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Original Research Article

Comparative Outcomes of Laparoscopic Clipless Cholecystectomy Using Harmonic Scalpel versus Conventional Technique with Liga Clips: A Clinical Study

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Abstract: *Gallstone disease is an increasingly prevalent global health issue. Laparoscopic cholecystectomy, a minimally invasive surgical approach, ensures smaller incisions and quicker recovery. The Harmonic scalpel offers a safe and efficient tool for dissection and haemostasis, but conflicting evidence regarding its efficacy exists in the literature.* ***Objective:*** *To compare intraoperative and postoperative outcomes of clipless laparoscopic cholecystectomy using the Harmonic scalpel versus conventional clip-based cholecystectomy for managing gallbladder stones.* ***Methods:*** *A randomized controlled trial was conducted at the Department of General Surgery, Nishtar Medical University/Hospital, Multan, over six months, from January 1, 2025, to June 30, 2025. A total of 120 patients were enrolled via non-probability consecutive sampling and randomly divided into two equal groups. Group A underwent clipless cholecystectomy with the Harmonic scalpel, while Group B underwent conventional clip-based cholecystectomy. Outcomes measured included operative time, gallbladder perforation, intraoperative blood loss, postoperative pain (Visual Analogue Scale), bile leakage, and wound infection. Follow-up assessments were conducted at 24 hours, 3 days, and 7 days postoperatively. Data were recorded on a standardized proforma and analyzed using SPSS 26.0.* ***Results:*** *Patients in the Harmonic scalpel group (Group A) had a mean age of 44.12±13.84 years, while the conventional group (Group B) had a mean age of 47.08±13.16 years. The Harmonic scalpel group demonstrated significantly shorter operative times (49.82±6.06 min vs. 55.43±9.39 min, p<0.001), reduced intraoperative blood loss (65.58±8.94 ml vs. 74.00±14.79 ml, p<0.001), and fewer complications, including gallbladder perforation (1.7% vs. 11.7%, p<0.05), postoperative pain (15% vs. 31.7%, p<0.05), bile leakage (8.3% vs. 21.7%, p<0.05), and wound infections (5.0% vs. 16.7%, p<0.05).* ***Conclusion:*** *The Harmonic scalpel demonstrates superior outcomes and fewer complications compared to conventional methods in laparoscopic cholecystectomy. Its adoption may enhance surgical practices and improve patient satisfaction.*

Keywords: Laparoscopic cholecystectomy, gallstone disease, Harmonic scalpel, conventional cholecystectomy, wound infection, bile leakage, operative time, blood loss.

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Introduction

Laparoscopic cholecystectomy has become the gold standard for the treatment of symptomatic cholelithiasis due to its associated benefits, including reduced postoperative pain, shorter hospital stays, and faster recovery compared to open surgery (1, 2). Traditionally, the technique involves ligating the cystic duct and artery with metal clips; however, recent advancements have introduced clipless alternatives, such as the harmonic scalpel. This technique is associated with concerns regarding bile leaks and clip migrations, which can lead to significant morbidity and prolonged hospitalizations (3, 4).

The harmonic scalpel, which uses high-frequency ultrasonic vibrations to cut and coagulate tissue, offers several potential advantages. It minimizes thermal damage to surrounding tissues, potentially enhancing recovery times and reducing postoperative complications (5, 6). A comparative analysis of laparoscopic cholecystectomy methods found that using the harmonic scalpel can lead to shorter operative times and fewer complications compared with traditional methods involving metal clips (1, 2). This attribute is particularly crucial in resource-limited settings, where efficient use of surgical time can significantly influence healthcare delivery and outcomes.

While the benefits of both techniques are supported in various studies, the debate on bile leak incidence remains contentious. Some studies suggest that clipless laparoscopic cholecystectomy reduces overall complications and hospital stays, while others express concerns regarding bile leakage associated with the absence of traditional clipping methods (3, 4). A systematic review indicated that harmonic dissection with a harmonic scalpel could mitigate the risks associated with cystic duct closure, thus presenting a safer alternative (5, 6).

In Pakistan, where the prevalence of gallstones is notably high due to dietary factors and metabolic-related comorbidities, optimizing surgical techniques is crucial. The introduction of advanced surgical methods, such as clipless cholecystectomy using harmonic scalpels, may directly impact patient outcomes, especially in urban healthcare facilities where laparoscopic techniques are becoming increasingly prevalent (1, 7). The efficiency and safety of these techniques could alleviate healthcare burdens by reducing postoperative complications and hospitalization time, which are critical in a developing country context that often grapples with limited resources and high patient load.

Thus, while both conventional and clipless cholecystectomy techniques have their merits, the harmonic scalpel method presents a compelling alternative that warrants further exploration in terms of clinical outcomes and long-term patient safety. Emphasizing this technique within the Pakistani population may improve patient satisfaction and outcomes while optimizing surgical workflows in a high-demand surgical environment.

Methodology

This randomized controlled trial was conducted in Unit II, Department of General Surgery, Nishtar Medical University/Hospital, Multan, from January 1, 2025, to June 30, 2025. A total of 120 patients with gallbladder

stones were included, with 60 patients randomly assigned to two groups. The sample size was calculated using the two-proportion z-test formula, considering 80% study power, a 5% significance level, and postoperative pain rates of 37.5% with the harmonic scalpel and 60% with conventional clip cholecystectomy. Patients were selected using non-probability consecutive sampling.

Patients aged 16–70 years of either gender with gallbladder stones (cholelithiasis) were included. Exclusion criteria included uncontrolled diabetes, chronic renal failure, bleeding disorders, liver disease, previous upper abdominal surgery, stones in the cystic or common bile duct, or conversion to open surgery. Eligible patients were recruited after obtaining informed consent. Demographics, including age, gender, BMI, ASA status, and gallstone duration, were recorded. Patients were randomly assigned to two groups using a lottery method.

In Group A, clipless laparoscopic cholecystectomy using the harmonic scalpel was performed. Pneumoperitoneum was created with a Verres needle, and a 30° laparoscope was introduced. The gallbladder was retracted, adhesions cleared, and Calot's triangle dissected using harmonic scalpel shears. The cystic duct and artery were sealed and divided at power level "2" to ensure no microcalculi or bile leakage, and the gallbladder was extracted.

In Group B, a conventional laparoscopic cholecystectomy was performed. Calot's triangle was dissected, the cystic duct and artery were clipped with reusable metal clips, and the gallbladder was separated using electrocautery. A drain was placed in the abdomen.

Operative outcomes, including operative time, blood loss, gallbladder perforation, postoperative pain (VAS >4), bile leakage, and wound infections, were recorded. Postoperatively, patients were monitored in the surgical ward and discharged after recovery. All data were documented in a structured proforma.

Data analysis was performed using SPSS version 26.0. Quantitative variables (e.g., age, BMI, operative time, blood loss) were presented as mean ± standard deviation, and qualitative variables (e.g., gender, ASA status, gallbladder perforation, pain, wound infection, bile leakage) as frequencies and percentages. An independent samples t-test was used for continuous variables, and a chi-square test for categorical variables, with $p<0.05$ considered significant. Data were stratified by age, gender, BMI, ASA status, and gallstone duration, with post-stratification tests applied to assess group differences.

Results

The study compared the outcomes of laparoscopic cholecystectomy using the Harmonic scalpel versus the conventional clip-based method. In the harmonic scalpel group, the mean age of patients was 44.12±13.84 years, compared to 47.08±13.16 years in the traditional group. There were more females in the harmonic group (68.3%) than in the conventional group (55.0%). The mean BMI was higher in the harmonic group (34.93±4.12 kg/m²) than in the traditional group (32.59±5.16 kg/m²). ASA I patients were more frequent in the conventional group (66.7%) compared to the harmonic group (48.3%). The mean duration of gallstones was slightly shorter in the harmonic group (2.78±1.38 years) compared to the conventional group (3.07±1.37 years), as shown in Table NO.1.

The results demonstrated significant advantages of the Harmonic scalpel across multiple parameters. Operative time was significantly shorter with the Harmonic scalpel (49.82±6.06 min) compared to the conventional method (55.43±9.39 min; $p<0.001$), with notable reductions in obese patients and those classified as ASA I or II. Blood loss was also significantly less in the Harmonic group (65.58±8.94 ml vs. 74.00±14.79 ml; $p<0.001$), particularly in younger and obese patients. Gallbladder perforation rates were lower in the Harmonic group (1.7%) than in the conventional group (11.7%; $p < 0.05$), with significant reductions observed in patients aged 36–55 years. Postoperative pain scores were markedly lower in the Harmonic group (2.17±2.04 vs. 2.98±2.40; $p<0.05$), with fewer patients reporting moderate-to-severe pain (15% vs. 31.7%; $p<0.05$). Similarly, bile leakage was significantly less frequent with the Harmonic scalpel (8.3%) compared to the conventional technique (21.7%; $p<0.05$). Wound infection rates showed a remarkable improvement, with no cases reported in the Harmonic group compared with 8.3% in the conventional group ($p < 0.05$). Stratification by gallstone disease duration revealed that patients with disease duration ≥3 years had significantly lower wound infection rates with the Harmonic scalpel (3.3% vs. 20.0%; $p<0.05$). Additionally, stratification by BMI showed the Harmonic scalpel provided superior outcomes in terms of operative time and blood loss, especially in obese and morbidly obese patients. All these results are shown in Table NO.2

Overall, the Harmonic scalpel consistently outperformed the conventional method, demonstrating superior intraoperative and postoperative outcomes. It reduced operative time, blood loss, gallbladder perforation, postoperative pain, bile leakage, and wound infection rates across diverse patient groups. These findings highlight the Harmonic scalpel as a safer, more efficient, and patient-friendly alternative for laparoscopic cholecystectomy, with significant implications for improving surgical practices and outcomes in clinical settings.

Table 1: Descriptive Statistics and Group Comparisons

Parameter	Group	Harmonic Scalpel	Conventional Method	Total
Age (years)	N	60	60	120
	Mean	44.12	47.08	-
	Standard Deviation	13.84	13.16	-
	Minimum	26	25	-
	Maximum	69	70	-
Gender	Male (n, %)	19 (31.7%)	27 (45.0%)	46 (38.3%)
	Female (n, %)	41 (68.3%)	33 (55.0%)	74 (61.7%)
	Total	60 (100%)	60 (100%)	120 (100%)
BMI (kg/m²)	N	60	60	-
	Mean	34.93	32.59	-
	Standard Deviation	4.12	5.16	-
	Minimum	25.98	25.92	-
	Maximum	40.71	40.92	-
ASA Status	I (n, %)	29 (48.3%)	40 (66.7%)	69 (57.5%)
	II (n, %)	31 (51.7%)	20 (33.3%)	51 (42.5%)
	Total	60 (100%)	60 (100%)	120 (100%)
Duration of Gallstones (years)	N	60	60	-

	Mean	2.78	3.07	-
	Standard Deviation	1.38	1.37	-
	Minimum	1	1	-
	Maximum	5	5	-

Table 2: Comparison of Outcomes Between Harmonic Scalpel and Conventional Methods

Parameter	Group	Harmonic Scalpel	Conventional Method	P-Value
Operative Time (min)	N	60	60	
	Mean ± SD	49.82 ± 6.06	55.43 ± 9.39	0.000
	Range	40 – 60	40 - 70	
Intraoperative Blood Loss (ml)	N	60	60	
	Mean ± SD	65.58 ± 8.94	74.00 ± 14.79	0.000
	Range	50 – 79	50 - 100	
Gallbladder Perforation	Yes (%)	1 (1.7%)	7 (11.7%)	0.028
	No (%)	59 (98.3%)	53 (88.3%)	
Pain Score	Mean ± SD	2.17 ± 2.04	2.98 ± 2.40	0.047
	Pain >4 (Yes %)	9 (15.0%)	19 (31.7%)	0.031
	Pain ≤4 (No %)	51 (85.0%)	41 (68.3%)	
Bile Leakage	Yes (%)	5 (8.3%)	13 (21.7%)	0.041
	No (%)	55 (91.7%)	47 (78.3%)	
Wound Infection	Yes (%)	0 (0.0%)	5 (8.3%)	0.033
	No (%)	60 (100%)	55 (91.7%)	
Operative Time by Age Strata (min)	16-35: Mean ± SD	47.45 ± 5.75	59.07 ± 7.45	0.000
	36-55: Mean ± SD	52.59 ± 4.71	55.83 ± 9.43	0.153
	56-70: Mean ± SD	49.25 ± 6.88	52.68 ± 9.97	0.244
Blood Loss by Age Strata (ml)	16-35: Mean ± SD	64.91 ± 8.52	78.57 ± 14.56	0.001
	36-55: Mean ± SD	64.91 ± 8.59	73.13 ± 15.80	0.036
	56-70: Mean ± SD	67.44 ± 10.20	72.05 ± 13.82	0.267

Discussion

The present study aimed to compare the outcomes of laparoscopic cholecystectomy using the Harmonic scalpel with those of the conventional method using Liga clips. The results of our research, encompassing various surgical parameters, provide insights into the effectiveness and safety profiles of these techniques.

The mean age of patients in the Harmonic group was 44.12 ± 13.84 years, while the conventional group had a mean age of 47.08 ± 13.16 years. This finding is supported by Kousar et al., who reported similar demographics in their patient cohort undergoing laparoscopic cholecystectomy (8). The gender distribution also leaned toward females in the Harmonic group (68.3%) compared to the conventional group (55.0%), which aligns with the literature indicating a higher prevalence of gallbladder disease in females due to hormonal influences (9). The body mass index (BMI) was notably higher in the Harmonic group (34.93 ± 4.12 kg/m²) than in the conventional group (32.59 ± 5.16 kg/m²), corroborating findings from Ahmed et al. that higher BMI is associated with increased operative risks and complications (10).

One of the significant parameters evaluated was the operative time. Our findings indicated that operative time was shorter in the Harmonic group (49.82 ± 6.06 min) than in the conventional method group (55.43 ± 9.39 min; $p < 0.001$). This result is consistent with previous studies by Ahmed et al., which demonstrated that the Harmonic scalpel technique significantly reduced operative time through more efficient tissue dissection and coagulation (10). Moreover, our study suggests that the reduction in operative time is particularly notable for obese patients and those classified as ASA I and II, findings supported by Kousar et al., who advocated the efficiency of laparoscopic procedures in these cohorts (8).

Another critical outcome measure was intraoperative blood loss, which was significantly lower in the Harmonic group (65.58 ± 8.94 ml) compared to the conventional group (74.00 ± 14.79 ml; $p < 0.001$). This aligns with studies by Manan et al., who reported lower blood loss with the Harmonic scalpel due to enhanced vessel sealing (10). The significant reduction in gallbladder perforation rates in our study (1.7% in the Harmonic group versus 11.7% in the conventional group; $p < 0.05$) further reinforces these findings, as documented by Ahmed et al., who found that the Harmonic scalpel contributes to better control during dissection (9). Similarly, our results on postoperative pain scores indicated that the Harmonic scalpel group experienced less pain (mean 2.17 ± 2.04) compared to the conventional technique (mean 2.98 ± 2.40; $p < 0.05$), aligning with findings from Roy and Sheikh, who noted improved pain management associated with the Harmonic scalpel due to reduced tissue trauma (11).

Furthermore, the incidence of bile leakage was significantly lower in the Harmonic group (8.3% versus 21.7% in the conventional group; $p < 0.05$). This finding is particularly noteworthy as bile leaks are one of the most concerning complications of laparoscopic cholecystectomy. Similar findings were reported by Pereira et al., highlighting that the use of the Harmonic scalpel resulted in lower rates of bile leakage due to enhanced ability to create secure surgical closures (12). Wound infection rates also showed a significant advantage for the Harmonic scalpel, with no reported cases in this group compared to 8.3% in the conventional method ($p < 0.05$), reinforcing the safety margins associated with the Harmonic technique, as indicated in studies by Burki et al., who observed reduced infection rates with advanced surgical techniques (13).

Thus, our findings demonstrate that the Harmonic scalpel significantly improves intraoperative and postoperative outcomes during laparoscopic cholecystectomy compared with the conventional LigaClip method. These findings suggest a shift towards adopting the Harmonic scalpel in surgical practice, particularly in contexts characterized by high patient loads, such as in Pakistan, where optimizing surgical efficiency and reducing complications are crucial (14). By employing innovative methodologies such as the Harmonic scalpel, healthcare providers can

potentially improve patient outcomes and streamline surgical workflows in resource-limited settings.

Conclusion

The harmonic scalpel has proven to be a safer and more effective tool for laparoscopic cholecystectomy compared to conventional methods. It significantly reduces operative time, blood loss, and postoperative complications, including pain, bile leakage, and wound infections. These findings support its adoption as the preferred technique in local surgical practices to enhance patient outcomes. Training and accessibility efforts should focus on their broader implementation. This transition will elevate the standard of care and improve surgical outcomes.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)
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Conflict of interest

The authors declared no conflict of interest.

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the study's integrity.

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