

A Comparative Study on Knotting vs Clip Ligation of Cystic Duct in Laparoscopic Cholecystectomy

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Abstract: **Introduction:** Laparoscopic cholecystectomy requires secure cystic duct closure to prevent bile leak. Metallic clips are standard but associated with slippage and migration, prompting interest in suture knotting. This study compares knotting versus clip ligation regarding safety, bile leak, operative time, feasibility, cost, and outcomes. **Aim and objective:** The aim is to identify a reliable, context-appropriate technique to optimize patient safety and surgical results across diverse clinical settings worldwide. To compare knotting versus clip ligation of the cystic duct in laparoscopic cholecystectomy regarding complications, cost, recovery, outcomes. **Methodology:** This was a prospective study carried out in tertiary health centre from February 2024 to January 2026 in 70 patients after taking an informed and written consent of patient having cholelithiasis. patients undergoing laparoscopic cholecystectomy were evaluated clinically and investigated. Standard four-port laparoscopic technique under general anaesthesia was used. Following Calot's triangle dissection, patients were divided into two groups: Group A underwent intracorporeal cystic duct knotting, while Group B received titanium clip ligation. **Result:** Gallbladder removal, haemostasis, and standardized closure were performed in all cases. Both groups were comparable demographically and clinically. Knotting significantly reduced intraoperative bile spillage, wound infection, hospital stay, costs, and overall complications, despite longer operative time. Clip ligation showed higher intra- and postoperative complication rates. Multivariate analysis confirmed clip use and increasing age as independent predictors of postoperative complications. **Conclusion:** Intracorporeal knotting of the cystic duct is safer and more cost-effective than clip ligation, with fewer complications and shorter hospital stay, despite longer operative time.

Keywords: Laparoscopic, Cystic duct, Bile leak, Metallic clips, Knotting

1. Introduction

Laparoscopic cholecystectomy is the gold standard for gallbladder disease, but bile leak due to inadequate cystic duct closure remains a significant complication. Metallic clips are commonly used for cystic duct closure because of ease and speed, yet are associated with complications such as slippage, migration, bile leak, and bile duct injury. Knotting (intracorporeal suture ligation) offers a more secure and adjustable closure, particularly in wide or inflamed cystic ducts, and eliminates the risk of clip migration. Although knotting requires greater laparoscopic skill and may increase operative time, advances in training and instruments have reduced technical barriers. Cost-effectiveness favours knotting, especially in resource-limited settings, as sutures are inexpensive compared with clips and applicators. Ongoing debate persists due to variable evidence, highlighting the need for direct comparative evaluation of knotting versus clip ligation to guide safer, evidence-based practice.

2. Materials and Methods

Inclusion Criteria:

Patients presenting to the surgical outpatient department with cholelithiasis and planned for elective laparoscopic cholecystectomy were included in the study

Exclusion Criteria:

The following patients were excluded from the study:

- Patients with common bile duct (CBD) stones
- Patients with significant co-morbid conditions
- Pregnant females
- Patients unfit for general anaesthesia

Hospital-based comparative study on patients undergoing laparoscopic cholecystectomy. Non-probability consecutive sampling method was used. Eligible patients were enrolled consecutively until the required sample size was achieved. Patients were allocated alternately into two study groups:

Group A: Cystic duct ligation performed by intracorporeal knotting

Group B: Cystic duct ligation performed using titanium clips
Ethical clearance was obtained from the Institutional Ethics Committee. Written informed consent was also obtained from all participants.

3. Results

Table: Comparison of Bile Spillage between groups

Bile Spillage	Clip (n=35)	Knot (n=35)	Total (n= 70)
No	28 (80.0%)	35 (100%)	63 (90.0%)
Yes	7 (20.0%)	0 (0%)	7 (10.0%)
Total	35	35	70
$\chi^2 = 7.778$, df= 1, p= 0.005 (Significant)			

Bile spillage occurred only in the clip group and was significantly higher compared to the knotting group (p=0.005).

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This strongly suggests that knotting provides better intraoperative duct security

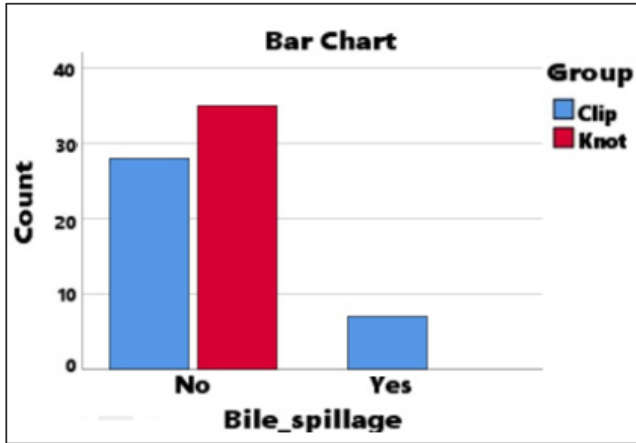


Figure: Comparison of Bile Spillage between groups

Table: Comparison of Post- Operative Bile leak between groups

Bile Leak	Clip (n=35)	Knot (n=35)	Total (n= 70)
No	33 (94.3%)	35 (100%)	68 (97.1%)
Yes	2 (5.7%)	0 (0%)	2 (2.9%)
Total	35	35	70

$\chi^2 = 2.059, df = 1, p = 0.151$ (Non-Significant)

Although bile leaks occurred only in the clip group, the association was not statistically significant ($p = 0.151$). However, clinically, knotting still shows a more secure closure.

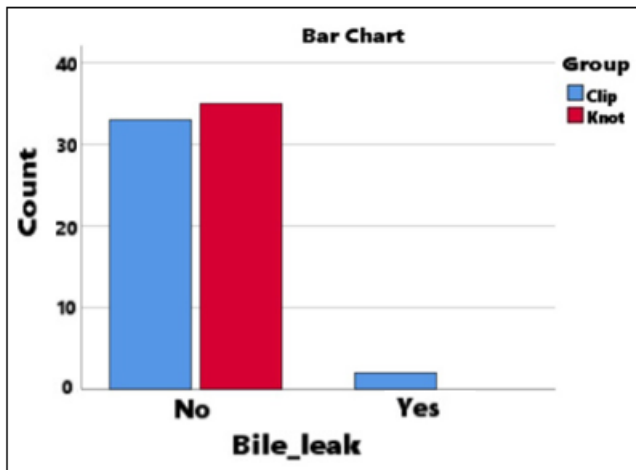


Figure: Comparison of post-operative Bile Leak between groups

Variable	Clip (n=35) Mean ± SD	Knot (n=35) Mean ± SD	Mean Difference	p-Value
Operative Time (mm)	59.57 ± 4.86	78.60 ± 7.29	-19.03	<0.001
Estimated Blood Loss (ml)	37.66 ± 16.45	26.66 ± 17.21	+1.00	0.805

Operative duration was significantly higher in the knot group ($p < 0.001$), indicating that clip ligation is a faster method. Estimation blood loss was similar between both groups ($p = 0.805$), showing no difference in intraoperative bleeding risk

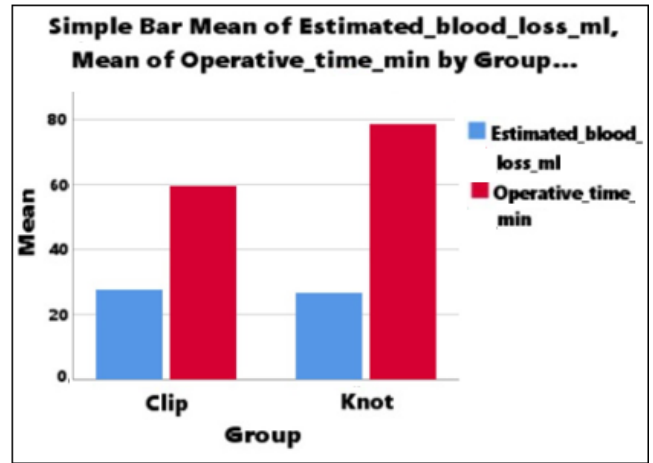


Figure: Operative time and Estimation Blood Loss

Table: Post operative pain, recovery Timings, and Length of Stay

Variable	Clip (n=35) Mean ± SD	Knot (n=35) Mean ± SD	Mean Difference	p-Value
Post- op Day-1 VAS	3.15 ± 0.92	3.05 ± 7.29	+0.10	0.694
Time to Oral Intake (hr)	8.03 ± 4.34	8.11 ± 17.21	-0.09	0.929
Time to ambulation (hr)	12.80 ± 7.51	11.77 ± 4.27	+1.03	0.484
Length of Stay (days)	2.80 ± 1.21	1.63 ± 0.69	+1.17	<0.001

Pain Scores and early recovery parameters (Oral intake and ambulation) were not significantly different between the two groups.

However, length of hospital stay was significantly shorter in the knot group ($p < 0.001$), suggesting better postoperative recovery with knotting

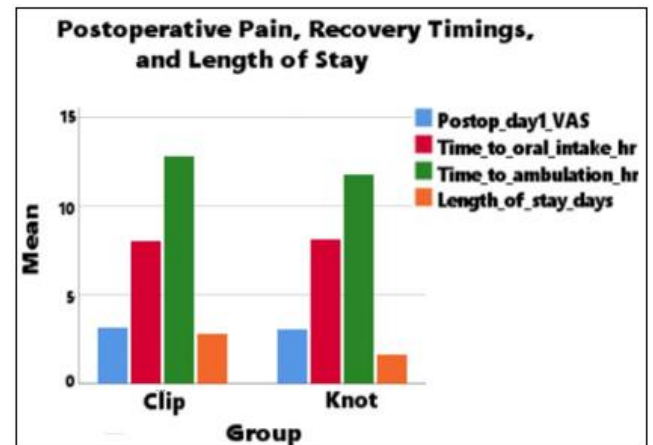


Figure: Post Operative Pain, Recovery Timings and Length of Stay

Table: Cost of implants used for Cystic Duct Closure

Variable	Clip (n=35) Mean ± SD	Knot (n=35) Mean ± SD	Mean Difference	p-Value
Cost of Implants (INR)	754.29 ± 197.55	218.57 ± 29.92	+535.71	<0.001

The cost of the procedure was significantly higher in the clip group ($p < 0.001$). Knotting is markedly more economical and cost-effective compared to clip ligation

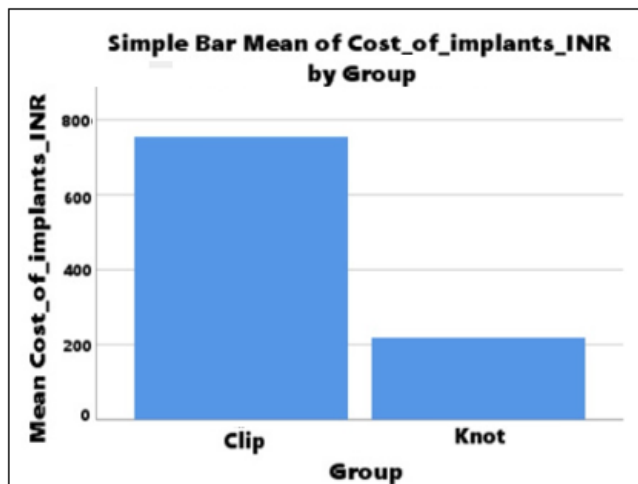


Figure: Cost of Implants used for Cystic Duct Closure

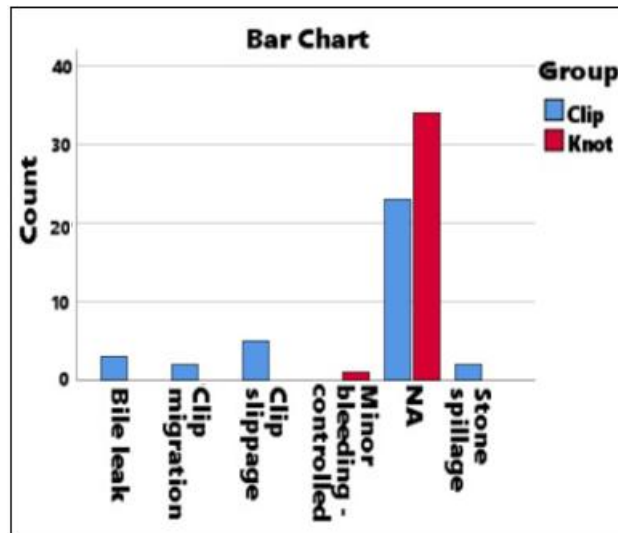


Figure: Intraoperative complications patters between groups

Table: Intraoperative complications patters between groups

Variable	Clip (n=35)	Knot (n=35)	Total (n= 70)
Bile Leak	3	0	3
Clip Migration	2	0	2
Clip Slippage	5	0	5
Minor Bleeding- Controlled	0	1	1
Stone Spillage	2	0	2
No Complication (NA)	23	34	57
Total	35	32	70
$\chi^2= 715.123, df= 5, p= 0.010$ (Significant)			

Intraoperative complications were significantly more common in the clip group (p=0.010), particularly clip slippage, bile leak, and clip migration

The knot group had only one minor complication, indicating greater procedural safety with knotting

Table: Post- operative complications between groups

Post- operative complications	Clip (n=35)	Knot (n=35)	Total (n= 70)
No Complications (0)	24 (68.6%)	34 (97.1%)	58 (82.9%)
Complication Present (1)	11 (31.4%)	1 (2.9%)	12 (17.1%)
Total	35	35	70
$\chi^2= 10.057, df= 1, p= 0.002$ (Highly Significant)			

Post- operative complications were significantly higher in the clip group (31.4%) compared to the knot group (2.9%) (p= 0.002).

This demonstrates a clear post operative advantage of knotting over clip ligation in terms of safety and recovery

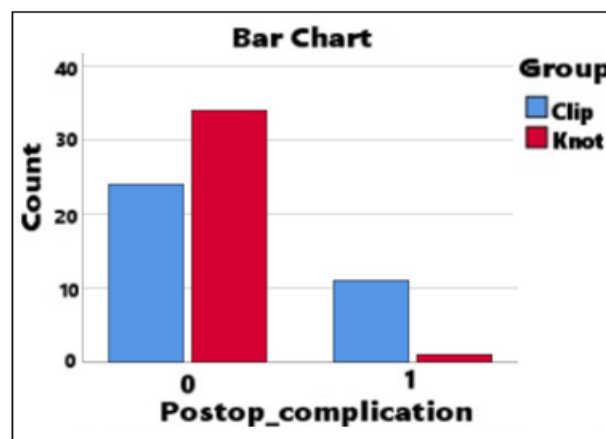
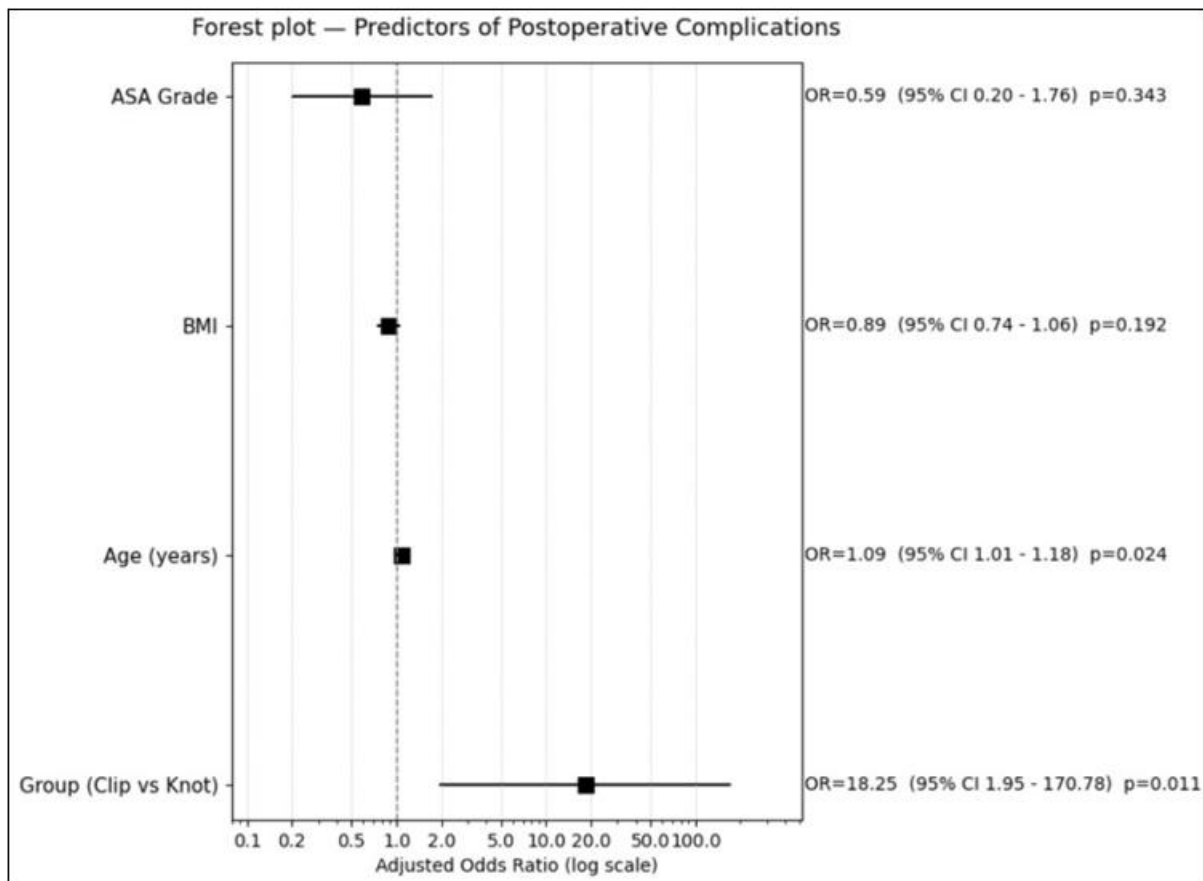


Figure: Post- operative complications between groups

Table: Multivariate Logistics Regression for Predicators of Post Operative Complications

Predictor	B (Coefficient)	SE	Wald	df	p-value	Adjusted OR (Exp(B))	95% CI (Approx.)
Group (Clip vs Knot)	2.904	1.141	6.476	1	0.011	18.253	↑ Strong risk (CI wide)
Age (years)	0.088	0.039	5.075	1	0.024	1.092	↑ Slight risk per year
BMI	-0.121	0.093	1.702	1	0.192	0.886	NS
ASA Grade	-0.531	0.559	0.901	1	0.343	0.588	NS
Constant	-3.682	3.132	1.382	1	0.24	0.025	

Logistic regression showed that the clip group had a significantly higher risk of postoperative complications compared to the knot group (OR = 18.25, p = 0.011). Age was also a significant predictor (OR = 1.09, p = 0.024), indicating slightly increased risk with older age. BMI and ASA grade were not significant predictors. Overall, the model correctly classified 87.1% of cases.



4. Discussion

Estimated blood loss was comparable between clip ligation and knotting, indicating that the latter does not introduce additional haemorrhagic risk. However, the length of hospital stay was significantly shorter in the knotting group, reflecting a reduced overall complication burden. This safety advantage was further evidenced by the higher incidence of overall postoperative complications associated with clip ligation. Regarding intraoperative outcomes, knotting demonstrated superior cystic duct control, resulting in significantly lower rates of bile spillage and a lower frequency of intraoperative complications compared to the clip group. Most notably, postoperative bile leaks occurred exclusively in patients treated with clip ligation, whereas no such cases were observed in the knotting group.

5. Conclusion

Estimated blood loss was comparable between the two techniques, and operative time was significantly shorter with clip ligation; however, these efficiencies were offset by a higher incidence of complications. Intraoperative bile spillage occurred significantly more often in the clip group (20%) compared to the knotting group (0%, $p = 0.005$), demonstrating more secure cystic duct closure with the latter. Furthermore, intraoperative complications—including bile leak, clip migration, and clip slippage—were significantly higher among patients receiving clips ($p = 0.010$), whereas procedures in the knotting group were almost entirely uncomplicated. While early postoperative recovery parameters such as pain, oral intake, and ambulation remained similar across both cohorts, the clinical outcomes favoured

knotting. Overall postoperative complications were markedly higher in the clip group (31.4%) compared with the knotting group (2.9%, $p = 0.002$). Postoperative bile leaks and 30-day readmissions occurred exclusively in the clip group, representing a consistent, albeit statistically non-significant, trend. Consequently, the length of hospital stay was significantly shorter for patients in the knotting group, reflecting a lower complication burden. Finally, cost analysis revealed that knotting is substantially more economical due to the elimination of expensive implant costs.

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