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A comparative study of end loop knot versus harmonic scalpel in sealing the appendicular stump during laparoscopic appendectomy

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Abstract

Introduction: Introduction: Laparoscopic Appendectomy (LA) is increasingly used as standard surgical treatment for acute appendicitis. The choice of technique for securing the appendicular stump remains a critical and debated issue. The Endoloop (EL) is a safe, reliable, cost-effective suture ligation compared to Harmonic Scalpel (HS) which utilizes an advanced ultrasonic device to provide faster sealing. This study aimed to compare the clinical outcomes and efficiency of the EL versus the HS for stump closure in a resource-constrained setting.

Method: A prospective observational comparative study was conducted at Chitwan Medical College, Nepal from Jul to Dec 2025 after ethical approval. Patients undergoing LA were alternately allocated to EL or HS groups. Primary outcomes were surgery time and hospital stay. Data normality was verified using the Shapiro-Wilk test. Continuous variables (mean±SD) were compared using the independent t-test; categorical variables using the chi-square test in IBM SPSS v20.0. A p-value <0.05 was considered significant.

Result: A total of 70 patients were included for analysis (EL group, n=38; HS group, n=32). The mean age was comparable between the EL (36.34±17.62 years) and HS (36.69±16.64 years) groups (p=0.933). The HS group had a significantly shorter mean surgery time (32.34±7.21 min) versus the EL group (48.95±8.47 min; p<0.001). Mean hospital stay was also shorter in the HS group (2.09±0.82 days vs. 3.26±1.48 days; p<0.001). Rates of surgical site infection (p=0.589) and conversion to open surgery (p=0.625) did not differ significantly between groups.

Conclusion: Both EL and HS are safe for appendicular stump closure. The HS has advantages of reduced operative time and hospital stay.

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Introduction

Laparoscopic Appendectomy (LA) has gained popularity globally for treating acute appendicitis, offering superior patient outcomes compared to the traditional open appendectomy.[1] This includes shorter hospital stays, less pain, and lower rates of surgical site infection.[1,2] Despite the procedure's wide acceptance, a persistent technical debate centres on the better method for sealing the appendicular stump, with no single approach yet achieving universal acceptance.[3,4] This choice is highly critical in resource-limited settings, such as Nepal, where LA is increasingly feasible and safe, but where overall cost-effectiveness is paramount due to financial constraints and low rates of insurance coverage.[3]

The End Loop Knot (EL) utilizes simple mechanical ligation, representing a highly cost-effective and reliable option.[5–7] Meta-analyses confirm EL's safety profile is high and equal to more expensive devices, even in complicated cases.[8] Its main limitation is a slightly longer mean operative time.[9] Conversely, the Harmonic Scalpel (HS) uses advanced ultrasonic energy to provide a faster, sutureless sealing method that consistently reduces total operative time.[8] However, the substantial cost of the HS disposable tip poses a significant challenge, with material costs far more than those of EL.[8,10] This comparative study focuses on the outcome between two vastly different methods. Therefore, a study comparing the time-saving efficiency of HS against the established safety and financial sustainability of EL is necessary to define a responsible standard of care for the Nepali public health system.

Method

A prospective observational comparative study was conducted in the Department of Surgery (Unit I) at Chitwan Medical College, Nepal from Jul to Dec 2025. Approval was obtained from the Institutional Review Committee of CMC (IRC-CMC) prior to data collection. Written informed consent was obtained from all participating patients.

The sample size was calculated using a difference in means formula, based on previously reported mean surgical duration values. The required sample size was determined to be 30 patients per group, achieving a 99% confidence interval and 90% power.

The sample size was calculated using the formula[11], $n=(r+1)SD^2(Z_{(1-\alpha/2)}+Z_\beta)^2/rd^2$; Where, r=ratio of two groups=1 that is equal in each group, at 99% confidence interval and 90% power, $Z1-\alpha/2=2.57$, $Z_\beta=1.28$, d=μ1–μ2, μ1=mean duration of surgery using Endo-loop=49.8312, μ1=mean duration of surgery using harmonic scalpel=38.9513, SD=standard deviation of surgery using Endo-loop[12] and n=sample size in one group was calculated to be 30. Accounting for potential attrition, a total of 70 patients were enrolled.

The study population included all patients presenting with a diagnosis of appendicitis who subsequently underwent laparoscopic appendectomy. Patients were included if they provided written informed consent. Exclusion criteria were: symptoms for more than four days, palpable mass in the right lower quadrant, diffuse peritonitis, evidence of pelvic inflammatory disease, or anticipated need for conversion to open procedure due to extensive adhesions or improper anatomical conditions.

A convenience sampling technique with alternating allocation was employed. Eligible patients were assigned to the EL or HS groups alternately until the required sample size was reached for each group.

All laparoscopic appendectomies were performed by a senior resident under direct supervision of a consultant GI surgeon or by the consultant surgeon. The standard procedure involved three ports (supraumbilical optical port via open method, one in hypogastrium, and one in the right side of the abdomen).

Patients were positioned in the Trendelenburg position with a left tilt. For the EL Group, pre-formed loops of suture material (catgut) were used to ligate and secure the appendicular stump before appendix removal. In the HS Group, an ultrasonic energy device was utilized to simultaneously cut and coagulate the tissue, achieving sealing of the appendicular stump without sutures.

Data were collected pre-operatively, intra-operatively, and post-operatively using an observational checklist and data form. Surgery time (minutes) was measured from skin incision to final skin closure. Postoperative pain (Visual Analogue Scale - VAS) was assessed at 12 hours post-operatively. Hospital stay (days) was measured from surgery day to discharge day. Surgical site infection (SSI) was categorized as present or absent based on CDC guideline definitions and evaluated at the second postoperative day or at discharge (whichever came earlier) and confirmed via phone call or OPD follow-up at 30 days post-operation. Postoperative bleeding was defined as requirement for evacuation of a local hematoma or need for re-exploration due to intra-abdominal bleeding. Appendiceal diameter (mm) was measured intra-operatively.

Collected data were entered into Microsoft Excel for initial cleaning and subsequently exported to IBM SPSS version 20.0 for statistical analysis. Descriptive statistics including frequency and percentage were used for categorical variables, while mean±standard deviation was used for continuous variables. The Shapiro-Wilk test was employed to check for normality of data distribution. The student's t-test was used to compare mean values between the two intervention groups. Chi-square test was used to compare differences in proportions for categorical outcomes. A two-tailed p-value of <0.05 was predetermined as the threshold for statistical significance.

Result

A total of 70 patients were included in the study among which 39(55.7%) were male and 31(44.3%) were female. The mean age was 36.5±17.05 years. The most common presentation was acute appendicitis (45.7%), Figure 1.

The mean diameter was statistically significantly larger in the HS group compared to the EL group (p=0.046). The mean hospital stay was significantly shorter in the HS group compared to the EL group (p<0.001), Table 2.

There was no statistically significant difference found in the mean VAS score between the two groups (p=0.206). There was no statistically significant difference in conversion to open in the two groups (p=0.625). Also, the occurrence of SSI was similar in both the groups (p=0.589), Table 3.

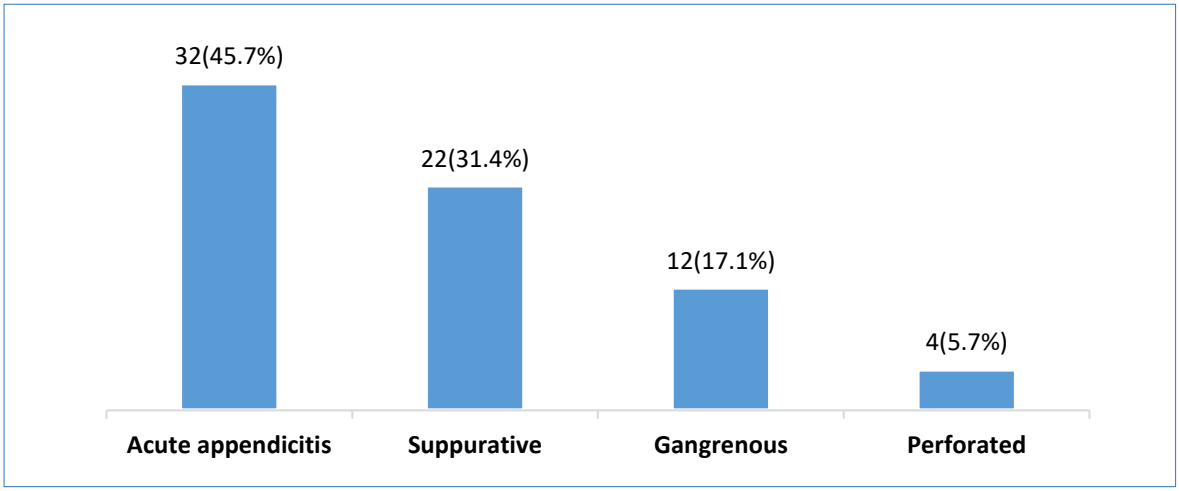

Figure 1. Type of acute appendicitis underwent laparoscopic appendicectomy, n=70

Table 1. Patient outcomes following laparoscopic appendectomy (LA), n=70

Parameters	Mean	±SD
Surgery time (min)	41.36	11.45
Diameter (mm)	7.83	1.87
Pain (VAS)	3.90	1.55
Hospital stays	2.73	1.35

SD=standard deviation, VAS=Visual Analogue Scale

Table 2. Comparison of baseline characteristics and surgical outcomes between EL (n=38) and HS (n=32) groups of LA patients, n=70

Parameter	EL (Mean±SD)	HS (Mean±SD)	p-value
Age(years)	36.34±17.62	36.69±16.64	0.933
Surgery Time(min)	48.95±8.47	32.34±7.21	<0.001
Diameter(mm)	7.42±1.88	8.32±1.76	0.046
Pain (VAS)	4.12±1.43	3.65±1.66	0.206
Hospital stays	3.26±1.48	2.09±0.82	<0.001

EL: Endoloop; HS: Harmonic scalpel

Table 3. Comparison of complications between EL (n=38) and HS (n=32) groups of LA patients, n=70

Complication	EL n(%)	HS n(%)	p-value
Conversion to open	2(5.3)	2(6.3)	0.625
Surgical Site Infection (SSI)	1(2.6)	2(6.3)	0.589

Discussion

The findings demonstrate that the HS significantly reduces both operative time and hospital stay compared to the EL for appendicular stump closure during laparoscopic appendectomy, while maintaining equivalent safety profiles. The comparable baseline characteristics, particularly mean age (p=0.933), suggest that observed differences are attributable to the intervention rather than demographic factors.

The result showed a significant reduction in mean surgery time in the HS group (32.34±7.21 minutes) compared to the EL group (48.95±8.47 minutes) (p<0.001). This 34% reduction in operative duration is most likely due to the function of HS, which allows for a simultaneous dissection, coagulation, and division of the mesoappendix and the stump itself without the need for multiple instrument exchanges or intracorporeal knot tying. This result is consistent with other study comparing advanced energy devices to traditional ligation methods for various laparoscopic procedures.[5,13,14]

These findings are common with the meta-analysis which showed that ultrasonic devices make the procedure easy significantly.[8] While traditional suture ligation requires high manual handiwork and time for precise knot placement, the ultrasonic technology provides a more standardized and faster alternative.

The mean Diameter (mm) of the appendicular stump showed a statistically significant difference between the groups (p=0.046). The HS group had a slightly larger mean diameter (approximately 8.32 mm) compared to the EL group (approximately 7.42 mm). While statistically significant, this minor difference in stump diameter does not affect the surgical outcome. However, it may suggest a tendency for the HS to be selected for, or more effectively used on, appendices with slightly larger bases.

Safety is one of the main concerns in stump closure. Our data showed no statistically

significant difference in SSI (p=0.589) or conversion to open surgery (p=0.625) between the two groups. This similarity in safety confirms that despite the speed of the HS, it does not compromise the outcome of the seal compared to the mechanical reliability of the EL. These results are consistent with global literature suggesting that various techniques, when performed correctly, result in similar complication rates.[5,12,14,15]

While the lack of a significant difference in post-operative pain (VAS) scores (p=0.206) indicates similar acute pain management requirements, that can play an important role in deciding the discharge time and to a faster overall functional recovery. This may be an indirect effect of the shorter surgical time and reduced tissue manipulation.[2,6,14]

The significantly shorter hospital stays for the HS group (2.09±0.82 days vs. 3.26±1.48 days, p<0.001) is an important finding for healthcare systems in developing countries. Faster discharge not only increases patient satisfaction but also improves hospital bed availability. However, the use of HS in countries like Nepal must be balanced against the high cost of disposable tips. While the device itself is expensive, the reduction in anaesthesia time, operating room costs, and hospital stay duration may balance the initial investment, potentially making it a hidden cost-effective solution in high-volume centres.

Reduced hospitalization decreases costs and hospital-acquired infection risks, particularly relevant in resource-constrained healthcare systems.

Limitations of this study include an observational design with alternating allocation rather than randomization which may introduce selection bias, though comparable baseline characteristics mitigates this concern. The single-centre nature limits generalizability to other settings with different resources and expertise. Cost-effectiveness analysis was not performed, which has implications in resource-limited settings. Finally, follow-up was limited to 30 days, and telephone inquiry for SSI may not have captured details.

Conclusion

This study demonstrated that both Endoloop and Harmonic Scalpel are safe and effective methods for appendicular stump closure during laparoscopic appendectomy. The Harmonic Scalpel offers clinical advantages of reduced operative time and shorter hospital stay. These benefits should be weighed against the higher device cost of Harmonic Scalpel in resource-constrained settings like Nepal.

Author contribution

Concept design: RKM, AR; Literature search: AS, BKY; Data collection: RD, SKS; Data analysis: AR; Draft manuscript: RKM, AR, AS; Final manuscript and accountability: All

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Conflict of Interest

None

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Supplementary material

The data and supplementary material that support the findings of this study are available from the corresponding author upon reasonable request.

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