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Diagnostic Accuracy of MRCP for Detecting Choledocholithiasis in Patients with Obstructive Jaundice Keeping ERCP as Gold Standard

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ABSTRACT

Choledocholithiasis is a common cause of obstructive jaundice and may lead to serious complications if diagnosis or treatment is delayed. While ERCP is the gold standard for diagnosis and therapy, its invasive nature carries risks. MRCP offers a non-invasive alternative, but its accuracy may be influenced by clinical and technical factors. **Objectives:** To evaluate the diagnostic accuracy of MRCP in detecting choledocholithiasis using ERCP as the reference standard, and to assess the impact of stone size, location, number, and MRCP-ERCP interval. **Methods:** This analytical cross-sectional diagnostic accuracy study was conducted in the Department of Radiology, Bahawal Victoria Hospital, Bahawalpur (March 13, 2023, to March 12, 2024). A total of 271 patients with suspected choledocholithiasis underwent both MRCP and ERCP. Sensitivity, specificity, predictive values, overall accuracy, and Cohen's kappa were calculated with subgroup analyses by stone size, location, number, and MRCP–ERCP interval. **Results:** MRCP showed a sensitivity of 88.9% (95% CI: 83.5–92.7%), specificity of 67.0% (95% CI: 56.9–75.8%), PPV of 84.2% (95% CI: 78.4–88.7%), NPV of 75.3% (95% CI: 64.9–83.4%) and an overall accuracy of 81.5% (95% CI: 76.5–85.7%). Agreement with ERCP was moderate (Cohen's kappa = 0.55). Diagnostic performance was highest for stones measuring 5-10 mm, distally located stones, and when ERCP was performed within 3 days of MRCP. **Conclusions:** MRCP demonstrates good diagnostic accuracy and moderate agreement with ERCP, particularly for medium-sized distal stones and when ERCP is not delayed.

INTRODUCTION

Choledocholithiasis, or stones in the common bile duct, is a major cause of obstructive jaundice and may lead to ascending cholangitis, pancreatitis, or hepatic dysfunction if diagnosis is delayed [1]. Endoscopic Retrograde Cholangiopancreatography (ERCP) has long been the diagnostic and therapeutic gold standard, but its invasive nature carries risks such as pain, pancreatitis, bleeding, and perforation [2]. Magnetic Resonance Cholangiopancreatography (MRCP) provides detailed, non-invasive images of the biliary and pancreatic ducts without contrast or instrumentation and has emerged as a safe, robust tool for evaluating obstructive jaundice [3, 4]. Numerous studies report high diagnostic accuracy of MRCP for choledocholithiasis, with sensitivity and specificity frequently exceeding 90% [5–8]. Sherpa et al. noted an overall accuracy of 92.4% and identified choledocholithiasis as the most common benign cause of obstruction [6]. Isram et al. demonstrated sensitivity and specificity of 96.2% and 91.8%, supporting MRCP as a reliable prelude to therapeutic ERCP [9]. A 2025 tertiary-care study also reported sensitivity of 86.4% and specificity of 88% (AUC 0.864), reinforcing MRCP's role as a frontline modality [10]. Most prior studies assessed sensitivity and specificity in isolation, without considering clinical or technical factors that may influence MRCP performance. Our study addresses this gap by stratifying

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diagnostic accuracy by stone size, location, number, and MRCP–ERCP interval. Including one of the largest cohorts from a tertiary center in South Punjab, Pakistan, our work provides context-specific evidence on when MRCP is most reliable and where it may underperform, thereby enhancing its practical relevance for managing obstructive jaundice.

This study aims to evaluate the diagnostic accuracy of MRCP in detecting choledocholithiasis using ERCP as the reference standard, and to assess the impact of stone size, location, number, and MRCP–ERCP interval.

METHODS

This analytical cross-sectional study was carried out in the Department of Radiology, Bahawal Victoria Hospital, Bahawalpur, from 13 March 2023 to 12 March 2024. Ethical approval was obtained (IRB No. 2079/DME/QAMC Bahawalpur), and written informed consent was obtained from all participants. Sample size was estimated for a diagnostic accuracy study using Buderer's method [11], which incorporates sensitivity (Se), specificity (Sp), and disease prevalence (Prev). For Sensitivity, $N(Se)=Z^2 \times Se \times (1-Se)/d^2 \times Prev$. For specificity, $N(Sp)=Z^2 \times Sp \times (1-Sp)/d^2 \times Prev$. With Z=1.96 (95% confidence), d=0.05, Se=0.881, and Sp=0.944 from Kumar *et al.* [12], and Prev=0.70 (70% expected prevalence), the calculations yielded N (Se)=230 and N (Sp)=271; the larger (271) was adopted as the final sample size. This ensured >80% power to estimate sensitivity and specificity with 5% precision. The formula was taken from Buderer NM [11]. Adults (≥18 years) with clinical and biochemical evidence of obstructive jaundice (raised bilirubin, ALP, GGT) undergoing both MRCP and ERCP within seven days were included. Exclusion criteria were prior biliary surgery, known hepatobiliary malignancy, inconclusive ERCP, or incomplete records. Demographics, presenting symptoms (jaundice, abdominal pain, fever, vomiting), and laboratory parameters (total/direct bilirubin, ALT, AST, ALP, GGT, WBC) were recorded. All examinations were performed on a 1.5 T MRI scanner with a standard hepatobiliary protocol. Axial and coronal T2-weighted SSFSE and respiratory-triggered 3D MRCP sequences were acquired (slice thickness 5 mm axial/coronal, 1.5 mm 3D; TR 2000–2500 ms; TE 600–800 ms; FOV 32–36 cm; matrix 256×256). Breath-hold or respiratory-triggered techniques were applied as tolerated; maximum-intensity projections were generated for uniform image review. MRCP findings (presence of stones, size, location, number) were interpreted independently by two radiologists blinded to ERCP results; ERCP by expert endoscopists served as the gold standard. Stone size was measured as the maximum short-axis diameter of the largest stone; number classified as single (1) or multiple (≥2); location as common hepatic duct, proximal CBD, or distal CBD. In multiple segments, the largest stone determined the location. Discrepancies were resolved by consensus. Data were analyzed using SPSS 26.0. Continuous variables were expressed as mean ± SD, categorical variables as frequencies/percentages. Diagnostic performance of MRCP was assessed with 2×2 tables against ERCP, calculating sensitivity, specificity, PPV, NPV, overall accuracy, and Cohen's kappa. Subgroup analyses evaluated performance by stone size (<5 mm, 5–10 mm, >10 mm), location (distal CBD, proximal CBD, common hepatic duct), number (single vs. multiple), and MRCP–ERCP interval (≤3 vs. >3 days). Chi-square test assessed differences; p<0.05 was considered significant.

RESULTS

A total of 271 patients were included. Baseline demographic and clinical characteristics are shown in Table 1. The mean age was 52.13 ± 16.21 years. There were 124 male (45.8%) and 147 female (54.2%). The most common presenting symptom was abdominal pain (234; 86.3%), followed by jaundice (207; 76.4%), vomiting (101; 37.3%), and fever (98; 36.2%) (Table 1).

Table 1: Demographic and Clinical Characteristics of Study Participants (n=271)

Variables	n (%) or Mean ± SD
Age	
Years	52.13 ± 16.21
Gender	
Male	124 (45.8%)
Female	147 (54.2%)
Presenting Symptoms	
Jaundice	207 (76.4%)
Abdominal Pain	234 (86.3%)
Fever	98 (36.2%)
Vomiting	101 (37.3%)

Laboratory parameters of the study participants are summarized. The mean total bilirubin was 4.58 ± 1.20 mg/dL and direct bilirubin 2.54 ± 0.83 mg/dL. Mean ALT was 143.56 ± 64.26 U/L, AST 123.65 ± 58.17 U/L, ALP 452.38 ± 202.09 U/L, GGT 322.11 ± 167.86 U/L and WBC count 10.65 ± 3.18 × 10^3/μL (Table 2).

Table 2: Laboratory Parameters of Study Participants (n=271)

Parameters	Mean ± SD
Total Bilirubin (mg/dL)	4.58 ± 1.20
Direct Bilirubin (mg/dL)	2.54 ± 0.83
ALT (U/L)	143.56 ± 64.26
AST (U/L)	123.65 ± 58.17
ALP (U/L)	452.38 ± 202.09
GGT (U/L)	322.11 ± 167.86
WBC Count (×10^3/μL)	10.65 ± 3.18

All 271 patients underwent both MRCP and ERCP for evaluation of suspected choledocholithiasis. According to

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ERCP findings, 180 patients (66.4%) had choledocholithiasis, while 91 patients (33.6%) did not. MRCP correctly identified 160 of the 180 ERCP-positive cases, yielding a sensitivity of 88.9% (95% CI: 83.5–92.7%). Among the 91 ERCP-negative cases, MRCP correctly reported 61 as negative, resulting in a specificity of 67.0% (95% CI: 56.9–75.8%). The positive predictive value was 84.2% (95% CI: 78.4–88.7%), while the negative predictive value was 75.3% (95% CI: 64.9–83.4%). The overall diagnostic accuracy was 81.5% (95% CI: 76.5–85.7%). Importantly, Cohen's kappa was 0.55 (95% CI: 0.45–0.65; p<0.05), indicating moderate agreement between MRCP and ERCP. These results confirm MRCP as a reasonably accurate and reliable non-invasive tool for detecting choledocholithiasis, particularly in confirming the presence of bile duct stones (Table 3).

Table 3: Cross-tabulation of MRCP Results Against ERCP (Gold Standard) for Diagnosing Choledocholithiasis (n=271)

ERCP Result (Gold Standard)	MRCP Negative	MRCP Positive	Total
Negative	61 (67.0%)	30 (33.0%)	91 (33.6%)
Positive	20 (11.1%)	160 (88.9%)	180 (66.4%)
Total	81 (29.9%)	190 (70.1%)	271 (100%)

Percentages are row-wise within the ERCP result.

Subgroup analysis of MRCP performance relative to ERCP revealed several clinically important trends. With respect to stone size, MRCP showed the highest diagnostic performance in the 5–10 mm subgroup, correctly identifying 85 true positives (66.4%) with only 6 false negatives (4.7%). Diagnostic accuracy was comparatively lower in the <5 mm group, with 30 true positives (50.0%) but 8 false negatives (13.3%) and 10 false positives (16.7%), reflecting the challenge of detecting very small stones. In the >10 mm group, MRCP demonstrated good performance with 45 true positives (54.2%) and only 6 false negatives (7.2%). For stone location, the highest diagnostic yield was observed in distal CBD stones, with 95 true positives (66.4%) and only 6 false negatives (4.2%). Performance declined slightly for proximal CBD stones (38 true positives, 55.1%; 7 false negatives, 10.1%) and common hepatic duct stones (27 true positives, 48.2%; 4 false negatives, 7.1%), indicating greater effectiveness in distal locations. When stratified by number of stones, MRCP was more accurate in patients with multiple stones, yielding 108 true positives (63.9%) and only 7 false negatives (4.1%). In the single stone subgroup, MRCP identified 72 true positives (59.0%) but missed 13 cases (10.7%), possibly due to subtle imaging findings when only one small stone is present. The MRCP–ERCP interval also significantly affected diagnostic accuracy. When ERCP was performed within ≤3 days of MRCP, 110 true positives (68.8%) were recorded, with only 6 false negatives (3.8%). However, when ERCP was delayed beyond 3 days, true positives declined to 90 (59.6%) and false negatives rose to 14 (9.3%), suggesting that stone migration, passage, or evolving biliary dynamics may reduce agreement when there is a longer interval. Overall, these subgroup findings confirm that MRCP is most reliable for detecting medium-sized, distally located, or multiple stones, and when ERCP is performed soon after MRCP. Greater caution is needed when interpreting MRCP results in patients with very small stones, more proximal locations, or longer imaging-to-intervention delays (Table 4).

Table 4: Diagnostic Performance of MRCP vs ERCP Stratified by Stone Characteristics and MRCP–ERCP Interval (n=271)

Subgroups	True -ve	False -ve	True -ve	False -ve	Total
<5 mm	30 (50.0%)	10 (16.7%)	12 (20.0%)	8 (13.3%)	60
5–10 mm	85 (66.4%)	12 (9.4%)	25 (19.5%)	6 (4.7%)	128
>10 mm	45 (54.2%)	8 (9.6%)	24 (28.9%)	6 (7.2%)	83
Distal CBD	95 (66.4%)	14 (9.8%)	28 (19.6%)	6 (4.2%)	143
Proximal CBD	38 (55.1%)	9 (13.0%)	15 (21.7%)	7 (10.1%)	69
Common Hepatic Duct	27 (48.2%)	7 (12.5%)	18 (32.1%)	4 (7.1%)	56
Single	72 (59.0%)	12 (9.8%)	25 (20.5%)	13 (10.7%)	122
Multiple	108 (63.9%)	18 (10.7%)	36 (21.3%)	7 (4.1%)	169
≤3 Days	110 (68.8%)	10 (6.2%)	34 (21.2%)	6 (3.8%)	160
>3 Days	90 (59.6%)	20 (13.2%)	27 (17.9%)	14 (9.3%)	151

Diagnostic Performance Indicators (with 95% CI): Sensitivity: 88.9% (95% CI: 83.5–92.7). Specificity: 67.0% (95% CI: 56.9–75.8). Positive Predictive Value (PPV): 84.2% (95% CI: 78.4–88.7). Negative Predictive Value (NPV): 75.3% (95% CI: 64.9–83.4). Overall Accuracy: 81.5% (95% CI: 76.5–85.7). Cohen's Kappa: 0.55 (95% CI: 0.45–0.65), p<0.05 (moderate agreement)

DISCUSSIONS

MRCP is now a widely accepted non-invasive modality for evaluating biliary and pancreatic pathologies. In this study, using ERCP as the gold standard, MRCP achieved a sensitivity of 88.9% (95% CI: 83.5–92.7%), specificity of 67.0% (95% CI: 56.9–75.8%), PPV 84.2% (95% CI: 78.4–88.7%), NPV 75.3% (95% CI: 64.9–83.4%) and an overall accuracy of 81.5% (95% CI: 76.5–85.7%), with moderate agreement (κ=0.55; p<0.05). Diagnostic performance was highest for stones 5–10 mm, distal CBD location, and when ERCP was performed within three days of MRCP, confirming MRCP's reliability while highlighting some limitations. Our results parallel recent reports of high diagnostic accuracy for MRCP. Kumar *et al.* found sensitivity and specificity of 88.1% and 94.4% [12], and Isram *et al.* found 96.2% and 91.8% [13]. Although our specificity was slightly lower, sensitivity and overall accuracy were comparable, supporting MRCP as a reliable non-invasive tool. Variation in specificity across studies may reflect imaging quality, expertise, and small filling

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defects mimicking sludge or air, causing false positives. Nayab *et al.* (87% sensitivity, 80% specificity) [14], Qaisar *et al.* (accuracy 90%, PPV 95.3%, NPV 76.9%) [15], Bilal *et al.* (accuracy 89.4%, sensitivity 83.3%, specificity 93.9%) [16] and Javaid *et al.* (accuracy 90.6%, sensitivity 95%, specificity 73.3%) [17] all demonstrate a pattern of high sensitivity with moderate-high specificity consistent with our findings. MRCP also showed better accuracy in multiple-stone cases, though overestimation may reduce specificity. Timing influenced performance: ERCP within three days yielded more true positives and fewer false negatives, while longer delays likely allowed stone migration or passage, reducing agreement. Tariq *et al.* also reported MRCP outperforming ultrasound (sensitivity 99%, specificity 94%) [18]. Varsha *et al.* (sensitivity 86.4%, specificity 88%, AUC 0.864) [19], Rashid *et al.* (accuracy 82%) [20], and Swaraj *et al.* (accuracy 94.8% vs. 48.9% for ultrasound) [21] further underscore MRCP's robustness and superiority to ultrasonography, especially where ERCP is unavailable or carries a higher risk.

CONCLUSIONS

In conclusion, MRCP demonstrates high sensitivity and reasonably good specificity for the detection of choledocholithiasis, making it a reliable and non-invasive diagnostic tool in patients with obstructive jaundice. In this study, MRCP achieved an overall diagnostic accuracy of 81.5% with moderate agreement to ERCP (Cohen's kappa = 0.55), and performed best in detecting medium- to large-sized stones and those located in the distal common bile duct. Diagnostic accuracy was further enhanced when ERCP was performed within three days of MRCP, underscoring the importance of timely follow-up. Although limitations remain, particularly in detecting very small or proximally located stones, MRCP provides a valuable initial assessment that can guide further management.

Authors Contribution

Conceptualization: KN
Methodology: KN
Formal analysis: KN, SN, FM
Writing review and editing: SN

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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