Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v6i9.2266
*Biol. Clin. Sci. Res. J., Volume 6(9), **2025**: 2266*
Original Research Article

A Comparative Study of the Results Between Choledocholithotomy and ERCP-Assisted Stone Extraction in the Treatment of Choledocholithiasis

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(Received, 8th August 2025, Accepted 28th September 2025, Published 30th September 2025)

Abstract: *Choledocholithiasis is a common and clinically significant complication of gallstone disease that may lead to obstructive jaundice, cholangitis, pancreatitis, and other serious biliary complications. Although endoscopic retrograde cholangiopancreatography (ERCP) is widely regarded as the preferred first-line treatment in many settings, open choledocholithotomy remains a commonly performed procedure in resource-limited settings. Comparative local data from Pakistan remains limited.* ***Objective:*** *To compare the outcomes of choledocholithotomy and ERCP-assisted stone extraction in the treatment of choledocholithiasis.* ***Methods:*** *This prospective cohort study was conducted in the Department of General Surgery, Nishtar Medical University and Hospital, Multan, Pakistan, from 20 March 2025 to 20 July 2025. A total of 60 patients with choledocholithiasis were enrolled using non-probability, consecutive sampling and allocated to two groups: ERCP-assisted stone extraction (n=30) and choledocholithotomy (n=30). Patients aged 18–60 years of either sex with imaging-confirmed choledocholithiasis were included. Primary and secondary outcomes included stone clearance, operative time, hospital stay, postoperative pain, bile leak, surgical site infection, raised bilirubin, and overall postoperative morbidity. Data were analyzed using SPSS version 29. Continuous variables were compared using the independent-samples t-test, while categorical variables were compared using the chi-square test or Fisher's exact test. A p-value ≤0.05 was considered statistically significant.* ***Results:*** *The overall mean age was 41.87 ± 10.94 years, and 58.3% of participants were male. ERCP was associated with significantly shorter operative time (46.80 ± 12.44 vs 92.57 ± 18.63 minutes, p<0.001), shorter hospital stay (2.87 ± 1.11 vs 6.73 ± 1.86 days, p<0.001), and lower pain scores on postoperative day 4 (2.13 ± 0.86 vs 4.77 ± 1.25, p<0.001) and day 8 (0.73 ± 0.52 vs 1.93 ± 0.83, p<0.001). Stone clearance was comparable between the ERCP and choledocholithotomy groups (90.0% vs 96.7%, p=0.301). Surgical site infection occurred only in the choledocholithotomy group (13.3%, p=0.038). Overall postoperative morbidity was significantly lower in the ERCP group than in the choledocholithotomy group (13.3% vs 43.3%, p=0.010).* ***Conclusion:*** *ERCP-assisted stone extraction achieved stone clearance comparable to choledocholithotomy while offering significantly shorter operative time, reduced hospital stay, less postoperative pain, and lower overall morbidity. Where expertise and facilities are available, ERCP may be considered the preferred treatment option for choledocholithiasis.*

Keywords: Choledocholithiasis; Cholangiopancreatography, Endoscopic Retrograde; Common Bile Duct Calculi; Stone Extraction; Cholecystectomy; Postoperative Complications

[***How to Cite:*** Anjum Z, Hassan U, Khan MMURH. A comparative study of the results between choledocholithotomy and ercp assisted stone extraction in the treatment of choledocholithiasis. *Biol. Clin. Sci. Res. J.*, **2025;** 6(9): 90-94. doi: https://doi.org/10.54112/bcsrj.v6i9.2266

Introduction

Choledocholithiasis, defined as the presence of calculi within the common bile duct (CBD), represents one of the most clinically significant complications of gallstone disease. Gallstones affect an estimated 10–20% of the adult population worldwide, with choledocholithiasis complicating approximately 10–20% of these cases (1). The condition may arise as primary stones formed de novo within the biliary system or as secondary stones that migrate from the gallbladder. Its clinical presentation ranges from asymptomatic incidental findings to life-threatening biliary sepsis, obstructive jaundice, and acute biliary pancreatitis, rendering timely and effective management imperative (2).

The therapeutic approach to choledocholithiasis has undergone a substantial transformation over recent decades. Historically, open surgical choledocholithotomy involving incision of the CBD with stone extraction and T-tube drainage constituted the definitive standard of care. While effective in achieving ductal clearance, this approach carries considerable perioperative morbidity, including prolonged operative duration, extended inpatient stay, wound-related complications, and significant postoperative pain (3). The imperative to reduce this burden has driven the evolution of minimally invasive strategies for CBD stone management (4).

Endoscopic retrograde cholangiopancreatography (ERCP) with endoscopic sphincterotomy and stone extraction has emerged as the preferred first-line treatment modality for choledocholithiasis in most international guidelines, including those issued by the American Society for Gastrointestinal Endoscopy (ASGE) and the European Society of Gastrointestinal Endoscopy (ESGE) (3,4). ERCP offers the dual advantage of diagnostic visualisation and therapeutic stone removal without the need for general anaesthesia or an abdominal incision. Contemporary series report CBD stone clearance rates of 85–95% for ERCP, with an overall adverse event rate of approximately 5–10% (5). The principal ERCP-related complications include post-procedure pancreatitis, bleeding, cholangitis, and perforation, each of which is generally manageable with conservative or endoscopic measures (6).

Surgical choledocholithotomy, whether performed as an open or laparoscopic procedure, remains a valid and frequently utilised option, particularly in settings where ERCP expertise is unavailable, in cases of failed or contraindicated endoscopic clearance, or when concomitant surgical pathology necessitates operative intervention (7). Laparoscopic common bile duct exploration has been shown to achieve stone clearance rates comparable to ERCP, with the advantage of single-stage management when combined with laparoscopic cholecystectomy (8). However, open choledocholithotomy, which remains the predominant approach in many resource-limited settings, is associated with a substantially higher morbidity profile compared with endoscopic management (5). Several meta-analyses and randomised controlled trials have directly compared endoscopic and surgical strategies for CBD stone

clearance. A meta-analysis by Lyu et al. (9) demonstrated that laparoscopic CBD exploration achieved stone clearance rates comparable to those of ERCP-based approaches, whilst a subsequent meta-analysis by Lei et al. (10) similarly reported no significant difference in overall clearance but identified advantages of the endoscopic approach in terms of hospital stay and complication rate. The ESGE guideline on ERCP-related adverse events by Dumonceau et al. (6) provides a comprehensive framework for understanding the complication profile of endoscopic interventions, which is essential for contextualising safety data in comparative studies. The optimal therapeutic strategy must therefore be individualised, taking into account stone burden, patient comorbidities, institutional infrastructure, and operator competence (3,4).

In the Pakistani healthcare context, choledocholithiasis constitutes a considerable proportion of biliary surgical admissions. However, access to ERCP services remains largely confined to major tertiary care centres in urban areas such as Lahore, Karachi, and Islamabad, with district-level and secondary hospitals continuing to rely predominantly on open surgical choledocholithotomy for the management of CBD stones. This disparity in access to advanced endoscopic facilities translates into a significant burden of surgical morbidity that may be preventable with wider availability of endoscopic expertise. Despite this, there exists a critical paucity of locally generated evidence comparing these two approaches within the Pakistani population. The present study was therefore designed to compare the perioperative and postoperative outcomes of ERCP-assisted stone extraction and open choledocholithotomy in patients with choledocholithiasis presenting to a tertiary care hospital in Pakistan, to generate locally relevant data to inform clinical and policy decisions regarding the management of this common biliary condition.

Methodology

This prospective cohort study was conducted in the Department of General Surgery at Nishtar Medical University and Hospital, Multan, Pakistan, over six months from 20 March 2025 to 20 July 2025. The study was designed to compare the outcomes of choledocholithotomy and endoscopic retrograde cholangiopancreatography (ERCP)-assisted stone extraction in the treatment of choledocholithiasis. A non-probability consecutive sampling technique was used, and all eligible patients presenting during the study period were considered for enrollment. According to the detailed sampling and data-collection plan provided in the synopsis, a total of 60 patients were included, with 30 patients in each group. The sample size was calculated using the WHO sample size calculator for a two-group comparison with 95% confidence, 80% power, and a 5% significance level, based on previously reported complication rates in the ERCP and choledocholithotomy groups.

Patients of either sex, aged 18 to 60 years, with a diagnosis of choledocholithiasis for the preceding six months as suggested by ultrasonography or magnetic resonance cholangiopancreatography, and who were willing to provide informed consent, were included in the study. Patients were excluded if they had clinical or sonographic evidence of suppurative or necrotizing cholecystitis, gallbladder empyema, or perforation on ultrasonography or computed tomography. Patients with clinical, radiological, or biochemical evidence of cirrhosis, portal vein thrombosis, intrahepatic gallbladder, liver mass, liver abscess, or periampullary neoplasm were also excluded. Pregnant women were not included in the study. Written informed consent was obtained from all participants before enrollment.

After recruitment, baseline demographic and clinical information, including age and gender, was recorded on a structured proforma. The enrolled patients were allocated into two groups according to stone characteristics and planned treatment modality, as described in the synopsis. Patients with stones measuring less than 12 mm and located in the lower end of the common bile duct were managed with ERCP-assisted stone extraction and were assigned to Group I. Patients with stones larger than 12 mm and situated in the upper end of the common bile duct underwent open common bile duct exploration with choledocholithotomy and were assigned to Group II. During ERCP, an endoscopic balloon was used for extraction of small stones and sludge. For larger stones, lithotripsy followed by removal of fragments and endoscopic stenting was performed where required. In the open choledocholithotomy group, standard surgical exploration of the common bile duct was carried out, followed by placement of a T-tube according to routine surgical practice. The primary and secondary outcome variables were assessed according to the operational definitions provided in the synopsis. Choledocholithiasis was defined as the presence of one or more calculi within the common bile duct causing biliary obstruction for more than one month, confirmed on ultrasonography, MRCP, or ERCP, in the presence of associated symptoms such as jaundice, right upper quadrant pain, or other signs of biliary obstruction, along with raised serum bilirubin. Stone clearance was defined as the complete removal of all identified stones from the common bile duct. In the ERCP group, stone clearance was confirmed intraoperatively, whereas in the choledocholithotomy group, it was confirmed by T-tube cholangiography on the 14th postoperative day. Operative time was measured in minutes from the insertion of the endoscope or the first surgical incision to the completion of the procedure. Hospital stay was calculated in days from admission to discharge. Postoperative abdominal pain was assessed using the Visual Analog Scale on the 4th and 8th postoperative days. Bile leak was considered present within the first four postoperative weeks if bile was detected in the drainage fluid, if imaging demonstrated bile collection or fistula formation, or if clinical or biochemical evidence suggested biliary leakage. Surgical site infection was recorded if, within four weeks after the procedure, the patient developed a fever of more than 100°F for more than 3 days or local signs of infection, such as redness, warmth, swelling, or discharge at the surgical site. Raised bilirubin was defined as a serum bilirubin level above the normal reference range, typically greater than 1.2 mg/dL, occurring within two days to four weeks after the procedure.

All study-related information was documented prospectively on a predesigned proforma. In patients undergoing choledocholithotomy, the T-tube was clamped for two days, followed by an additional 24-hour clamping period. If the patient remained clinically stable without abdominal pain, bile leakage, fever, or jaundice, the T-tube was subsequently removed. Patients in both groups were followed to assess postoperative outcomes and complications during the defined observation period. Every effort was made to ensure uniform data collection and outcome assessment in both groups to minimize information bias.

The collected data were entered and analyzed using SPSS version 29. The normality of continuous variables was assessed by Shapiro-Wilk or Kolmogorov-Smirnov tests. Qualitative variables such as gender, treatment group, stone clearance, bile leak, surgical site infection, and raised bilirubin were presented as frequencies and percentages. Quantitative variables such as age, operative time, hospital stay, and pain scores were summarized as mean and standard deviation. Categorical variables between the two groups were compared using the chi-square test or Fisher's exact test where appropriate. Continuous variables were compared using the independent-samples t-test. Stratification by age and gender was planned to control for potential confounding, and post-stratification comparisons were performed accordingly. A p-value of 0.05 or less was considered statistically significant.

Results

A total of 60 patients with choledocholithiasis were included in the study, with 30 patients in the ERCP-assisted stone extraction group and 30 patients in the choledocholithotomy group. The overall mean age of the study population was 41.87 ± 10.94 years. There were 35 males (58.3%) and 25 females (41.7%). The mean age was 41.13 ± 10.61 years in the ERCP group and 42.60 ± 11.39 years in the choledocholithotomy group, showing comparable baseline distribution. Male patients were slightly more common in both groups. (Table 1)

Table 1. Demographic characteristics of the study population (n = 60)

Variable	ERCP group (n=30)	Choledocholithotomy group (n=30)	Total (n=60)	p-value
Age, mean ± SD (years)	41.13 ± 10.61	42.60 ± 11.39	41.87 ± 10.94	0.607
Age group 18–30 years	8 (26.7%)	7 (23.3%)	15 (25.0%)	0.913
Age group 31–45 years	11 (36.7%)	12 (40.0%)	23 (38.3%)	
Age group 46–60 years	11 (36.7%)	11 (36.7%)	22 (36.7%)	
Male	18 (60.0%)	17 (56.7%)	35 (58.3%)	0.793
Female	12 (40.0%)	13 (43.3%)	25 (41.7%)	

Regarding operative outcomes, ERCP-assisted stone extraction was associated with a markedly shorter mean operative time than choledocholithotomy (46.80 ± 12.44 vs 92.57 ± 18.63 minutes, $p < 0.001$). Similarly, the mean hospital stay was significantly shorter in the ERCP group compared with the choledocholithotomy group (2.87 ± 1.11 vs 6.73 ± 1.86 days, $p < 0.001$). Postoperative pain scores were also lower in the ERCP group on days 4 and 8, with statistically significant differences between groups. (Table 2)

Table 2. Comparison of continuous perioperative and postoperative outcomes

Outcome	ERCP group (n=30)	Choledocholithotomy group (n=30)	p-value
Operative time (minutes), mean ± SD	46.80 ± 12.44	92.57 ± 18.63	<0.001
Hospital stay (days), mean ± SD	2.87 ± 1.11	6.73 ± 1.86	<0.001
VAS pain score on day 4, mean ± SD	2.13 ± 0.86	4.77 ± 1.25	<0.001
VAS pain score on day 8, mean ± SD	0.73 ± 0.52	1.93 ± 0.83	<0.001

Stone clearance was achieved in 27 patients (90.0%) in the ERCP group and in 29 patients (96.7%) in the choledocholithotomy group. Although the choledocholithotomy group showed a slightly higher clearance rate, the difference was not statistically significant. In contrast, postoperative complications were more frequent in the choledocholithotomy group. Bile leak was observed in 1 patient (3.3%) in the ERCP group and 5 patients (16.7%) in the choledocholithotomy group. Surgical site infection occurred only in the choledocholithotomy group, affecting 4 patients (13.3%), while none of the ERCP patients developed surgical site infection. Raised bilirubin after the procedure was noted in 3 patients (10.0%) in the ERCP group and 8 patients (26.7%) in the choledocholithotomy group. (Table 3)

Table 3. Comparison of stone clearance and postoperative complications

Outcome	ERCP group (n=30)	Choledocholithotomy group (n=30)	p-value
Stone clearance achieved	27 (90.0%)	29 (96.7%)	0.301
Stone clearance not achieved	3 (10.0%)	1 (3.3%)	
Bile leak	1 (3.3%)	5 (16.7%)	0.085
Surgical site infection	0 (0.0%)	4 (13.3%)	0.038
Raised bilirubin	3 (10.0%)	8 (26.7%)	0.095

When overall postoperative morbidity was assessed, at least one complication occurred in 4 patients (13.3%) in the ERCP group compared with 13 patients (43.3%) in the choledocholithotomy group, demonstrating a significantly lower complication burden in patients managed endoscopically. (Table 4)

Table 4. Overall postoperative morbidity between groups

Overall complication status	ERCP group (n=30)	Choledocholithotomy group (n=30)	p-value
At least one complication is present	4 (13.3%)	13 (43.3%)	0.010
No complication	26 (86.7%)	17 (56.7%)	

Post-stratification analysis showed that the advantage of ERCP-assisted stone extraction, in terms of a shorter hospital stay and lower postoperative pain, remained consistent across younger and older patients. Likewise, overall complication rates remained lower in the ERCP group in both males and females, suggesting that the observed treatment effect was not explained solely by age or gender differences. (Table 5)

Table 5. Stratification of overall complications by age group and gender

Stratification variable	ERCP group with complication	Choledocholithotomy group with complication	p-value
Age 18–40 years (n=27)	2/14 (14.3%)	5/13 (38.5%)	0.156
Age 41–60 years (n=33)	2/16 (12.5%)	8/17 (47.1%)	0.031
Male (n=35)	2/18 (11.1%)	7/17 (41.2%)	0.046
Female (n=25)	2/12 (16.7%)	6/13 (46.2%)	0.116

Discussion

This study compared the outcomes of ERCP-assisted stone extraction and open choledocholithotomy in 60 patients with choledocholithiasis. It demonstrated that ERCP was associated with significantly shorter operative time, reduced hospital stay, lower postoperative pain scores, and a substantially lower overall complication rate, whilst both procedures achieved comparable stone clearance rates. These findings are consistent with a growing body of international literature supporting ERCP as the preferred modality for CBD stone management in settings with endoscopic expertise.

The mean operative time was markedly shorter in the ERCP group compared with the choledocholithotomy group (46.80 ± 12.44 vs 92.57 ± 18.63 minutes, $p < 0.001$). This finding aligns with data reported by Vakayil et al. (11), who compared single-stage laparoscopic CBD exploration with intraoperative ERCP and found that endoscopic approaches consistently resulted in shorter total procedural times. Morton et al. (12) similarly demonstrated that endoscopic management of CBD stones required significantly less procedural time compared with laparoscopic common bile duct exploration, with direct implications for theatre efficiency and anaesthetic risk. The reduced operative time observed in the present study is particularly relevant in resource-constrained environments, such as Pakistani public-sector hospitals, where operative capacity is limited.

Hospital stay was significantly shorter in the ERCP group (2.87 ± 1.11 vs 6.73 ± 1.86 days, $p < 0.001$). This is consistent with the findings of Muhammedoğlu et al. (13), who reported in a randomised controlled trial that single-stage ERCP combined with laparoscopic cholecystectomy resulted in substantially reduced inpatient duration compared with staged surgical approaches. Lyu et al. (9) similarly documented that endoscopic stone extraction was associated with a shorter hospital stay than surgical CBD exploration in multiple randomised controlled trials, as reported in their meta-analysis. A reduction in hospitalisation of approximately four days, as observed in our study, carries significant implications for bed occupancy, healthcare costs, and patient productivity, which are particularly important in a healthcare system with finite resources.

Postoperative pain was significantly lower in the ERCP group on both day 4 (VAS 2.13 ± 0.86 vs 4.77 ± 1.25, $p < 0.001$) and day 8 (VAS 0.73 ± 0.52 vs 1.93 ± 0.83, $p < 0.001$). Shen et al. (14) reported analogous findings in a study evaluating concurrent ERCP and laparoscopic cholecystectomy versus open surgical approaches, noting that avoidance of laparotomy was the primary driver of improved pain profiles in endoscopically managed patients. The absence of an abdominal incision in ERCP directly accounts for the attenuated pain trajectory observed in the current study, contributing to faster functional recovery and earlier return to normal activity.

Stone clearance was achieved in 27 patients (90.0%) in the ERCP group and 29 patients (96.7%) in the choledocholithotomy group, with no statistically significant difference between groups ($p = 0.301$). These clearance rates are consistent with those reported in large comparative series. Liu et al. (15) reported an overall stone clearance rate of 88–94% for endoscopic approaches in their retrospective cohort of patients with combined cholelithiasis and choledocholithiasis, whilst Zhu et al. (8) demonstrated comparable clearance between laparoscopic CBD exploration and ERCP in a meta-analysis of randomised trials. The marginally higher clearance rate in the surgical group in the present study is consistent with the established principle that open choledocholithotomy affords direct intraductal access and tactile stone extraction, which may be advantageous for impacted or multiple stones. Adjunctive techniques such as mechanical or electrohydraulic lithotripsy during ERCP may further close this gap in future practice (6).

Postoperative complications were significantly more frequent in the choledocholithotomy group. Overall morbidity was recorded in 43.3% of surgical patients compared with 13.3% of ERCP patients ($p = 0.010$). Bile leak occurred in 16.7% of the surgical group versus 3.3% of the ERCP group; surgical site infection occurred exclusively in the choledocholithotomy group (13.3%); and elevated postoperative bilirubin was more prevalent after surgery (26.7% vs 10.0%). These findings are consistent with those reported by Wang et al. (16), who documented a significantly higher rate of postoperative biliary complications following open choledochotomy with primary closure compared with endoscopic management in patients with acute cholangitis. Jiang et al. (17) similarly demonstrated that bile leak and wound infection were substantially more frequent after open surgical CBD exploration than after laparoscopic or endoscopic procedures. The threefold higher overall complication burden in the surgical group underscores the perioperative safety advantage of ERCP-assisted stone extraction.

Stratified analysis by age and gender confirmed that the clinical benefits of ERCP were not confined to a specific subgroup. In patients aged 41–60 years, complication rates were 12.5% in the ERCP group versus 47.1% in the choledocholithotomy group ($p = 0.031$), and among male patients, the respective rates were 11.1% and 41.2% ($p = 0.046$). Wu et al. (18) reported comparable findings in a study specifically examining outcomes of laparoscopic CBD exploration versus ERCP followed by laparoscopic cholecystectomy in elderly patients, demonstrating that endoscopic approaches conferred consistent safety advantages across age strata. These stratified findings reinforce the generalisability of the observed treatment effect and suggest that ERCP should be considered the preferred approach across a broad patient demographic, where technically feasible.

The findings of this study are particularly relevant in the Pakistani setting, where open choledocholithotomy remains performed at high volume due to limited ERCP infrastructure outside major urban centres. The significantly lower complication rate, reduced operative time, and shorter hospitalisation associated with ERCP observed in this study provide compelling evidence base for investment in endoscopic training and infrastructure within the national healthcare system. These results align with the conclusions of the ASGE (3) and ESGE (4) guidelines, both of which advocate ERCP as the first-line approach for choledocholithiasis when endoscopic expertise is available. The study acknowledges limitations inherent to its sample size and single-centre design; however, the consistency of its findings with the international literature strengthens their validity and generalisability within comparable resource settings.

Conclusion

ERCP-assisted stone extraction was safer and less morbid than choledocholithotomy, while maintaining comparable ductal clearance, suggesting a clear clinical advantage in appropriately selected patients.

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-NHMU-03222-24)

Consent for publication
Approved

Funding
Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

ZA (PGR)
Manuscript drafting, Study Design,
UH (PGR)
Review of Literature, Data entry, Data analysis, and drafting articles.
MMURHK (Professor & HOD)
Conception of Study, Development of Research Methodology Design,

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

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