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Research Article

Clipless Versus Conventional Clip-Based Laparoscopic Cholecystectomy: A Prospective Comparative Study Of Operative Safety and Early Recovery Outcomes

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ABSTRACT
Background: Clipless laparoscopic cholecystectomy has emerged as a technically appealing alternative to conventional clip-based cystic pedicle control, but its practical value depends on operative efficiency, safety, postoperative pain, and return to routine activity.
Objective: To compare clipless and conventional laparoscopic cholecystectomy with respect to operative time, intra-operative blood loss, perioperative safety, postoperative pain, hospital stay, and early functional recovery.
Materials and Methods: This prospective comparative study was conducted from March 2025 to November 2026. Eighty patients undergoing laparoscopic cholecystectomy were analyzed, with 40 managed by the clipless technique and 40 by the conventional technique. Demographic profile, ASA grade, indication for surgery, prior abdominal surgery, operative duration, blood loss, intra-operative complications, bile duct injury, conversion to open surgery, 6-hour pain score, hospital stay, time to return to normal activity, Clavien-Dindo grade, and 30-day readmission were assessed. Continuous variables were compared using Welch independent-samples t-test, and categorical variables were assessed using chi-square or Fisher exact test as appropriate.
Results: The groups were comparable for age (48.08 ± 9.79 vs 50.15 ± 9.90 years; p=0.349), BMI (27.14 ± 2.92 vs 27.59 ± 2.80 kg/m2; p=0.487), sex distribution, ASA class, and operative indication. Clipless cholecystectomy was associated with shorter operative time (46.70 ± 6.46 vs 65.53 ± 6.11 minutes; p<0.001), lower blood loss (23.25 ± 9.81 vs 32.42 ± 12.93 mL; p=0.001), lower 6-hour VAS score (3.21 ± 0.61 vs 4.81 ± 0.61; p<0.001), shorter hospital stay (1.92 ± 0.46 vs 2.66 ± 0.44 days; p<0.001), and earlier return to normal activity (7.78 ± 2.25 vs 11.55 ± 2.26 days; p<0.001). No bile duct injury or conversion to open surgery occurred in either group. Postoperative complications were mild to moderate and did not differ significantly between groups (15.0% vs 22.5%; p=0.568).
Conclusion: In this cohort, clipless laparoscopic cholecystectomy demonstrated better operative efficiency and faster early recovery while maintaining a safety profile comparable to conventional clip-based surgery. The findings support clipless technique as a feasible option in appropriately selected patients, provided safe dissection principles are strictly followed.

Keywords: Clipless Laparoscopic Cholecystectomy; Conventional Laparoscopic Cholecystectomy; Cystic Duct Closure; Harmonic Scalpel; Postoperative Pain; Hospital Stay.

INTRODUCTION

Laparoscopic cholecystectomy remains the standard operative treatment for symptomatic gallstone disease, with advantages over open surgery in terms of incision size, pain, recovery, and hospital stay. Contemporary guidelines continue to support laparoscopic management across elective and selected emergency settings, provided patient selection, operative expertise, and safety principles are respected [1] [2]. Even so, cholecystectomy is not a trivial operation. The operative field around Calot's triangle is compact, inflamed gallbladders are common in Indian surgical practice, and a seemingly routine case may become technically demanding once adhesions, edema, obesity, or distorted anatomy are encountered.

The gravest concern during laparoscopic cholecystectomy is bile duct injury. Its frequency is low, but its consequences are disproportionate: bile leak, biliary stricture, repeated intervention, prolonged morbidity, referral to hepatopancreatobiliary centres, and

litigation. International guidance therefore places strong emphasis on safe ductal identification, intra-operative judgement, and early recognition of injury [3]. The critical view of safety has become the preferred conceptual framework for identifying the cystic duct and artery before division [4,5]. What follows from that principle is equally important: any device or closure method used at the cystic pedicle must preserve safety rather than merely shorten the operation.

Conventional laparoscopic cholecystectomy commonly uses titanium clips for the cystic duct and cystic artery, combined with electrocautery for gallbladder bed dissection. The method is familiar, inexpensive, and widely available. However, clips can occasionally slip, become displaced, interfere with later imaging, or create technical crowding in a narrow Calot's triangle. Energy-assisted clipless approaches were introduced to simplify dissection and pedicle control, reduce instrument exchanges, and potentially minimize bleeding or bile spillage. Published experience with ultrasonic clipless dissection has shown encouraging safety and feasibility in selected cases [6].

The literature, however, is not entirely uniform. Kandil and colleagues reported shorter operative duration and less blood loss with clipless harmonic dissection compared with the conventional method [7]. Wills and Crawford found comparable bile leak rates between harmonic and clip-based cystic duct occlusion in a retrospective comparison [8]. More recent syntheses have suggested that clipless approaches may reduce operative time in some settings, although bile leak, conversion, complication rate, and cost-effectiveness remain dependent on patient selection, anatomy, operator experience, and the specific device used [9]. Other studies have shown no clear advantage over conventional surgery, reminding clinicians that a technology-driven benefit cannot be assumed without local outcome assessment [10].

For postgraduate and tertiary-care hospitals in India, this question has practical value. Operating-room turnover, affordability, postoperative bed use, and early return to work matter to patients and institutions. Yet any gain in efficiency must be judged against safety endpoints such as bile duct injury, conversion, readmission, and clinically meaningful complications. Standardized reporting of postoperative complications, commonly by the Clavien-Dindo system, allows such comparisons to be interpreted with more discipline [11]. The present study compared clipless and conventional laparoscopic cholecystectomy in terms of operative safety, blood loss, postoperative pain, hospital stay, and early return to normal activity.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective comparative study conducted from March 2025 to November 2026 in patients undergoing laparoscopic cholecystectomy. The manuscript is framed for a tertiary-care institutional setting; the institution name may be inserted before submission.

Study Population

A total of 80 patients were analyzed. Forty patients underwent clipless laparoscopic cholecystectomy and forty underwent conventional clip-based laparoscopic cholecystectomy. Patients were operated for benign gallbladder disease, including cholelithiasis, acute cholecystitis, chronic cholecystitis, and gallstone pancreatitis.

Eligibility Criteria

Adult patients undergoing laparoscopic cholecystectomy for benign gallbladder indications were included. No additional exclusion criteria were specified. Patients were assessed for demographic characteristics, ASA class, surgical indication, prior abdominal surgery, and perioperative outcomes.

Operative Techniques

In the clipless group, laparoscopic cholecystectomy was performed without clip application for cystic pedicle control. In the conventional group, standard clip-based control of the cystic duct and cystic artery was used. The operative approach otherwise followed routine laparoscopic cholecystectomy practice, with attention to safe dissection and recognition of biliary anatomy.

Outcome Measures

The primary operative outcomes were operative time, measured in minutes, and intra-operative blood loss, measured in millilitres. Safety outcomes included intra-operative complications, bile duct injury, conversion to open surgery, postoperative complication grade, and 30-day readmission. Recovery outcomes included 6-hour postoperative pain measured by visual analogue scale, hospital stay in days, and time to return to normal activity in days.

Statistical Analysis

Continuous variables were summarized as mean ± standard deviation and compared between groups using Welch independent-samples t-test. Categorical variables were summarized as frequency and percentage and compared using chi-square test or Fisher exact test where expected cell counts were small. Effect estimates for key continuous outcomes were expressed as mean difference with 95% confidence interval. A p-value <0.05 was considered statistically significant. Statistical estimates were generated from patient-level observations.

Ethical Considerations

Patient confidentiality was maintained by using anonymized study numbers rather than personal identifiers. Institutional ethics approval details should be inserted before journal submission.

RESULTS

Eighty patients were included, with equal distribution between the clipless and conventional groups (40 patients each). The overall operative indication profile is shown in Figure 1; cholelithiasis was the commonest indication, accounting for 52/80 patients (65.0%).

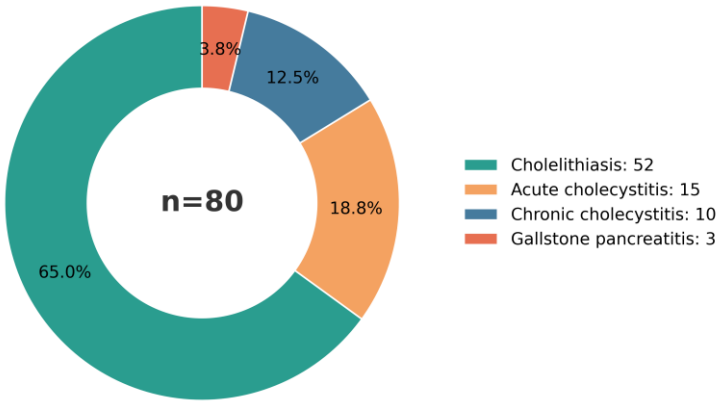

Figure 1. Distribution of operative indications in the study cohort

Donut chart displays the overall indication profile; counts are shown in the legend.

Table 1. Baseline Clinical Profile of the Two Study Groups.

Variable	Clipless (n=40)	Conventional (n=40)	p-value
Age (years)	48.08 ± 9.79	50.15 ± 9.90	0.349
Sex: Female	27 (67.5)	26 (65.0)	1.000
Sex: Male	13 (32.5)	14 (35.0)	
BMI (kg/m2)	27.14 ± 2.92	27.59 ± 2.80	0.487
ASA I	13 (32.5)	9 (22.5)	0.486
ASA II	22 (55.0)	23 (57.5)	
ASA III	5 (12.5)	8 (20.0)	
Cholelithiasis	26 (65.0)	26 (65.0)	0.940
Acute cholecystitis	7 (17.5)	8 (20.0)	
Chronic cholecystitis	5 (12.5)	5 (12.5)	
Gallstone pancreatitis	2 (5.0)	1 (2.5)	
Previous abdominal surgery	6 (15.0)	4 (10.0)	0.737

Values are mean ± SD or n (%).

The groups were demographically comparable. Mean age was 48.08 ± 9.79 years in the clipless group and 50.15 ± 9.90 years in the conventional group (p=0.349). BMI, sex distribution, ASA class, surgical indication, and prior abdominal surgery were also balanced between groups (Table 1).

Intra-Operative Outcomes

Operative time was substantially lower in the clipless group, with a mean duration of 46.70

± 6.46 minutes compared with 65.53 ± 6.11 minutes in the conventional group (p<0.001). The operative-time comparison is shown in Figure 2.

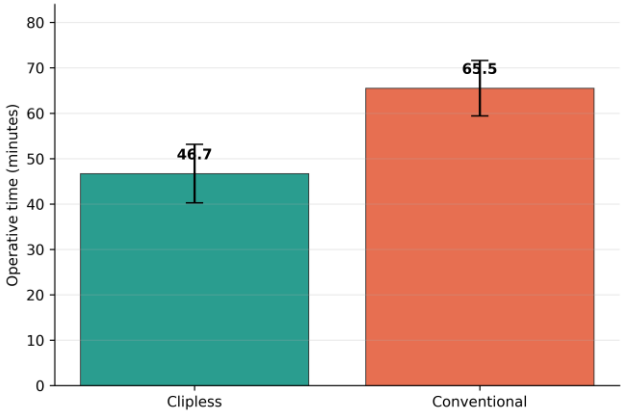

Figure 2. Mean Operative Time According To Operative Technique

Bars show mean values with standard deviation; values above bars indicate mean operative time in minutes.

Table 2. Intra-Operative Outcomes and Safety Endpoints.

Outcome	Clipless (n=40)	Conventional (n=40)	p-value
Operative time (min)	46.70 ± 6.46	65.53 ± 6.11	<0.001
Intra-operative complication	0 (0.0)	1 (2.5)	1.000
Bile duct injury	0 (0.0)	0 (0.0)	Not applicable
Blood loss (mL)	23.25 ± 9.81	32.42 ± 12.93	<0.001
Conversion to open surgery	0 (0.0)	0 (0.0)	Not applicable

Values are mean ± SD or n (%).

Mean blood loss was also lower in the clipless group (23.25 ± 9.81 mL) than in the conventional group (32.42 ± 12.93 mL; p=<0.001). One intra-operative complication was recorded in the conventional group, while none was recorded in the clipless group. No bile duct injury and no conversion to open surgery occurred in either group (Table 2). The relative reduction in key operative and recovery outcomes with clipless surgery is summarized in Figure 3.

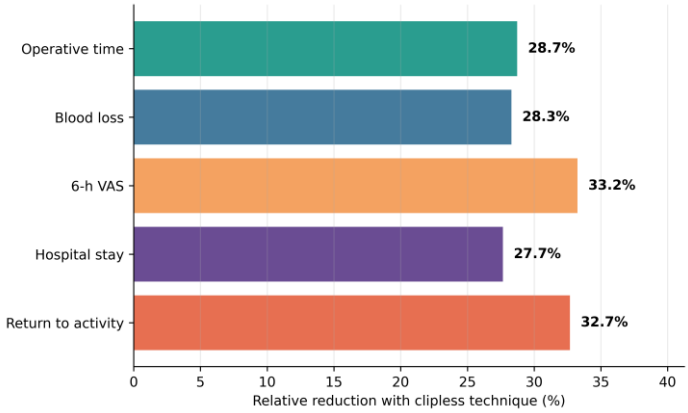

Figure 3. Relative Reduction in Key Outcomes with the Clipless Technique

Horizontal bars represent percentage reduction in clipless values compared with conventional values.

Postoperative Pain, Recovery, and Complications

The 6-hour postoperative pain score was lower in the clipless group (3.21 ± 0.61) than in the

conventional group (4.81 ± 0.61; p<0.001). Hospital stay and time to return to normal activity were also shorter in the clipless group (Table 3 and Figure 4).

Table 3. Postoperative Recovery and Complication Profile

Outcome	Clipless (n=40)	Conventional (n=40)	p-value
Pain VAS at 6 h	3.21 ± 0.61	4.81 ± 0.61	<0.001
Hospital stay (days)	1.92 ± 0.46	2.66 ± 0.44	<0.001
Return to normal activity (days)	7.78 ± 2.25	11.55 ± 2.26	<0.001
Any postoperative complication	6 (15.0)	9 (22.5)	0.568
Clavien-Dindo grade 0	34 (85.0)	31 (77.5)	0.677
Clavien-Dindo grade I	3 (7.5)	5 (12.5)	
Clavien-Dindo grade II	3 (7.5)	4 (10.0)	
30-day readmission	1 (2.5)	1 (2.5)	1.000

VAS: visual analogue scale. Values are mean ± SD or n (%).

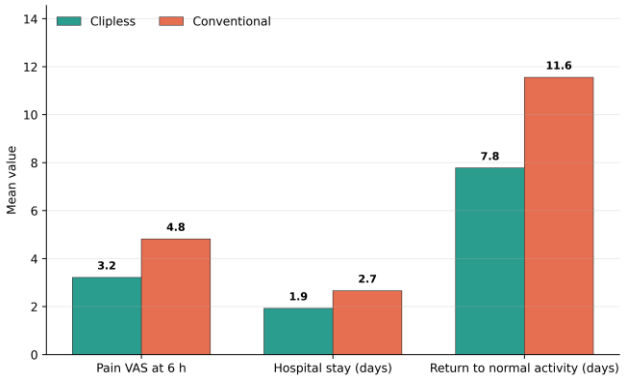

Figure 4. Early Postoperative Recovery Profile

Grouped bars show mean pain score, hospital stay, and return-to-activity time by operative technique.

Postoperative complication rates were numerically lower after clipless surgery but without statistical significance (6/40, 15.0% vs 9/40, 22.5%; p=0.568). All complications were Clavien-Dindo grade I or II. Readmission within 30 days occurred in one patient in each group (2.5% each). The Clavien-Dindo distribution is shown in Figure 5.

Figure 5. Distribution of Postoperative Complications by Clavien-Dindo Grade.

Stacked bars display the number of patients in each grade; no grade III or higher complication was recorded.

Table 4. Effect Estimates for Key Continuous Outcomes.

Outcome	Mean difference*	95% CI	p-value

Operative time	-18.83 min	-21.62 to -16.03	<0.001
Blood loss	-9.17 mL	-14.29 to -4.06	<0.001
Pain VAS at 6 h	-1.60 score	-1.87 to -1.33	<0.001
Hospital stay	-0.74 days	-0.94 to -0.53	<0.001
Return to normal activity	-3.78 days	-4.78 to -2.77	<0.001

**Mean difference calculated as clipless minus conventional; negative values favour the clipless group.*

The largest absolute effect was observed for operative time, with the clipless technique reducing mean operative duration by 18.83 minutes (95% CI: -21.62 to -16.03). Recovery also showed clinically visible separation: return to normal activity was earlier by 3.78 days in the clipless group (95% CI: -4.78 to -2.77) (Table 4).

DISCUSSION

This prospective comparison found that clipless laparoscopic cholecystectomy was associated with shorter operative time, lower recorded blood loss, lower early pain score, shorter hospital stay, and earlier return to normal activity when compared with the conventional clip-based technique. Safety outcomes were reassuring: no bile duct injury or conversion to open surgery was recorded in either group, and postoperative complications were limited to Clavien-Dindo grade I or II events. The practical meaning is straightforward. In a setting where operating-room efficiency and early discharge both matter, clipless surgery appeared to reduce perioperative burden without introducing an observable safety penalty.

The shorter operative duration is biologically and technically plausible. A clipless approach can reduce instrument exchange, allow continuous dissection, and avoid repeated clip application in a confined Calot's triangle. Bessa et al. reported favourable safety and efficacy with ultrasonic clipless dissection [6]. Kandil et al. observed shorter operative duration and lower blood loss in a prospective comparison of clipless harmonic and conventional methods [7]. Gelmini et al. similarly described the harmonic scalpel as a safe and effective instrument that could provide hemobiliary stasis during laparoscopic cholecystectomy [12]. Our mean operative-time difference of nearly 19 minutes is directionally consistent with that body of work, although the precise magnitude may depend on device type, inflammation severity, and surgeon familiarity.

Blood loss was also lower in the clipless group. In laparoscopic cholecystectomy, much of the bleeding that prolongs surgery arises from the gallbladder bed or small cystic artery branches rather than from a single large vessel. Energy-assisted dissection may provide simultaneous division and coagulation, thereby keeping the field cleaner. This matters in teaching hospitals too, because a clearer field can improve anatomic recognition and shorten the time spent managing minor ooze. Vu and colleagues described the clipless technique using harmonic scalpel as feasible in selected patients [13]. Later outcome-focused reports also emphasized reduced tissue handling and satisfactory postoperative recovery [14].

The postoperative findings deserve attention. The clipless group had lower 6-hour VAS scores, shorter admission, and earlier return to normal activity. These differences may be partly mediated by reduced operative time, less tissue trauma, lower bleeding, and fewer local inflammatory sequelae. At the same time, postoperative pain after laparoscopic cholecystectomy is multifactorial: pneumoperitoneum, port-site discomfort, gallbladder bed irritation, bile spillage, and patient pain sensitivity all contribute. Therefore, the pain advantage should not be interpreted as a device effect alone. Still, the recovery pattern in the present cohort is coherent, with pain, hospital stay, and return-to-activity metrics all moving in the same direction.

The absence of bile duct injury and conversion in both groups is clinically important but must be interpreted carefully. Bile duct injury is uncommon; a study of 80 patients is not powered to prove equivalence for rare catastrophic events. Safe cholecystectomy principles remain non-negotiable, regardless of whether clips or a clipless device is used. The WSES bile duct injury guideline emphasizes timely recognition and structured management when injury occurs [3]. The critical view of safety, readiness to use bailout strategies, and a low threshold for senior assistance remain central to operative safety [4]. Multi-society guidance has also reinforced these principles in routine and difficult cholecystectomy [5]. Thus, clipless surgery should be viewed as an operative technique nested within safe

dissection discipline, not as a shortcut around it.

The complication profile was mild and statistically comparable. Conventional surgery had slightly more Clavien-Dindo grade I and II events, but the difference was not significant. This resembles the mixed literature: some studies favour clipless surgery for operative time or postoperative comfort, while others have found no meaningful difference in complications or pain. Rajnish et al., for example, reported no significant advantage of harmonic-assisted over conventional laparoscopic cholecystectomy for operating time, pain, or perioperative complications [10]. Jain et al. also studied clipless versus conventional cholecystectomy prospectively, contributing to the view that benefits may be context-dependent rather than universal [15].

From an Indian clinical standpoint, the choice between clipless and conventional surgery will also be shaped by cost, device availability, maintenance, case volume, and patient affordability. A shorter operation and quicker recovery may be attractive, but advanced energy devices carry acquisition and consumable costs. In high-volume centres, the economic balance may differ from smaller hospitals where conventional clip-based surgery remains efficient and affordable. The findings of this study therefore support feasibility and early outcome benefit, but they do not settle the cost-effectiveness question.

The study has limitations. It was not randomized, and allocation to operative technique may have been influenced by surgeon preference, perceived case difficulty, or device availability. The sample size was modest, particularly for uncommon outcomes such as bile duct injury, conversion, and readmission. The operative record did not specify the exact event underlying the single intra-operative complication in the conventional group. Long-term outcomes, delayed bile leak, retained stones, cost analysis, and patient-reported quality of life were not assessed.

Even with these limitations, the pattern is internally consistent. Clipless laparoscopic cholecystectomy showed measurable advantages in operative efficiency and early recovery, while major safety endpoints were preserved. Future studies should preferably use randomized allocation, standardized device description, cost accounting, and longer postoperative follow-up, especially in acute cholecystitis and high-BMI subgroups.

CONCLUSION

Clipless laparoscopic cholecystectomy was associated with significantly shorter operative time, lower intra-operative blood loss, less early postoperative pain, shorter hospital stay, and earlier return to normal activity compared with conventional clip-based laparoscopic cholecystectomy. No bile duct injury or conversion to open surgery occurred in either group, and complication rates were statistically comparable. Within the limits of a modest, non-randomized comparative study, the clipless technique appears safe and recovery-friendly in selected patients, provided that standard principles of safe cholecystectomy are meticulously followed.

Source of Funding

Nil.

Conflict of Interest

None declared.

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