction between the two techniques lies in their cost, with Hem-o-lok clips being significantly more expensive.

Given that both techniques yield comparable clinical outcomes, the choice between them should be guided by cost considerations and the specific context of the healthcare setting. Hand-made extracorporeal knotting may be more suitable in environments where cost is a critical factor, while Hem-o-lok clips may be preferred in settings where ease of use and standardization are prioritized. Further research is needed to explore strategies to reduce the cost of Hem-o-lok clips and to evaluate their long-term cost-effectiveness in various surgical contexts.

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**Ethical Approval:** The study protocol was reviewed and approved by The Board of Ethics Committee of Mersin University on 22/05/2024 with approval 2024/481. Written informed consent was obtained from all individual participants.

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