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BEYOND LENGTH OF STAY: PROSPECTIVE COMPARISON OF FUNCTIONAL RECOVERY AND READINESS FOR DISCHARGE AFTER LAPAROSCOPIC VERSUS OPEN COLORECTAL CANCER RESECTION

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ABSTRACT

Objective: To prospectively compare functional recovery and time to readiness for discharge between patients undergoing laparoscopic versus open colorectal cancer resection, and to determine whether the operative approach is independently associated with time to readiness for discharge after adjustment for clinically relevant confounders.

Study Design: Prospective comparative observational study.

Settings: Department of Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi.

Period: January 2026 to April 2026.

Material & Methods: Sixty-four adult patients undergoing elective curative-intent colorectal cancer resection were enrolled by non-probability purposive sampling and allocated to Group A (completed laparoscopic resection, n=32) or Group B (planned open resection, n=32) according to the treating surgical team's routine clinical decision. A blinded data collector recorded the first postoperative day on which oral intake, bowel function, oral-analgesic pain control, independent mobility and clinical stability were achieved; functional recovery day and clinical readiness-for-discharge day were derived from these prespecified milestones. Normally distributed continuous variables were compared using the independent-samples t-test, skewed continuous recovery variables using the Mann-Whitney U test, and categorical variables using the Chi-square or Fisher's exact test. Multivariable linear regression, adjusted for age, ASA grade, tumour site and stoma formation, evaluated the independent association between operative approach and time to readiness for discharge. $p \leq 0.05$ was taken as significant.

Results: Baseline age, gender, BMI and ASA grade were comparable between groups ($p>0.05$). Median time to readiness for discharge was 3.0 days (IQR 2.0–3.2) in the laparoscopic group versus 4.5 days (IQR 4.0–5.0) in the open group (Mann-Whitney U=139.5, $p<0.001$). Functional recovery (3.0 vs 4.0 days, $p<0.001$) and postoperative length of stay (3.7±1.2 vs 5.2±1.3 days, $p<0.001$) were also significantly shorter after laparoscopy. Seventy-five percent (24/32) of laparoscopic patients were ready for discharge by postoperative day 3 versus 12.5% (4/32) after open surgery ($\chi^2=22.92$, $p<0.001$; risk ratio 6.0, 95% CI 2.35–15.33). Discharge delay beyond the day of readiness was similar between groups (0.62 vs 0.56 days, $p=0.721$). On multivariable regression, laparoscopic approach remained independently associated with earlier readiness for discharge ($\beta=-1.68$ days, 95% CI –2.26 to –1.09, $p<0.001$), independent of age, ASA grade, tumour site and stoma formation.

Conclusion: Laparoscopic colorectal cancer resection was independently associated with significantly faster functional recovery and readiness for discharge than open resection, and this advantage was not explained by earlier hospital discharge processing. Readiness-for-discharge measurement can complement length of stay as a locally relevant, recovery-focused outcome for perioperative pathway design.

KEYWORDS: Colorectal Neoplasms, Enhanced Recovery After Surgery, Laparoscopy, Length of Stay, Patient Discharge.

INTRODUCTION

Colorectal cancer remains a major surgical burden worldwide. GLOBOCAN 2024 estimates reported just over two million new colorectal cancer cases and close to 918,000 deaths, making it the third most commonly diagnosed malignancy and the second leading cause of cancer death globally[1]. Surgical resection remains central to curative treatment of localized disease, and minimally invasive approaches are increasingly preferred whenever technically feasible, given their consistently reported advantages in blood loss, wound morbidity and short-term recovery[2,13,15]. Despite this, postoperative success continues to be judged in routine practice chiefly by hospital

length of stay (LOS), a measure that is shaped as much by bed availability, discharge logistics, family support and institutional discharge culture as by the patient's underlying biological recovery[3]. A metric that better isolates true physiological recovery from these administrative factors is therefore needed to fairly compare surgical approaches.

Time to readiness for discharge and recovery of specific postoperative functions have been proposed as constructs that better distinguish surgical recovery from administrative delay. Fiore et al. first validated time to readiness for discharge as a reliable short-term recovery outcome after colorectal surgery, independent of the discharge decision itself[9]. In a 714-patient registry, Braga et al. reported a mean readiness-for-discharge time of 4.5±2.5 days after successful laparoscopy versus 7.1±4.2 days after open surgery, with morbidity of 18.7% versus 32.6%[2]. Balvardi et al. subsequently confirmed readiness for discharge as a construct-valid recovery measure distinct from length of stay within an established enhanced recovery pathway[3], and a more recent cohort by Ceresoli et al. found that delayed recovery on postoperative day two occurred in 31.7% of elective colorectal resections, with successful laparoscopy independently favouring earlier recovery (adjusted OR 2.34)[4]. Recent meta-analytic and multicentre evidence continues to support this pattern: a 2025 outcome-mapping study of enhanced-recovery trials found that length of stay is still reported far more often than readiness for discharge or functional recovery, highlighting a persistent outcome-selection gap in the literature[5]; a 2024 systematic review and meta-analysis of over 216,000 patients confirmed faster recovery and fewer complications with laparoscopic rectal cancer surgery without compromising oncological safety[15]; and the multicentre LASRE trial demonstrated that laparoscopic resection for low rectal cancer achieves recovery and survival outcomes non-inferior to open surgery[13,14]. ERAS-based cohorts from Italy and elsewhere have similarly shown that combining a minimally invasive approach with a structured recovery pathway shortens hospital stay beyond what either intervention achieves alone[10,11].

In Pakistan's national cancer registry, colorectal cancer accounted for 6.43% of male and 3.36% of female cancers, confirming its local surgical relevance[6], and recent single-centre Pakistani series have reported favourable short-term outcomes with laparoscopic colorectal resection[20,21,22], but comparative, prospectively measured recovery data from a Pakistani teaching hospital are lacking. At JPMC, discharge after colorectal cancer surgery may reflect true recovery alongside bed pressure, family arrangements, stoma education, transport and other resource constraints, so length of stay alone may obscure whether laparoscopy genuinely accelerates recovery locally. We therefore designed this prospective study to measure oral intake, bowel function, oral-analgesic pain control, independent mobilization and clinical stability daily in order to identify the first day each patient was fit for discharge, with the objective of comparing mean time to readiness for discharge, functional recovery time, actual length of stay, discharge delay and the proportion of patients ready for discharge by postoperative day 3 between laparoscopic and open colorectal cancer resection.

MATERIAL AND METHODS

Study Design

This was a prospective comparative observational study.

Settings

Department of Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi.

Period

January 2026 to April 2026, following approval from the Institutional Review Board (IRB) clearance from JPMC.

Sample Size

Sample size was calculated using the WHO formula for comparison of two independent means, based on Braga et al.[2], which reported mean time to readiness for discharge of 4.5±2.5 days after successful laparoscopic colorectal surgery versus 7.1±4.2 days after open surgery. Using a 95% confidence level ($Z\alpha/2=1.96$), 80% power ($Z\beta=0.84$), and these group means and standard deviations, a minimum of 28 patients per group was required; after allowing 10% for incomplete outcome assessment, the adjusted sample size was 32 patients per group, giving a total sample of 64 patients (32 laparoscopic, 32 open).

Sampling Technique

Non-probability purposive sampling. Operative approach was decided by the treating surgical team according to routine clinical indications, tumour characteristics, surgeon expertise and available resources; the study did not assign or alter the operative approach.

Inclusion Criteria

Adult patients aged 18–80 years of either gender, with histologically confirmed primary colorectal adenocarcinoma, scheduled for elective curative-intent colorectal resection by a planned laparoscopic or planned open approach, ASA physical status I–III, able to ambulate independently before surgery and willing to provide written informed consent.

Exclusion Criteria

Emergency colorectal surgery for perforation, obstruction, uncontrolled bleeding or generalized peritonitis; unresectable/metastatic disease undergoing palliative bypass or stoma alone without tumour resection; planned multivisceral resection involving a major additional organ; severe pre-existing neurological, cognitive or mobility impairment precluding reliable assessment of functional recovery; and cases converted from a planned laparoscopic to an open procedure, which were recorded in the screening log and replaced by continued recruitment until the required number of completed cases was obtained.

Data Collection Procedure

Eligible patients admitted for elective colorectal cancer resection were approached preoperatively, and written informed consent was obtained after the study purpose was explained in a language understood by the patient. Baseline variables recorded included age, gender, BMI, ASA grade, diabetes, hypertension, other comorbidity, tumour site (colon/rectum), neoadjuvant therapy and preoperative mobility; operative variables included procedure performed, operative duration, new stoma formation and intraoperative complications. A trained data collector who was not responsible for the discharge decision assessed recovery once daily from postoperative day 1 until discharge. Functional recovery was defined as the first postoperative day on which oral diet/fluids were tolerated without vomiting or need for routine intravenous hydration, bowel function had returned (passage of flatus or stool), pain was controlled on oral analgesics alone with a Numeric Rating Scale score <4 at rest, and the patient was independently mobile to the toilet/ward at or near preoperative baseline[2,7,8]. Readiness for discharge was defined as the first day functional recovery was achieved together with clinical stability (temperature <38°C, haemodynamic stability, and no unresolved medical/surgical problem requiring inpatient treatment)[3,7], recorded independently of the actual discharge decision. Actual discharge date was taken from the medical record, from which postoperative length of stay and discharge delay (actual length of stay minus readiness-for-discharge day) were derived; a discharge delay of zero indicates discharge on the day readiness criteria were first met. Each participant was assigned a unique study identification number and no personal identifiers were entered into the analysis dataset.

Data / Statistical Analysis

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Quantitative variables were assessed for distribution; age, BMI and operative duration approximated a normal distribution and were compared between groups using the independent-samples t-test, while recovery-time variables (functional recovery, readiness for discharge, length of stay, discharge delay and individual milestone days) were discrete and right-skewed and were therefore compared using the Mann-Whitney U test, consistent with the pre-specified analysis plan. Continuous variables are presented as mean±standard deviation with median and interquartile range (IQR); categorical variables (gender, ASA grade, comorbidities, tumour site, stoma formation, and readiness by postoperative day 3) were compared using the Chi-square test or Fisher's exact test as appropriate, and are presented as frequencies and percentages. The risk ratio for readiness by postoperative day 3 was calculated with a 95% confidence interval. Because operative approach was not randomized, a multivariable linear regression model for time to readiness for discharge was constructed a priori, entering operative approach (laparoscopic versus open), age, ASA grade, tumour site (rectum versus colon) and new stoma formation as covariates; a sensitivity model additionally adjusted for diabetes, which differed at baseline between groups. Variance inflation factors were used to exclude problematic collinearity. A two-sided p-value ≤ 0.05 was considered statistically significant throughout.

Ethical Approval

The study was approved by the Institutional Review Board, JPMC. Written informed consent was obtained from all participants; participation was voluntary, patient identity was kept confidential, and the operative approach and discharge decision remained solely at the discretion of the treating surgical team throughout the study.

RESULTS

Sixty-four patients undergoing elective curative-intent colorectal cancer resection were enrolled, 32 in the laparoscopic group and 32 in the open group. Baseline age, gender distribution, BMI and ASA grade were comparable between the two groups (all p>0.05, **Table I**). Diabetes mellitus was more frequent in the laparoscopic group (37.5% vs 12.5%, p=0.041), and rectal tumours were numerically more common in the laparoscopic group without reaching significance (53.1% vs 28.1%, p=0.075); these imbalances, being typical of non-randomized allocation, were accounted for in the adjusted analysis described below.

Table I: Baseline demographic and clinical characteristics (n=64)

Variable	Laparoscopic (n=32)	Open (n=32)	Test statistic	p-value
Age, years (mean±SD)	60.9±7.8	62.6±8.2	t=−0.843	0.402
Gender – Male, n (%)	20 (62.5%)	24 (75.0%)	χ^2=0.655	0.418
BMI, kg/m² (mean±SD)	25.7±3.0	25.3±2.8	t=0.487	0.628
ASA Grade I / II / III, n	6 / 15 / 11	5 / 17 / 10	χ^2=0.264	0.877
Diabetes mellitus, n (%)	12 (37.5%)	4 (12.5%)	Fisher's	0.041
Hypertension, n (%)	14 (43.8%)	9 (28.1%)	χ^2=1.086	0.297
Other comorbidity, n (%)	3 (9.4%)	5 (15.6%)	Fisher's	0.708
Tumour site – Rectum, n (%)	17 (53.1%)	9 (28.1%)	χ^2=3.174	0.075

Neoadjuvant therapy, n (%)	11 (34.4%)	5 (15.6%)	χ^2=2.083	0.149

Operative duration was significantly longer in the laparoscopic group (226.1±37.4 vs 166.3±35.3 minutes, p<0.001, **Table II**), consistent with the added technical steps of a minimally invasive approach. New stoma formation, predominantly ileostomy, was more frequent after laparoscopic resection (40.6% vs 12.5%, p=0.019), reflecting the higher proportion of rectal resections in this group. Intraoperative and postoperative complication rates did not differ significantly between groups (p=0.355 and p=0.213, respectively), although postoperative complications were numerically more frequent after open surgery (28.1% vs 12.5%).

Table II: Operative characteristics and complications (n=64)

Variable	**Laparoscopic (n=32)**	**Open (n=32)**	**Test statistic**	**p-value**
Operative duration, min (mean±SD)	226.1±37.4	166.3±35.3	t=6.581	<0.001
New stoma – none / ileostomy / colostomy, n	19 / 11 / 2	28 / 2 / 2	χ^2=7.954	0.019
Intraoperative complication, n (%)	1 (3.1%)	4 (12.5%)	Fisher's	0.355
Postoperative complication, n (%)	4 (12.5%)	9 (28.1%)	Fisher's	0.213

Median time to readiness for discharge, the primary outcome, was significantly shorter after laparoscopic resection: 3.0 days (IQR 2.0–3.2) versus 4.5 days (IQR 4.0–5.0) after open resection (Mann-Whitney U=139.5, p<0.001, **Table III**). Functional recovery time followed the same pattern (3.0 vs 4.0 days, p<0.001), as did postoperative length of stay (3.7±1.2 vs 5.2±1.3 days, p<0.001) and patient-perceived readiness (3.0 vs 5.0 days, p<0.001). Every individual recovery milestone — oral intake, return of bowel function, oral-analgesic pain control, independent mobility and clinical stability — was achieved significantly earlier after laparoscopic resection (**Figure 1**). Discharge delay, the interval between readiness and actual discharge, was similar in both groups (median 1.0 day in each, p=0.721), indicating that once patients met readiness criteria, the time to actual discharge did not differ by surgical approach.

Table III: Primary and secondary recovery outcomes (Mann-Whitney U test, n=64)

Outcome	**Laparoscopic Median (IQR)**	**Open Median (IQR)**	**Mann-Whitney U**	**p-value**
Functional recovery, POD	3.0 (2.0–3.2)	4.0 (4.0–5.0)	140.0	<0.001
Readiness for discharge, POD (primary outcome)	**3.0 (2.0–3.2)**	**4.5 (4.0–5.0)**	**139.5**	**<0.001**
Postoperative length of stay, days	3.0 (3.0–5.0)	5.0 (4.0–6.0)	202.0	<0.001
Discharge delay, days	1.0 (0.0–1.0)	1.0 (0.0–1.0)	536.0	0.721
Patient-perceived readiness, POD	3.0 (3.0–4.0)	5.0 (4.0–6.0)	135.0	<0.001
Oral intake milestone, POD	2.0 (1.0–2.0)	3.0 (2.0–3.0)	237.5	<0.001
Bowel function milestone, POD	2.0 (2.0–3.0)	4.0 (4.0–5.0)	161.5	<0.001
Pain control milestone, POD	2.0 (1.0–2.2)	3.0 (3.0–4.0)	219.5	<0.001
Independent mobility milestone, POD	1.0 (1.0–2.0)	2.0 (1.0–2.0)	352.5	0.020
Clinical stability milestone, POD	2.0 (1.0–2.0)	3.0 (2.0–3.0)	243.0	<0.001

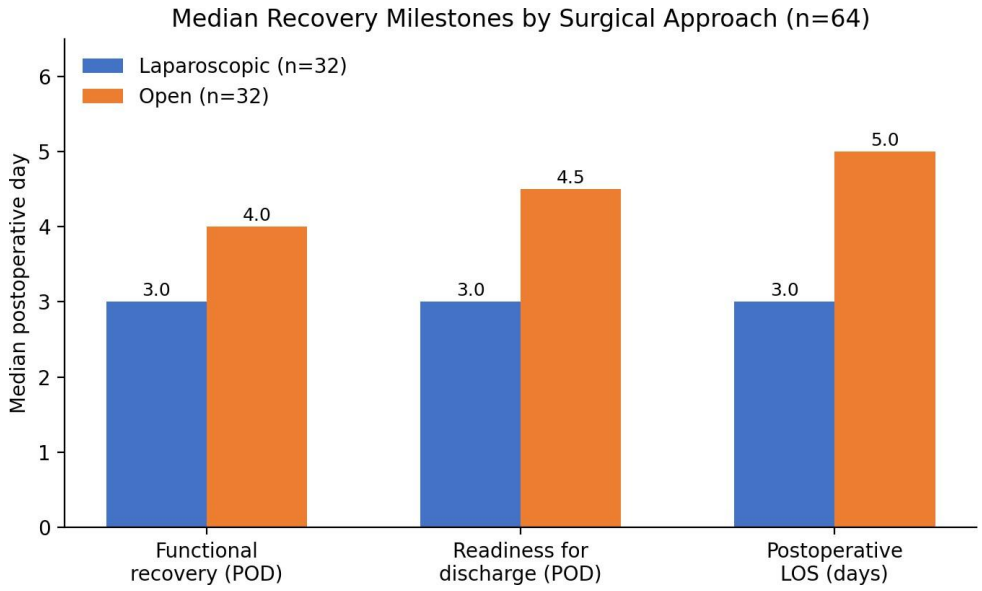


Figure 1: Median functional recovery, readiness for discharge and postoperative length of stay, laparoscopic versus open resection.

Seventy-five percent of laparoscopic patients (24/32) were ready for discharge by postoperative day 3, compared with 12.5% (4/32) after open surgery (χ^2=22.92, p<0.001, **Figure 2**). Patients undergoing laparoscopic resection were six times more likely to be ready for discharge by postoperative day 3 than those undergoing open resection (risk ratio 6.0, 95% CI 2.35–15.33).

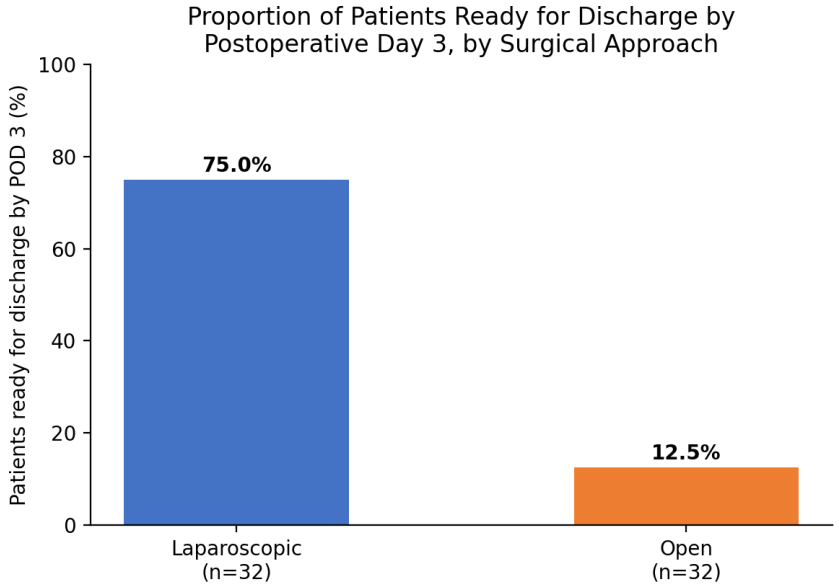


Figure 2: Proportion of patients ready for discharge by postoperative day 3, by surgical approach.

On multivariable linear regression for time to readiness for discharge (**Table IV**), laparoscopic approach remained independently associated with earlier readiness after adjustment for age, ASA grade, tumour site and new stoma formation (β=−1.68 days, 95% CI −2.26 to −1.09, p<0.001). Age, ASA grade, rectal tumour site and stoma formation were not independent predictors of readiness time in this model.

Table IV: Multivariable linear regression for time to readiness for discharge (dependent variable: readiness-for-discharge day)

Predictor	**β coefficient**	**95% CI**	**t**	**p-value**
Constant	3.955	1.704 to 6.206	3.517	0.001
Laparoscopic approach	**−1.677**	**−2.259 to −1.094**	**−5.766**	**<0.001**
Age (years)	0.011	−0.025 to 0.046	0.590	0.557
ASA grade	0.013	−0.405 to 0.431	0.062	0.951
Rectal site (vs colon)	−0.157	−0.828 to 0.514	−0.468	0.642

New stoma formation	0.497	−0.262 to 1.255	1.310	0.195

Model summary: R^2=0.386, Adjusted R^2=0.333, F(5,58)=7.290, p<0.001. Variance inflation factors ranged from 1.07–1.52, indicating no problematic collinearity. In the pre-specified sensitivity model additionally adjusted for diabetes mellitus, the laparoscopic effect was unchanged (β=−1.690 days, 95% CI −2.310 to −1.069, p<0.001), and diabetes was not an independent predictor (p=0.896).

DISCUSSION

This prospective study found that laparoscopic colorectal cancer resection was associated with significantly faster functional recovery, an approximately 1.5-day earlier readiness for discharge, and a shorter postoperative length of stay compared with open resection, and that this advantage persisted after adjustment for age, ASA grade, tumour site and stoma formation. These findings are consistent with the largest available evidence base for this comparison. Braga et al., in a 714-patient enhanced-recovery registry, reported a similar absolute difference in readiness for discharge (4.5 vs 7.1 days)[2], and Balvardi et al. confirmed that readiness for discharge captures recovery information that length of stay alone does not[3]. Our median readiness times of 3.0 and 4.5 days are shorter in absolute terms than these European cohorts, plausibly reflecting differences in baseline patient selection, milestone thresholds and local perioperative practice, but the direction and approximate magnitude of the laparoscopic advantage closely mirror those reports.

The finding that discharge delay — the gap between meeting readiness criteria and actual discharge — was virtually identical between groups (median 1.0 day in each, p=0.721) is, in our view, one of the more informative results of this study. It indicates that the length-of-stay advantage of laparoscopy in our setting was driven almost entirely by faster biological recovery rather than by differential administrative or logistic discharge processing, supporting the construct validity of readiness for discharge as a locally meaningful outcome, as previously argued by Fiore et al. and Tavernier et al.[7,9]. This is consistent with recent work by Ceresoli et al., who found that a successful laparoscopic approach independently favoured earlier recovery even after adjustment for other perioperative variables[4], and with the 2025 outcome-mapping review noting that recovery-focused endpoints remain comparatively under-reported relative to length of stay despite carrying more direct information about patient recovery[5].

Our regression findings add to this picture by showing that the laparoscopic effect on readiness for discharge was robust to adjustment for age, ASA grade, tumour site and stoma formation, and remained essentially unchanged in a sensitivity model that also adjusted for the baseline imbalance in diabetes mellitus. This is reassuring given that rectal tumours and new stoma formation were both numerically more frequent in the laparoscopic group, a pattern also observed in ERAS-based cohorts combining minimally invasive surgery with structured perioperative pathways[10,11]. The comparable rate of postoperative complications between groups in our study is broadly consistent with the safety profile reported in a large 2024 meta-analysis of over 216,000 patients, which found fewer complications and lower 30-day mortality with laparoscopic rectal cancer surgery without compromising resection margins[15], and with the LASRE trial, which demonstrated that laparoscopic resection for low rectal cancer achieves oncological and short-term outcomes non-inferior to open surgery[13,14]. The significantly longer operative duration in our laparoscopic group (226 vs 166 minutes) mirrors the learning-curve and technical-complexity findings widely reported in the literature, and underscores that the recovery advantage of laparoscopy was achieved despite, not because of, a shorter procedure.

Locally, our results extend a small but growing Pakistani experience with laparoscopic colorectal surgery. Series from Shaukat Khanum Memorial Cancer Hospital, Peshawar, have reported low conversion rates, minimal morbidity and favourable short-term recovery with elective laparoscopic colon and rectal cancer resection[20,21,22], but, to our knowledge, none has prospectively compared functional recovery milestones against open surgery within the same institution using a structured daily assessment tool. Our data suggest that a similar recovery advantage is achievable within a Pakistani tertiary-care teaching hospital, supporting the wider adoption of minimally invasive colorectal cancer surgery where surgical expertise and resources allow, and providing a locally derived readiness-for-discharge benchmark that may be useful for perioperative pathway design, bed utilization planning, and patient counselling at JPMC.

This study has several limitations. Operative approach was assigned by routine clinical decision rather than randomization, so residual confounding by unmeasured factors cannot be excluded despite multivariable adjustment; in particular, the imbalance in diabetes mellitus and the non-significant trend toward more rectal tumours and stomas in the laparoscopic group could reflect surgeon case-selection preferences that were only partially captured by the covariates available. The study was conducted at a single centre over a relatively short recruitment period with a modest sample size (n=64), which limits precision for secondary and subgroup comparisons and generalizability to other institutions. Assessors, although not responsible for the discharge decision, could not be fully blinded to operative approach given visible incision differences, which may have introduced subtle bias into milestone assessment. Long-term oncological outcomes, readmission rates and cost-effectiveness were beyond the scope of this study and warrant larger, ideally multicentre and randomized, follow-up investigation.

CONCLUSION

Laparoscopic colorectal cancer resection was independently associated with significantly faster functional recovery and earlier readiness for discharge than open resection at our centre, an advantage not explained by differential discharge processing. Readiness-for-discharge assessment offers a locally relevant, recovery-focused complement to length of stay for evaluating and designing colorectal perioperative pathways.

CONFLICT OF INTEREST / DISCLOSURE

The authors declare no conflict of interest.

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