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Safety and Efficacy of Intraoperative Colonoscopy During Laparoscopic Left-Sided Colorectal Surgery: A Prospective Observational Study

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Abstract **Background:** Accurate tumour localization in laparoscopic colorectal surgery remains challenging due to limited tactile feedback and dynamic bowel movement. Conventional modalities, including preoperative colonoscopy and cross-sectional imaging, may miss small or flat lesions, increasing the risk of mis-localization. Intraoperative colonoscopy (IOC) provides real-time mucosal visualization and can assist in confirming tumour position, resection margins and anastomotic integrity. **Objectives:** To assess the safety, feasibility and clinical utility of intraoperative colonoscopy during laparoscopic left-sided colorectal surgery. **Methods:** This prospective observational study included 30 patients with left-sided colorectal tumours undergoing elective laparoscopic resection at the Department of General Surgery, GMC Srinagar (March 2023–August 2024). IOC was employed to verify tumour localization, inspect resection margins and perform anastomotic leak testing. Demographic, intraoperative and postoperative variables were recorded and analysed using SPSS v24. Statistical significance was set at $p<0.05$. **Results:** The mean patient age was 42.1±6.8 years; 56.6% were male. The sigmoid colon (46.7%) and rectum (30%) were the most common tumour sites. IOC altered or corrected tumour localization in 46.6% of cases with uncertain preoperative findings. No IOC-related complications, such as perforation or bleeding, occurred. All patients had intact postoperative anastomoses with no detected leaks. **Conclusion:** Intraoperative colonoscopy is a safe and feasible adjunct in laparoscopic colorectal surgery. By improving intraoperative tumour localization and verifying anastomotic integrity, IOC enhances surgical decision-making and may reduce postoperative complications.

Key Words Intraoperative Colonoscopy, Laparoscopic Colorectal Surgery, Tumour Localization, Anastomotic Integrity, Surgical Precision

INTRODUCTION

Colorectal cancer (CRC) remains a major global health burden, ranking as the third most commonly diagnosed malignancy and a leading cause of cancer-related mortality [1-3]. Laparoscopic colorectal surgery has transformed CRC management by offering reduced postoperative pain, faster recovery, shorter hospital stays and oncologic outcomes comparable to open surgery. Owing to these advantages, laparoscopic techniques are now widely used across a spectrum of benign and malignant colorectal diseases, including inflammatory bowel disease, diverticulitis, polyps and obstructive lesions [4-6].

Despite these advancements, accurate intraoperative tumour localization continues to pose a significant challenge in minimally invasive surgery. Conventional preoperative modalities, high-resolution colonoscopy, computed tomography (CT) and magnetic resonance imaging (MRI), remain fundamental but are prone to limitations [7-10]. Factors such as incomplete bowel preparation, variable anatomy and small or flat tumour morphology may hinder colonoscopic detection, whereas CT and MRI offer static images that may fail to identify subtle lesions. These shortcomings can result in suboptimal tumour localization and increase the risk of inappropriate or inadequate resection [11,12].

Intraoperative colonoscopy (IOC) has emerged as a useful adjunct to overcome these limitations. By providing real-time mucosal visualization during laparoscopic resection,

IOC aids in verifying tumour position, confirming or evaluating tattoo marks and identifying synchronous lesions not evident on imaging or laparoscopy alone [13-15]. Additionally, IOC facilitates intraoperative leak testing, typically via air or dye insufflation, allowing direct assessment of anastomotic integrity [16-18]. Evidence suggests that systematic leak testing can significantly reduce postoperative anastomotic complications [16-18]. Through improved localization and intraoperative verification, IOC may help prevent unnecessary bowel resection and reduce postoperative morbidity.

Given these potential benefits, further evaluation of IOC in laparoscopic colorectal surgery is warranted. Current evidence on its routine use, particularly during laparoscopic colorectal cancer resections, remains limited. Therefore, the present study aims to assess the impact of intraoperative colonoscopy on tumour localization accuracy and intraoperative decision-making in patients undergoing laparoscopic colorectal cancer surgery.

METHODS

Study Design and Setting

This prospective observational study included consecutive adult patients (≥18 years) with left-sided colorectal tumours who were scheduled for elective laparoscopic resection at our institution between March 2023 and August 2024. All patients provided written informed consent prior to enrolment. Patients with synchronous extra-abdominal disease or contraindications to laparoscopy were excluded.

Preoperative Evaluation

All patients underwent standard preoperative assessment, including diagnostic colonoscopy and contrast-enhanced CT of the abdomen. MRI was performed when clinically indicated. Preoperative imaging and endoscopic findings were documented for comparison with intraoperative assessments.

Surgical Technique and Intraoperative Colonoscopy

Patients were positioned in lithotomy to allow endoscopic access to the colon up to the splenic flexure. After establishing pneumoperitoneum and completing colonic mobilization, intraoperative colonoscopy was performed using a high-definition flexible colonoscope (Olympus CV-170). Under simultaneous laparoscopic visualization, the colonoscope was advanced to the suspected tumour site. IOC was used to:

- Confirm tumour localization
- Inspect any preoperative tattoo marks
- Assess the integrity of the planned or freshly created anastomosis using air or dye leak testing

All IOC findings were recorded. Laparoscopic bowel resection and anastomosis were then completed according to standard surgical principles (Figure 1-10).

Figure 1: Sony Olumpus CV-170 HD system with flexible colonoscope

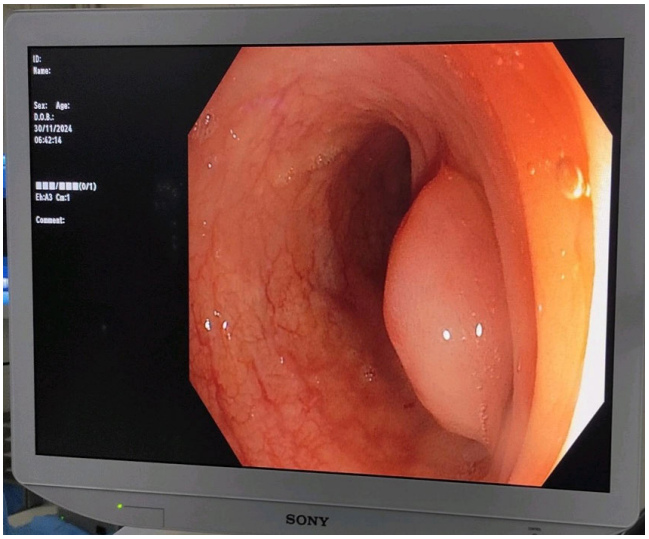

Figure 2: Descending colon broad based sensile polyp detected on intraoperative colonoscopy

Data Collection

Collected variables included patient demographics, tumour location, findings from preoperative colonoscopy, CT and MRI, as well as intraoperative colonoscopy observations. IOC findings were compared with preoperative localization to determine concordance.

The primary outcomes were accuracy of tumour localization and any resulting change in the surgical plan.

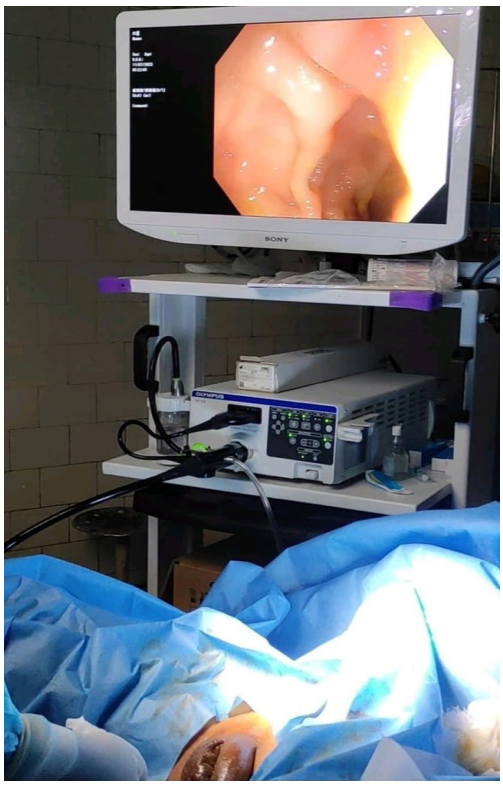

Figure 3: Scope negotiated beyond tumor site/rest of left colon normal

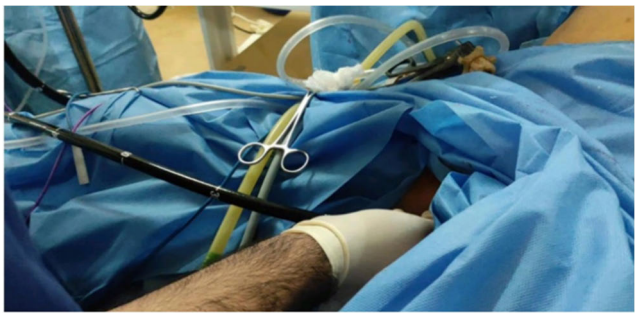

Figure 4: Insertion of flexible colonoscope intraoperative while maintaining patient position and pneumoperitoneum

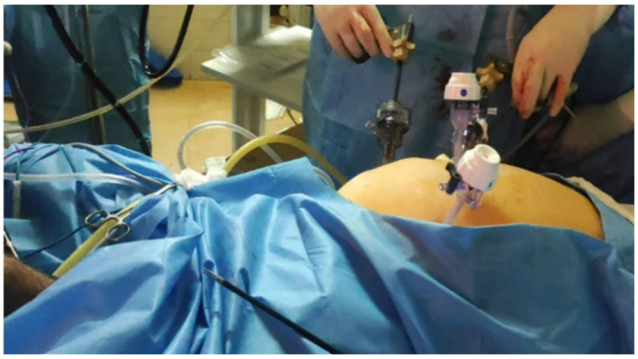

Figure 5: Intraoperative colonoscopy being done in laparoscopic colorectal surgery flexible colonoscope with torchers and lap working instruments in situ while maintaining pneumoperitoneum

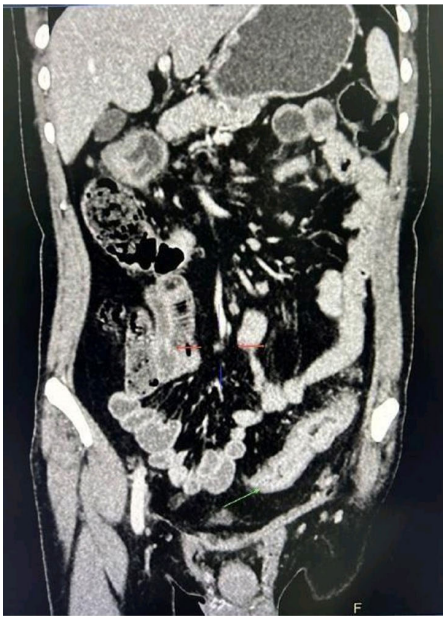

Figure 6: Sigmoid colon circumferential enhancing stenotic thickening (green arrow) (Coronal Plane)

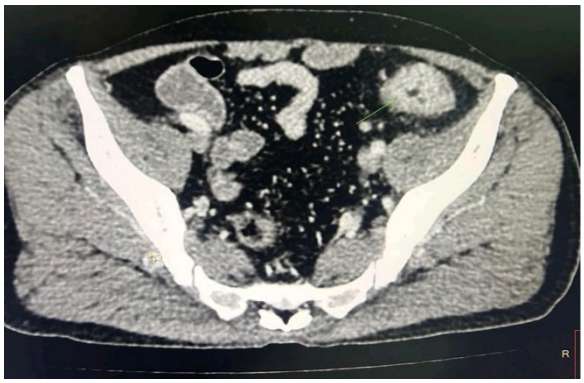

Figure 7: Distal descending colon circumferential enhancing growth (green arrow) (Axial Plane)

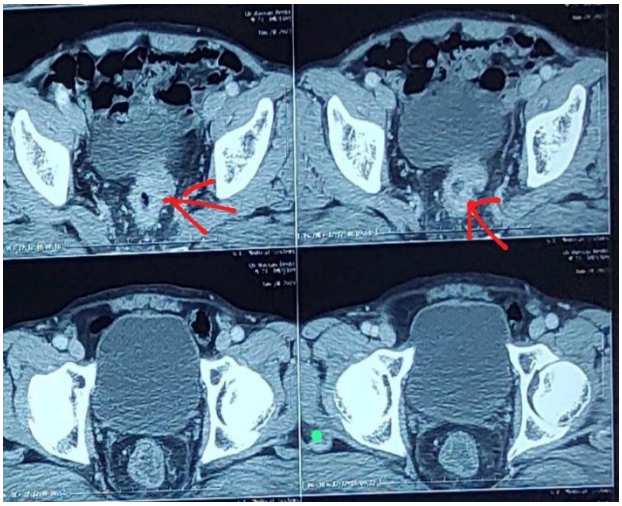

Figure 8: Patient with circumferential ulcer proliferative growth on CT scan

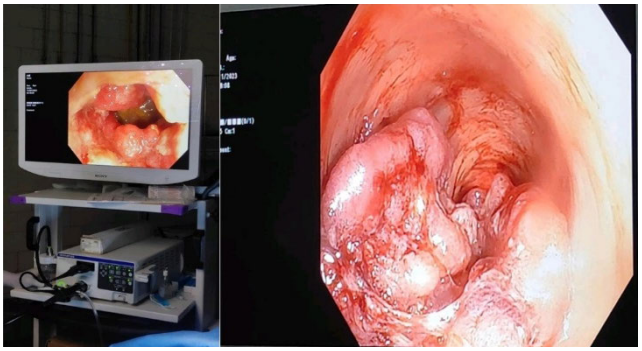

Figure 9: Intraoperative colonoscopic view of same tumour as shown by above figures

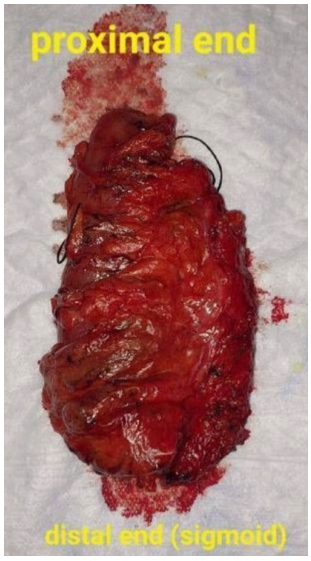

Figure 10: Specimen of sigmoid colon growth

Secondary outcomes included IOC sensitivity and specificity for tumour localization and any complications directly attributable to IOC.

Statistical Analysis

Statistical analysis was performed using SPSS version 24. Continuous variables were summarized as mean±standard deviation (SD) or median with interquartile range (IQR) and compared using Student's t-test. Categorical variables were reported as frequencies and percentages and analysed using the Chi-square test. A p-value <0.05 was considered statistically significant. Receiver operating characteristic (ROC) analysis was performed to evaluate the diagnostic performance of intraoperative colonoscopy.

RESULTS

Patient Demographics

The study cohort comprised 30 patients undergoing laparoscopic colorectal surgery. 56.6% were male and 43.3% female (Table 1). Most patients (73.3%) resided in rural areas and 26.6% in urban areas. Age distribution was as follows: 53.3% were 30–50 years, 30.0% were 50–70 years and 16.7% were ≥70 years. The mean age was 42.12±6.85 years. There was no significant difference in age distribution between males and females (p = 0.862), indicating a comparable age profile across genders.

Clinical Presentation

Presenting symptoms are summarized in Table 2. The most common complaint was rectal bleeding, reported by 60.0% of patients, followed by altered bowel habits in 43.3% and anaemia in 30.0%. Abdominal pain was noted in 36.6% of cases (Table 2). About 23.3% reported weight loss. On general physical examination (Table 3), 63.3% of patients were normal; pallor was present in 43.3% and cachexia in 33.3%. Abdominal examination (Table 4) was also normal in 63.3%; 33.3% had tenderness and 3.33% had a palpable mass.

Table 1: Socioeconomic status of study participants (N=30)

Socioeconomic status		N=30	%
Gender	Male	17	56.6
	Female	13	43.3
Residence	Rural	22	73.3
	Urban	8	26.6
Age(years)	30-50	16	53.3
	50-70	9	30.0
	70&above	5	16.7
Mean age (years)		42.12±6.85	

Table 2: Chief complaints of study participants (N=30)

Chief Complaints	N=30	%
Abdominal pain	11	3.66
Anaemia	9	30.0
Change in bowel habits	13	43.3
Rectal bleeding	18	60.0
Weight loss	7	23.3

Table 3: General physical examination findings (N=30)

Physical Examination	N=30	%
Normal	19	63.3
Pallor	13	43.3
Cachexia	10	33.3

Table 4: Abdominal examination findings (N=30)

Abdominal Examination	N=30	%
Normal	19	63.3
Palpable Mass	1	3.33
Tenderness	10	33.3

Table 5: Tumour localization (preoperative) (N=30)

Tumour Localization	N=30	%
Sigmoid colon	14	46.7
Rectum	9	30
Descending colon	5	16.7
Splenic Flexure	2	6.7

Table 6: CT and MRI findings (N=30)

CT Abdomen Results	N=30	%
Tumour detected	11	36.6
No Metastasis	19	63.6
MRI Findings		
Localized tumour	10	33.3
No metastasis	20	66.7

Table 7: Colonoscopy findings (N = 30)

Pre-op Colonoscopy	N = 30	Percentage
Localized	21	70.0
Uncertain	9	30.0
Per op Colonoscopy Findings		
Same	16	53.3
Different	14	46.6

Table 8: Intraoperative tumour findings (N = 30)

Intra-op Findings	N = 30	Percentage
Tumour well defined	10	33.3
Infiltrating	20	66.7

Table 9: Laboratory and biochemical parameters (N = 30)

Parameters	Mean	SD	Median	Min.	Max.	Range
Hb	10.97	1.14	10.85	9.3	12.9	3.6
TLC	7136.67	234.12	7100.00	6800	7500	700
N	57.93	2.08	58.00	55	61	6
L	32.07	2.08	32.00	29	35	6
Creatinine	1.04	.159	1.00	.8	1.3	0.5
Urea	30.73	2.53	30.50	27	35	8
SGOT	48.90	2.10	49.00	45	52	7
SGPT	41.13	1.94	41.00	38	44	6
ALP	102.43	4.82	102.00	95	110	15
Total Protein	6.89	0.210	6.900	6.5	7.2	0.7
Albumin	4.05	0.173	4.05	3.8	4.3	0.5
CEA	5.28	1.91	5.00	2.55	9.43	6.88
CA 19-9	57.16	30.40	50.06	12.55	99.82	87.27

Table 10: Intra-op findings vs Pre-op colonoscopy (N = 30)

	Pre-op Colonoscopy		
Intra-Op Findings	Localized (n = 21)	Uncertain (n = 9)	P-Value
Tumour Well Defined	7 (33.3%)	3 (33.3%)	0.001
Infiltrating	14 (66.6%)	6 (66.6%)	

Table 11: Per-op colonoscopy vs Pre-op colonoscopy (N = 30)

Per Op	Pre-op Colonoscopy		
Colonoscopy	Localized (n =21)	Uncertain (n = 9)	P-Value
Same	12 (57.14%)	4 (44.4)	0.394
Different	9 (42.8%)	5 (55.5%)	

Table 12: CT abdomen vs Pre-op colonoscopy (N = 30)

	Pre-op Colonoscopy		
CT Abdomen	Localized (n=21)	Uncertain (n = 9)	P-Value
Tumour Detected	8 (38.09%)	3 (33.3%)	0.059
No Spread	13 (61.9%)	6 (66.6%)	

Table 13: Tumour localization vs Pre-op colonoscopy (N = 30)

	Pre-op Colonoscopy		
Tumour Localization	Localized (n=21)	Uncertain (n = 9)	P-Value
Sigmoid colon	11(52.8%)	3(33.3%)	0.583
Rectum	6(28.7%)	3(33.3%)	
Descending colon	3(14.3%)	2(22.2%)	
Splenic Flexure	1(4.8%)	1(11.1%)	

Imaging Findings

Computed tomography (CT) of the abdomen detected the tumour in 11 cases (36.6%), whereas 63.6% showed no evidence of metastasis (Table 6). Magnetic resonance imaging (MRI) identified a localized tumour in 10 cases (33.3%); in 66.7% MRI showed no metastasis (Table 6). These results indicate that CT and MRI identified tumours in roughly one-third of patients, with the majority of cases showing no metastatic spread on imaging.

Colonoscopy Findings

Preoperative (diagnostic) colonoscopy findings are shown in Table 7. 70.0% of patients had a tumour clearly localized by colonoscopy, while in 30.0% the findings were uncertain. During surgery, intraoperative colonoscopy (performed per-operatively) confirmed the preoperative findings in 53.3% of cases; in 46.6% of patients, intraoperative colonoscopy findings differed from the preoperative assessment.

Intraoperative Findings

Intraoperatively 33.3% of tumours appeared well-defined and 66.7% appeared infiltrating (Table 8). This suggests that two-thirds of cases had invasive tumour characteristics at surgery.

Laboratory Results

Key laboratory and biochemical parameters are summarized in Table 9. The mean haemoglobin was 10.97 g/dL (SD 1.14), mean total leukocyte count (TLC) was 7136.7 cells/mm³ (SD 234.1) and mean absolute neutrophil and lymphocyte counts were 57.93% (SD 2.08) and 32.07% (SD 2.08), respectively. Renal (creatinine 1.04±0.16 mg/dL, urea 30.73±2.53 mg/dL) and liver function (SGOT 48.90±2.10 U/L, SGPT 41.13±1.94 U/L, ALP 102.43±4.82 U/L) tests were generally normal. Mean serum total protein was 6.89±0.21 g/dL and albumin 4.05±0.17 g/dL. Tumour markers showed mean CEA 5.28±1.91 ng/mL and CA 19-9 57.16±30.40 U/mL (Table 9).

Statistical and Comparative Analysis

Table 10 compares intraoperative findings with preoperative colonoscopy localization. There was a significant association (p = 0.001). Among patients with a localized tumour on pre-op colonoscopy (n = 21), 7 (33.3%) were well-defined intraoperatively and 14 (66.6%) infiltrating. In the pre-op "uncertain" group (n = 9), 3 (33.3%) were well-defined and 6 (66.6%) infiltrating (Table 10).

Table 11 compares per-operative colonoscopy findings with the pre-operative colonoscopy. No significant association was found (p = 0.394). In the pre-op localized group (n = 21), 12 (57.1%) per-op findings were the same as pre-op and 9 (42.8%) were different; in the pre-op uncertain group (n = 9), 4 (44.4%) were the same and 5 (55.5%) were different.

Table 12 shows CT findings versus pre-op colonoscopy; this also showed no significant association (p=0.059). In the pre-op localized group, 8 (38.1%) had a tumour detected on CT and 13 (61.9%) had no spread on CT. In the pre-op uncertain group, 3 (33.3%) had tumour on CT and 6 (66.6%) had no spread.

Table 13 compares tumour location by pre-op colonoscopy group. The sigmoid colon was the most common site in both groups (52.8% vs 33.3%); rectal tumours were 28.7% vs 33.3%. There was no significant association between tumour site and colonoscopy localization (p=0.583).

Table 14 examines tumour location by intraoperative (tumour well-defined vs infiltrating). Sigmoid colon was again

Table 14: Tumour localization vs Intra-op findings (N = 30)

Tumour Localization	Intra-op Findings		P-Value
	Tumour well Defined (n=10)	Infiltrating (n=20)	
Sigmoid colon	5(50%)	9(45%)	0.752
Rectum	3(30%)	6(30%)	

Table 15: MRI findings vs Intra-op findings (N = 30)

MRI Findings	Intra-op Findings		P-value
	Tumour well Defined	Infiltrating	
Localized Tumour	10 (100.0%)	0 (0.0%)	0.001
No metastasis	0 (0.0%)	20 (100.0%)	

Table 16: Tumour type distribution (N = 30)

Tumour Type	Frequency
Single	30

Table 17: Tumour size vs detection by modality (N = 30)

Tumour Size (cm)	Detected on CT (n)	Localized MRI (n)	Localized on Pre-op Colonoscopy (n)	Same on Intra-op Colonoscopy (n)	Well-defined Intra-op (n)
2	2	2	4	2	2
3	0	0	0	0	0
4	1	1	2	1	1
5	0	0	2	1	0
6	3	3	6	6	3
7	1	1	2	2	1
8	4	3	5	4	3

Table 18: Modality-wise tumour detection (N = 30)

Modality	Positive Detection (n)
CT	11
MRI	10
Pre-op Colonoscopy	21
Intra-op Colonoscopy	16
Intra-op Surgical Finding	10

Table 19: ROC analysis of intraoperative colonoscopy for tumour localization

Tumour localization	AUC	P-Value	95% CI	Sensitivity	Specificity
	0.515	0.895	0.295-0.735	75%	20%

most frequent (50% vs 45%) and distribution was otherwise similar; no significant association was found (p = 0.752).

Table 15 compares MRI findings with intraoperative tumour appearance. All cases with a localized tumour on MRI (n=10) were well-defined intraoperatively and all cases with no metastasis on MRI (n=20) were infiltrating. This association was highly significant (p=0.001).

All patients had a single tumour type (100% single; no mixed types) (Table 16).

Table 17 details tumour size and detection across modalities. Larger tumours tended to be detected by all methods more frequently. For example, 6 cm tumours were detected by CT and MRI in 3 cases each, by pre-op colonoscopy in 6 cases and all 6 were matched intraoperatively, with 3 appearing well-defined. In contrast, smaller tumours (2–3 cm) had lower detection rates.

Finally, Table 18 presents modality-wise tumour detection rates. Preoperative colonoscopy had the highest detection (21 cases), followed by intraoperative colonoscopy (16 cases). CT and MRI detected 11 and 10 tumours, respectively; intraoperative surgical inspection confirmed 10 cases.

The receiver operating characteristic (ROC) analysis for intraoperative colonoscopy yielded an area under the curve of 0.515 (95% CI: 0.295–0.735), sensitivity 75% and specificity 20% (p = 0.895), indicating moderate diagnostic performance (Table 19).

DISCUSSION

The findings of this study suggest that intraoperative colonoscopy (IOC) is a useful adjunct in laparoscopic colorectal surgery, particularly for enhancing tumour localization. Preoperative colonoscopy identified the tumour in 70% of cases, whereas cross-sectional imaging modalities detected lesions in roughly one-third of patients. In contrast, IOC confirmed or refined localization in a substantial proportion of cases, with nearly half (46.6%) demonstrating discrepancies between preoperative and intraoperative assessments. This aligns with previous studies reporting notable mis-localization rates. Nivaarrarsuwonnakul [19], for example, documented a 48% mismatch between imaging and intraoperative findings during laparoscopic colorectal resections, underscoring the limitations of preoperative modalities [19].

The 75% sensitivity observed for IOC in our cohort reflects its utility in accurately identifying true lesions. However, the low specificity (20%) and modest area under the ROC curve indicate that IOC may occasionally overestimate lesion significance or produce false-positive impressions. These diagnostic constraints highlight the importance of interpreting IOC findings within the broader clinical and anatomical context rather than relying on IOC as a standalone diagnostic tool.

Our results are consistent with those of Gorgun *et al.* [20], who demonstrated that IOC altered surgical management in nearly one-third of cases without increasing morbidity. In the present study, IOC contributed valuable real-time information by confirming tumour margins, identifying additional or mis-localized lesions and providing intraoperative guidance where preoperative data were uncertain [20]. Furthermore, IOC-assisted anastomotic leak testing, through air or dye insufflation, allowed immediate identification and correction of anastomotic defects. Prior studies have emphasized the role of routine leak testing in reducing postoperative complications and our findings support the integration of IOC as a mechanism to enhance intraoperative quality assurance.

Importantly, IOC was not associated with intraoperative complications in this series, nor did it appear to prolong operative duration meaningfully. Its favourable safety profile and procedural feasibility make IOC a practical adjunct in routine laparoscopic colorectal surgery.

CONCLUSIONS

Intraoperative colonoscopy is a safe and feasible adjunct during laparoscopic left-sided colorectal cancer surgery. By offering real-time confirmation of tumour location and facilitating anastomotic integrity assessment, IOC complements preoperative diagnostic methods and enhances intraoperative decision-making. Although it should not be used as a solitary localization tool due to specificity limitations, its integration may improve surgical accuracy and reduce postoperative complications. Further large-scale studies are warranted to refine its role within modern colorectal surgical practice.

Recommendations

Based on the findings of this study, several recommendations can be proposed:

- **Selective incorporation of IOC** may be beneficial in cases where preoperative localization is uncertain, tattoo visibility is questionable or lesions are small, flat or morphologically difficult to identify.
- **Routine anastomotic leak testing** using IOC should be considered, as it may help identify early defects and reduce postoperative complications.
- **Future multi-centre randomized studies** with larger sample sizes are needed to validate the diagnostic accuracy and clinical impact of IOC across diverse surgical teams and institutions
- **Cost-effectiveness analyses** should be incorporated to determine whether IOC use is financially justified in routine colorectal surgical practice
- **Integration with emerging technologies**, such as fluorescence imaging or augmented endoscopic guidance, may further improve intraoperative localization and should be explored

Strengths

This study has several notable strengths. Its prospective design minimized recall bias and ensured systematic data collection across all patients. The uniform application of intraoperative colonoscopy (IOC) by an experienced surgical team provided consistency in procedural technique and interpretation of findings. Additionally, the study specifically focused on left-sided colorectal tumours, creating a more homogenous patient cohort and enabling clearer assessment of IOC's role within this anatomical region.

Limitations

Despite these strengths, certain limitations must be acknowledged. The sample size was relatively small, which may limit the statistical power and the generalizability of the findings. Being a single-centre study, institutional practices and surgeon experience may have influenced outcomes and may not reflect broader clinical settings. The evaluation of IOC diagnostic performance was constrained by the lack of a universally accepted gold standard for intraoperative tumour localization, potentially affecting specificity estimates. Lastly, long-term oncologic and functional outcomes were not assessed and should be addressed in future research.

Acknowledgement

The authors extend their gratitude to the operating room staff, endoscopy unit personnel and postgraduate trainees of the Department of General Surgery, GMC Srinagar, for their assistance throughout the study period. Special thanks to the patients who consented to participate in this research.

Ethical Statement

The study was conducted in accordance with institutional ethical standards. Ethical approval was obtained from the Institutional Ethics Committee of Government Medical College, Srinagar and written informed consent was obtained from all participants prior to inclusion in the study.

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