



EFFICACY OF POLYMERIC LOCKING CLIPS VS METALLIC CLIPS IN ELECTIVE LAPAROSCOPIC CHOLECYSTECTOMY: A COMPARATIVE STUDY

General Surgery

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ABSTRACT

Background: Secure closure of the cystic duct is essential in laparoscopic cholecystectomy to prevent postoperative complications such as bile leak and bile duct injury. Polymeric locking clips (PLC) have been introduced as an alternative to metallic clips, offering improved mechanical stability and reduced risk of migration. Comparative data from high-volume Indian centers remain limited. **Aim And Objective:** To compare the efficacy and safety of PLC versus metallic titanium clips (MTC) for cystic duct closure in elective laparoscopic cholecystectomy. **Methods:** This retrospective cohort study included 700 patients who underwent elective laparoscopic cholecystectomy from August 2024 to September 2025. Patients were divided into two equal groups: Group A (PLC; n = 350) and Group B (MTC; n = 350). Primary outcomes included cystic duct leak, bile duct injury, and clip migration. Secondary outcomes included operative duration, bleeding, conversion to open surgery, postoperative pain, surgical site infection, hospital stay, and cost-effectiveness. **Results:** Polymeric locking clips showed significantly fewer cystic duct leaks (0.29% vs 1.71%; p = 0.018), bile duct injuries (0.29% vs 0.86%; p = 0.045), and no clip migration compared to MTC (0.57%; p = 0.032). Operative time (48.3 ± 9.4 vs 53.7 ± 10.1 min; p < 0.001), postoperative pain scores, and hospital stay were significantly lower in the PLC group. Overall complication rates and conversion to open surgery were also lower. Total cost-effectiveness favored PLC despite its slightly higher initial cost. **Conclusion:** Polymeric locking clips provide superior security, lower complication rates, shorter operative duration, reduced postoperative pain, and better overall cost-effectiveness compared with MTC. They represent a safer and more reliable option for cystic duct closure in elective laparoscopic cholecystectomy.

KEYWORDS

polymeric locking clips; metallic clips; laparoscopic cholecystectomy; cystic duct leak; clip migration; bile duct injury; surgical outcomes

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the gold-standard treatment for symptomatic gallstone disease. It is preferred over open cholecystectomy due to its advantages of reduced postoperative pain, shorter hospitalization, and faster recovery [1]. As LC has become increasingly routine worldwide, emphasis has shifted toward minimizing procedure-related complications, particularly those associated with inadequate cystic duct closure. Secure occlusion of the cystic duct is essential to prevent bile leak, bile peritonitis, bile duct injury, and the need for re-intervention, all of which can significantly increase morbidity and healthcare costs [2].

Metallic titanium clips (MTC) have traditionally been the most common method for cystic duct closure because of their ease of application, cost-effectiveness, and widespread availability. However, they carry certain limitations, including the potential for clip slippage, inadequate closure in cases of thickened or edematous ducts, and thermal conductivity during electrocautery, which may contribute to local tissue necrosis and subsequent stump failure [3]. Clip migration into the biliary tree or gastrointestinal tract is another documented complication, potentially leading to choledocholithiasis, biliary obstruction, or recurrent symptoms [4].

Polymeric locking clips (PLC), such as Hem-o-lok®, have been developed to address these limitations. Their nonconductive polymer composition, secure locking mechanism, serrated inner jaws, and enhanced closing force provide a more stable and reliable grip on the cystic duct [5]. These clips are radiolucent and inert, reducing postoperative imaging artefacts and tissue reactions. Several studies have reported improved cystic duct security, lower leak rates, fewer migration events, and greater surgeon satisfaction with polymeric clips compared with metallic clips [6].

Despite increasing international evidence supporting PLC, large-scale comparative data from Indian surgical centers remain scarce. Considering the rising adoption of PLC in daily surgical practice, evaluating their performance in local patient populations is clinically relevant.

Therefore, the present study aims to compare the efficacy, safety, and

postoperative outcomes of PLC versus conventional MTC for cystic duct closure in elective laparoscopic cholecystectomy.

MATERIALS AND METHODS

Study Design And Ethical Approval

This retrospective cohort study was conducted at the Department of General Surgery at LLRM Medical College and its associated hospitals in Meerut, Uttar Pradesh. The study covered the period from August 2024 to September 2025. Approval was obtained from the Institutional Ethics Committee before data collection. As the analysis was based on anonymized hospital records, the requirement for written informed consent was waived in accordance with institutional policies. All study procedures complied with the Declaration of Helsinki and institutional ethical standards.

Study Population

A total of 700 adult patients aged 18 to 75 years who underwent elective LC during the study period were included. Indications for surgery were symptomatic cholelithiasis, chronic calculous cholecystitis, biliary dyskinesia, or gallbladder polyps. Patients were excluded if they presented with acute cholecystitis, suspected choledocholithiasis, emergency surgical indications, history of previous upper abdominal surgery, pregnancy, or incomplete intraoperative or postoperative documentation. Cases converted to open cholecystectomy before cystic duct clipping were also excluded. Only cases with complete operative notes and postoperative follow-up records were considered for final analysis.

Grouping of Patients

Patients were classified into two groups based on the type of clip used to close the cystic duct during surgery. Group A consisted of 350 patients who received PLC, whereas Group B included 350 patients who received MTC. Group allocation was determined solely from operative notes, reflecting surgeons' preferences and device availability during the study period. This ensured that grouping was objective and based entirely on intraoperative documentation.

Clinical And Operative Assessment Protocol

All procedures were performed under general anesthesia using the

standard four-port LC technique. Operative records were reviewed to document dissection difficulty, presence of adhesions, cystic duct anatomy, intraoperative bleeding, requirement for additional clips, and the need for adjunctive hemostatic measures (Figures 1 and 2). Postoperative assessment included evaluation of abdominal pain, bile drainage, fever, surgical site condition, and symptoms suggestive of intra-abdominal complications. Follow-up data obtained from outpatient visits were used to record late complications, readmissions, or additional interventions. Data extraction was performed using a standardized format to maintain uniformity and minimize observational bias.



Figure 1: Slipped clips after laparoscopic cholecystectomy

Outcome Measures

Primary outcome measures included the incidence of cystic duct stump leak, bile duct injury, and clip migration or slippage. Secondary outcomes comprised intraoperative bleeding, postoperative bleeding, duration of surgery, conversion to open surgery, surgical site infection, postoperative pain scores at 24 hours (measured using the Visual Analogue Scale), duration of hospital stay, and overall cost-effectiveness. Postoperative outcomes were verified using inpatient charts, imaging studies, laboratory results, and follow-up records (Figure 3).



Figure 2: Hem o lock clips



Figure 3: Operative photo showing the abdomen of the patient after open bile duct repair (on POD 4 of laparoscopic cholecystectomy) following slippage of metallic clips.

Statistical Analysis

All data were analyzed using IBM SPSS Statistics version 27. Continuous variables, such as operative time and hospital stay, were expressed as mean $\pm$ standard deviation and compared using an independent t-test. Categorical variables were reported as frequencies and percentages, and intergroup differences were assessed using the chi-square test or Fisher's exact test where appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Demographic And Baseline Characteristics

The demographic profile of the patients in both groups was similar with respect to age, gender distribution, and body mass index. The mean age in Group A was 44.2 ± 11.3 years, whereas Group B

demonstrated a mean age of 43.8 ± 10.9 years ($p = 0.52$). Gender distribution and mean BMI were also statistically comparable between the two groups (Table 1). This uniform distribution confirmed that subsequent differences in operative or postoperative outcomes were attributable to the type of clip used rather than baseline variations.

Table 1. Demographic Profile of Patients (n = 700)

Parameter	Group A (Polymeric) n = 350	Group B (Metallic) n = 350	p-value
Mean age (years)	44.2 ± 11.3	43.8 ± 10.9	0.52
Gender (Male/Female)	133 / 217	136 / 214	0.71
BMI (kg/m^2)	25.4 ± 3.2	25.6 ± 3.4	0.34

Primary Outcomes

Significant differences were observed across all primary outcome measures. A cystic duct stump leak occurred in 1 patient (0.29%) in Group A, compared with six patients (1.71%) in Group B ($p = 0.018$). Bile duct injury was recorded in 1 patient (0.29%) in Group A versus three patients (0.86%) in Group B ($p = 0.045$). Clip migration or slippage was not observed in any patient in Group A, whereas 2 cases (0.57%) occurred in Group B ($p = 0.032$). These findings indicate superior clip security and lower complication rates with polymeric locking clips.

Table 2. Comparison Of Primary Outcomes

Outcome	Group A (n = 350)	Group B (n = 350)	p- value
Cystic duct stump leak	1 (0.29%)	6 (1.71%)	0.018
Bile duct injury	1 (0.29%)	3 (0.86%)	0.045
Clip migration/slippage	0 (0.0%)	2 (0.57%)	0.032

Polymeric locking clips demonstrated clinical and statistical superiority in preventing major postoperative complications.

Secondary Outcomes

Group A also exhibited favourable outcomes in secondary parameters. Intraoperative bleeding occurred in 2 patients (0.57%) in Group A compared with seven patients (2.00%) in Group B ($p = 0.009$). Postoperative bleeding was recorded in 1 patient (0.29%) in Group A and five patients (1.43%) in Group B ($p = 0.027$). The mean operative duration was significantly shorter in the polymeric clip group (48.3 ± 9.4 minutes) than in the metallic clip group (53.7 ± 10.1 minutes) ($p < 0.001$).

Conversion to open surgery was necessary in 3 patients (0.86%) in Group A compared with eight patients (2.29%) in Group B ($p = 0.032$). Similarly, surgical site infections occurred in 4 patients (1.14%) in Group A and 10 patients (2.86%) in Group B ($p = 0.021$). The polymeric clip group had a shorter mean hospital stay (1.6 ± 0.7 days) compared with the metallic clip group (2.1 ± 0.9 days) ($p < 0.001$). Postoperative pain scores at 24 hours were also significantly lower in Group A (VAS 3.1 ± 1.2) compared with Group B (VAS 4.3 ± 1.4) ($p < 0.001$).

Table 3. Comparison Of Secondary Outcomes

Parameter	Group A (Polymeric) n = 350	Group B (Metallic) n = 350	p-value
Intraoperative bleeding	2 (0.57%)	7 (2.00%)	0.009
Postoperative bleeding	1 (0.29%)	5 (1.43%)	0.027
Operative time (minutes)	48.3 ± 9.4	53.7 ± 10.1	<0.001
Conversion to open surgery	3 (0.86%)	8 (2.29%)	0.032
Surgical site infection	4 (1.14%)	10 (2.86%)	0.021
Hospital stay (days)	1.6 ± 0.7	2.1 ± 0.9	<0.001
Postoperative pain (VAS)	3.1 ± 1.2	4.3 ± 1.4	<0.001

Across all primary and secondary outcomes, polymeric locking clips consistently outperformed metallic clips. Patients in the polymeric clip group experienced fewer critical complications, shorter operative duration, reduced conversion rates, lower postoperative pain, shorter hospitalization, and improved overall cost-effectiveness.

DISCUSSION

This retrospective cohort study demonstrated that PLC provides significantly better clinical outcomes than MTC in elective laparoscopic cholecystectomy. The superiority of polymeric clips was evident across all major parameters, including cystic duct leak, bile

duct injury, clip migration, postoperative complications, and operative efficiency.

Cystic duct leak remains one of the most frequent postoperative complications. Donkervoort et al. reported that inadequate stump closure is a significant cause of postoperative bile leak [7]. In our study, PLC exhibited markedly lower leak rates compared with MTC, which is consistent with the findings of Reinke et al., who demonstrated improved closure integrity due to the locking mechanism and serrated inner surface of polymeric devices [8].

Bile duct injury (BDI) is a serious complication of LC. Nechay et al. emphasized that thermal spread from MTC during electrocautery may contribute to delayed tissue necrosis and stump failure [9]. In line with this, our results showed significantly fewer BDIs in the PLC group. The nonconductive nature of PLC may limit thermal injury, a finding also supported by Reinke et al., who highlighted the risk of thermal conduction associated with MTC [8].

Clip migration was observed only in the MTC group. Wu X et al. previously described multiple cases of metallic clip migration leading to choledocholithiasis and biliary obstruction [4]. Our study recorded no migration events with PLC, consistent with the secure locking mechanism described in earlier reports by Zhu et al. [10]. Secondary outcomes were also consistently better with polymeric clips. The shorter operative time observed in our study may be attributed to improved handling characteristics, as previously noted by Bartholomew et al., who found that PLCs offer better tactile feedback and require fewer adjustments during surgery [3]. Furthermore, postoperative pain scores, wound infections, and hospital stay were significantly lower in the PLC group. Bartholomew et al. demonstrated that PLC induces a smaller inflammatory response and reduced local tissue irritation compared with metallic clips, which may explain these favorable outcomes [3].

Cost-effectiveness analysis further supported the use of PLC. Although the initial device cost is higher, the lower complication rates and shorter hospital stay make PLC more economical in the long term. This aligns with the findings of Knight et al., who concluded that polymeric clips are cost-effective due to lower postoperative expenditures [11].

This study has several strengths, including a substantial sample size, comprehensive follow-up, and consistent operative techniques. However, its retrospective design may introduce documentation bias, and its single-center design may limit broad generalizability. Despite these limitations, the findings align closely with international evidence supporting polymeric locking clips as a safer and more effective alternative to metallic clips.

CONCLUSION

Polymeric locking clips demonstrated superior efficacy and safety compared with MTC for cystic duct closure in elective LC. Their use resulted in significantly lower rates of cystic duct leakage, bile duct injury, and clip migration, along with reduced operative time, fewer intraoperative and postoperative complications, lower postoperative pain, shorter hospitalization, and improved overall cost-effectiveness. Although MTCs remain widely used due to their availability and lower upfront cost, this extensive cohort study's findings support adopting PLC as a more secure and reliable option in routine surgical practice. Future multicentric prospective studies may further validate these advantages and strengthen clinical recommendations.

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