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Anastomotic leakage and permanent stoma after short- course radiotherapy versus long-course chemoradiotherapy for rectal cancer resection: a retrospective cohort study

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Abstract

Background

Neoadjuvant radiotherapy is widely used for stage II–III rectal cancer but may impair anastomotic healing through chronic vascular injury and tissue fibrosis. Whether the lower total radiation dose delivered with short-course radiotherapy (SCRT) reduces anastomotic leakage or permanent stoma formation compared with long-course chemoradiotherapy (LCCRT) remains uncertain.

Methods

This retrospective cohort study included patients with stage II–III rectal adenocarcinoma treated at a tertiary referral center between 2011 and 2024. Patients receiving SCRT or LCCRT followed by restorative minimally invasive rectal resection were compared. Patients undergoing abdominoperineal resection, Hartmann's procedure, total pelvic exenteration, TaTME, upfront surgery, or planned open surgery were excluded. The primary outcomes were anastomotic leakage and permanent stoma formation; secondary outcomes included factors associated with permanent stoma and oncological outcomes.

Results

The analysis included 171 patients: 66 received SCRT and 105 received LCCRT. Baseline characteristics were generally comparable, although low rectal tumors were more frequent in the LCCRT group. Anastomotic leakage rates were similar between the SCRT and LCCRT groups (7.6% vs. 8.6%; p = 0.817), as were permanent stoma rates (7.6% vs. 11.4%; p = 0.412). On multivariable analysis, LCCRT was not independently associated with anastomotic leakage (adjusted odds ratio [aOR], 1.22; 95% confidence interval [CI], 0.39–3.86; p = 0.730) or permanent stoma formation (aOR, 1.90; 95% CI, 0.61–5.87; p = 0.265). Higher ypStage was independently associated with permanent stoma formation. Three-year overall survival and local recurrence-free survival did not differ significantly between the groups.

Conclusions

The lower total radiation dose delivered with SCRT did not result in a detectable reduction in anastomotic leakage or permanent stoma formation compared with LCCRT. Permanent stoma formation was associated with advanced post-treatment pathological stage. Larger prospective studies are needed to confirm these findings.

Introduction

Colorectal cancer is the third most commonly diagnosed malignancy and the second leading cause of cancer-related death worldwide(1). Rectal cancer poses particular therapeutic challenges because of its location within the narrow pelvic cavity, where achieving adequate local disease control while preserving adjacent pelvic organs can be difficult(2). For patients with clinical stage II–III rectal cancer, multimodal treatment incorporating neoadjuvant therapy followed by total mesorectal excision has therefore become an established treatment strategy(3).

Neoadjuvant treatment for rectal cancer has evolved considerably. Conventional approaches include short-course radiotherapy (SCRT), typically delivered as 25 Gy in five fractions, and long-course chemoradiotherapy (LCCRT), generally consisting of 45–50.4 Gy with concurrent fluoropyrimidine-based chemotherapy. More recently, total neoadjuvant therapy has incorporated systemic chemotherapy with either SCRT or LCCRT. Trials such as RAPIDO, PRODIGE-23, and OPRA have demonstrated favorable tumor response and disease-control outcomes with different treatment sequences and radiation schedules (4–6).

Despite its oncological benefits, pelvic radiotherapy may impair tissue perfusion and healing through vascular injury, inflammation, and fibrosis(7, 8). These changes may adversely affect anastomotic integrity and contribute to anastomotic

leakage, delayed stoma reversal, and permanent stoma formation after rectal resection(9). Concerns regarding the long-term functional effects of pelvic radiotherapy have also stimulated interest in treatment de-escalation. In appropriately selected patients, upfront surgery or neoadjuvant chemotherapy with selective use of radiotherapy has produced favorable oncological outcomes, highlighting the importance of balancing tumor control against treatment-related morbidity(10–13).

Although SCRT delivers a lower total radiation dose than LCCRT, whether this difference translates into improved anastomotic healing or a reduced risk of permanent stoma remains uncertain. We therefore compared postoperative and oncological outcomes between patients receiving SCRT and those receiving LCCRT before minimally invasive low anterior resection for stage II–III rectal cancer. The primary outcomes were anastomotic leakage and permanent stoma formation, while secondary outcomes included the identification of associated risk factors of permanent stoma and oncological outcomes.

Material and Methods

Study design and patient selection

This retrospective cohort study included patients with stage II–III rectal adenocarcinoma treated at Taichung Veterans General Hospital between January 1, 2011 and October 31, 2024. Patients were identified from the institutional Cancer Registry. During the study period, 2,331 patients with rectal cancer were registered. Patients with stage 0–I or stage IV disease were excluded, as were those who underwent local excision or a watch-and-wait strategy, had incomplete or unclear medical records, had an ASA physical status of IV, or discontinued radiotherapy because of treatment-related complications.

For the present analysis, we included patients who received neoadjuvant SCRT or LCCRT followed by restorative minimally invasive rectal resection. Patients undergoing abdominoperineal resection, Hartmann's procedure, or total pelvic exenteration were excluded because bowel continuity was not restored. Patients who underwent upfront surgery, planned open surgery, or TaTME were also excluded. Conversion from minimally invasive to open surgery was not an exclusion criterion. TaTME procedures were excluded because they were predominantly performed during the early institutional adoption period and could introduce confounding related to the surgical learning curve.

Patients were categorized according to the neoadjuvant radiotherapy regimen received. The final analysis included 171 patients: 66 in the SCRT group and 105 in the LCCRT group. Surgical, pathological, postoperative, stoma-related, and oncological outcomes were compared between the groups (Figure 1).

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2.2 Neoadjuvant treatment strategies

Short-course radiotherapy (SCRT) consisted of a total radiation dose of 25–30 Gy delivered in five fractions, generally administered on five consecutive treatment days. Treatment interruptions due to weekends, public holidays, institutional non-operating days, or equipment-related issues were permitted, with subsequent fractions delivered on the next available treatment day. The timing of surgery after SCRT varied according to the planned treatment strategy. Patients receiving SCRT alone underwent either early or delayed surgery, whereas those treated using a total neoadjuvant therapy (TNT) strategy received systemic chemotherapy before definitive surgery.

Long-course chemoradiotherapy (LCCRT) consisted of 45–50.4 Gy delivered in 25–28 fractions with concurrent fluoropyrimidine-based chemotherapy using capecitabine or 5-fluorouracil. In patients receiving conventional LCCRT, surgery was generally performed 6–8 weeks after completion of chemoradiotherapy. For patients treated with a TNT approach, SCRT or LCCRT was followed by at least four cycles of FOLFOX before definitive surgery.

The choice of radiotherapy strategy, timing of surgery, and incorporation of TNT was determined through multidisciplinary team discussion according to tumor characteristics, patient condition, and contemporary treatment protocols. The radiotherapy-to-surgery interval was defined as the number of days from the final fraction of radiotherapy to the date of definitive surgery.

2.3 Surgical techniques

All patients underwent restorative rectal resection with an intended minimally invasive approach using either laparoscopic or robotic surgery. Robotic surgery was increasingly adopted during the later study period, particularly after 2020(14, 15). Rectal dissection was performed according to the principles of sharp mesorectal excision, with meticulous dissection along the embryological plane to preserve the integrity of the mesorectal fascia and adjacent autonomic nerves(16). Total mesorectal excision (TME) was performed for mid- and low-rectal tumors, whereas tumor-specific mesorectal excision was performed for more proximal tumors when appropriate.

Following rectal transection, bowel continuity was restored predominantly using a **double-stapling technique** with a circular stapler. The level of rectal transection and anastomosis was determined according to tumor location and the ability to achieve an adequate oncological margin while preserving sphincter function. A diverting stoma, predominantly a **loop ileostomy**, was routinely constructed for low colorectal anastomosis and was selectively performed for higher anastomoses according to intraoperative findings, tissue condition, and the operating surgeon's assessment of anastomotic risk.

All procedures were performed by dedicated colorectal surgeons at a high-volume tertiary referral center. Postoperative management followed standardized institutional care pathways. Anastomotic leakage and postoperative complications were assessed during the index admission and subsequent follow-up according to predefined study criteria. Postoperative management followed the institutional care pathway. An enhanced recovery after surgery (ERAS) protocol was progressively implemented from **2021 onward**; patients treated before its implementation received conventional postoperative care(14, 15, 17).

2.4 Outcomes and definitions

Baseline demographic and clinical variables included age, sex, body mass index (BMI), clinical stage, tumor location, radiotherapy regimen, radiation dose, chemotherapy regimen, use of TNT, and the interval between completion of radiotherapy and surgery. Operative variables included conversion to open surgery, operative time, estimated blood loss, high ligation of the inferior mesenteric artery, and stoma creation, categorized as protective or salvage. Pathological variables included pathological stage, circumferential resection margin status, and tumor regression grade (TRG).

Postoperative complications occurring within 90 days after surgery were recorded and classified as minor (Clavien–Dindo grades I–II) or major (grades III–V). Anastomotic leakage was diagnosed based on clinical and/or radiological findings and graded according to the International Study Group of Rectal Cancer classification. Grade A leakage required no active therapeutic intervention; grade B leakage required active therapeutic intervention but could be managed without surgical reoperation; and grade C leakage required surgical reoperation.

2.5 Follow-up

Permanent stoma was defined as a stoma that remained in place at the end of follow-up, was re-created after initial closure because of postoperative complications or disease recurrence, or was considered irreversible because of unacceptable bowel function, including severe low anterior resection syndrome. The reasons for permanent stoma formation were recorded.

Overall survival was calculated from the initiation of radiotherapy to death from any cause. Local recurrence-free survival was calculated from the initiation of radiotherapy to local recurrence or death, whichever occurred first. Patients without an event were censored on the date of their last follow-up.

2.6 Statistical analysis

Continuous variables are presented as mean ± standard deviation or median with interquartile range, as appropriate. Comparisons between the two groups were performed using the independent-samples *t* test or Mann–Whitney *U* test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate.

Univariable and multivariable logistic regression analyses were performed to identify factors associated with anastomotic leakage and permanent stoma formation. Results are presented as odds ratios and adjusted odds ratios, respectively, with 95% confidence intervals. Clinically relevant variables and variables with a p value < 0.10 in univariable analysis were considered for inclusion in the multivariable models. The radiotherapy regimen was retained in each model as the primary exposure of interest.

Survival outcomes were estimated using the Kaplan–Meier method and compared between groups using the log-rank test. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA), and R, version 4.1.3. All tests were two-sided, and a p value < 0.05 was considered statistically significant.

This study was reported in accordance with the STROCSS 2025 guidelines and complies with the TITAN 2025 recommendations(18, 19).

2.7 Ethics

Ethical approval was obtained from the institutional review board (IRB number: CE24540A), and registered at ClinicalTrials.gov (Identifier: NCT06713824). The requirement for informed consent was waived owing to the retrospective design of the study.

Results

3.1 Patients characteristics

Between January 1, 2011, and October 31, 2024, 2,331 patients with rectal cancer were registered at our institution. After excluding 418 patients with stage 0–I disease and 468 with stage IV disease, 1,445 patients with stage II–III disease remained. Further exclusions were abdominoperineal resection (n = 72), local excision (n = 46), watch-and-wait management (n = 173), incomplete or unclear records (n = 143), ASA physical status IV (n = 6), upfront surgery (n = 782), radiotherapy discontinuation (n = 1), TaTME (n = 25), and planned open surgery (n = 21) and Hartmann procedures (n = 5). The final cohort comprised 66 patients treated with SCRT and 105 treated with LCCRT followed by restorative minimally invasive rectal resection (Fig. 1). Baseline demographic and clinical characteristics were comparable except for tumor location and the interval between completion of radiotherapy and surgery. Low rectal tumors were more common in the LCCRT group than in the SCRT group (61.0% vs. 40.9%, p = 0.028). The median interval from completion of radiotherapy to surgery was shorter in the SCRT group (11.5 vs. 64.0 days, p < 0.001) (Table 1).

Table 1
Baseline demographic and clinical characteristics of the study population

Gender	**SCRT(n = 66)**		**LCCRT (n = 105)**		***p* value**
					0.178
Female	20	(30.3%)	35	(33.3%)	
Male	46	(69.7%)	70	(66.7%)	
Age	61.0	(52.0-68.3)	60.0	(49.0-69.5)	0.381
BMI	23.6	(21.9–25.1)	23.5	(21.5–26.9)	0.709
ASA					0.845
1	9	(13.6%)	17	(16.2%)	
2	43	(65.2%)	64	(61.0%)	
3	14	(21.2%)	24	(22.9%)	
clinical stage					0.959
II	23	(34.8%)	37	(35.2%)	
III	43	(65.2%)	68	(64.8%)	
Lesion site					0.028*
upper	6	(9.1%)	9	(8.6%)	
middle	33	(50.0%)	32	(30.5%)	
low	27	(40.9%)	64	(61.0%)	
TNT Strategy	19	(28.8%)	28	(26.7%)	0.762
wait after surgery, day	11.5	(3.8–69.3)	64.0	(46.0-92.5)	< 0.001**
wait period					< 0.001**
0-4wk	38	(57.6%)	3	(2.9%)	
4-10wk	13	(19.7%)	58	(55.2%)	
> 10 wk	15	(22.7%)	44	(41.9%)	
Cigeratte	3	(4.5%)	7	(6.7%)	0.743
Alcohol	1	(1.5%)	1	(1.0%)	1.000
CAD+ PAOD	0	(0.0%)	2	(1.9%)	0.523
CVA	4	(6.1%)	3	(2.9%)	0.431
DM	17	(25.8%)	16	(15.2%)	0.090
Chi-square test/Fisher's exact test or Mann-Whitney U test, Median(IQR). *$p < 0.05$, **$p < 0.01$					

3.2 Surgical and pathological outcomes

Operative time, conversion to open surgery, blood loss, blood transfusion, length of hospital stay, and protective diversion rates did not differ significantly between the groups. Pathological stage, circumferential resection margin positivity, and distal resection margin were also comparable. The median number of harvested lymph nodes was lower in the LCCRT group than in the SCRT group (15.0 vs. 20.0, $p < 0.001$). Among patients with available TRG data, complete or near-complete tumor regression (TRG 0–1) was more common after LCCRT than after SCRT (42.9% vs. 12.1%, $p < 0.001$) (Table 2).

Table 2
Operative, pathological, and postoperative outcomes

MIS convert to Open	**SCRT(n = 66)**		**LCCRT (n = 105)**		***p* value**
	0	**(0.0%)**	**3**	**(2.9%)**	**0.285**
Operation time					
median	311.5	(268.0-390.2)	298.0	(225.0-389.5)	0.211
Blood loss					
Median	30.0	(30.0-100.0)	30.0	(30.0-125.0)	0.204
Bood transfusion	1	(1.5%)	4	(3.8%)	0.650
Hospital stay					
Man	9.5	± 6.3	9.8	± 8.2	0.809
Mdian	7.5	(5.0-11.3)	7	(6–10)	0.935
High ligation	64	(97.0%)	96	(91.4%)	0.207
yp stage					0.552
0-I	23	(34.8%)	43	(41.0%)	
II	17	(25.8%)	29	(27.6%)	
III	26	(39.4%)	33	(31.4%)	
LN harvested	20.0	(15.8–27.3)	15.0	(12.0–20.0)	< 0.001**
CRM positive	4	(6.1%)	6	(5.7%)	1.000
Distal cut end (cm)	1.9	(1.0–3.0)	2.0	(1.0-3.5)	0.471
TRG					< 0.001**
0	5	(7.6%)	24	(22.9%)	
1	3	(4.5%)	21	(20.0%)	
2	25	(37.9%)	38	(36.2%)	
3	14	(21.2%)	11	(10.5%)	
NA	19	(28.8%)	11	(10.5%)	
Protected Diversion	59	(89.4%)	99	(94.3%)	0.240
Salvage Diversion	0	(0.0%)	1	(1.0%)	1.000
Any complications	37	(56.1%)	53	(50.5%)	0.476
Minor complications	32	(48.5%)	45	(42.9%)	0.471
Major complications	5	(7.6%)	8	(7.6%)	0.992
Mortality	1	(1.5%)	1	(1.0%)	1.000
Leakage	5	(7.6%)	9	(8.6%)	0.817
Diagnosed by clinical	5	(100.0%)	9	(100.0%)	--
Diagnosed by image	4	(80.0%)	8	(88.9%)	1.000
ISREC					0.752

MIS convert to Open	SCRT(n = 66)		LCCRT (n = 105)		*p* value
	0	**(0.0%)**	**3**	**(2.9%)**	**0.285**
ISREC Gr A	1	(20.0%)	3	(33.3%)	
ISREC Gr B	2	(40.0%)	2	(22.2%)	
ISREC Gr C	2	(40.0%)	4	(44.4%)	
Chi-square test/Fisher's exact test or Mann-Whitney U test, Median(IQR). *$p < 0.05$, **$p < 0.01$					

3.3 Anastomotic leakage and permanent stoma

The rates of overall, minor, and major postoperative complications were comparable between the groups. Anastomotic leakage occurred in 5 patients (7.6%) in the SCRT group and 9 patients (8.6%) in the LCCRT group (p = 0.817). The distribution of ISREC leakage grades was also similar between the groups (p = 0.752). Permanent stoma occurred in 5 patients (7.6%) in the SCRT group and 12 patients (11.4%) in the LCCRT group (p = 0.412) (Table 2). Permanent stoma due to surgical complications was similar in both groups. Disease progression accounted for one permanent stoma in the SCRT group and five in the LCCRT group. However, the distribution of reasons for permanent stoma did not differ significantly between the groups (Table 3).

Table 3
Follow-up, permanent stoma formation, and reasons for permanent stoma

Follow time, month	SCRT(n = 66)		LCCRT (n = 105)		*p* value
	26.5	**(15.4–42.3)**	**41.7**	**(21.6–85.7)**	**< 0.001****
Permanent stoma	5	(7.6%)	12	(11.4%)	0.412
Reasons					0.793
Without stoma	61	(92.4%)	93	(88.6%)	
PD (disease progression)	1	(1.5%)	5	(4.8%)	
Complications	3	(4.5%)	5	(4.8%)	
LARS	1	(1.5%)	2	(1.9%)	
Chi-square test/Fisher's exact test or Mann-Whitney U test, Median(IQR). *$p < 0.05$, **$p < 0.01$					

3.4 Risk for Anastomosis leakage and permanent stoma

On multivariable logistic regression, LCCRT was not independently associated with anastomotic leakage compared with SCRT (adjusted odds ratio [aOR], 1.22; 95% confidence interval [CI], 0.39–3.86; p = 0.730). Similarly, LCCRT was not independently associated with permanent stoma formation (aOR, 1.90; 95% CI, 0.61–5.87; p = 0.265). Compared with ypStage 0–I, both ypStage II (aOR, 5.38; 95% CI, 1.05–27.66; p = 0.044) and ypStage III (aOR, 5.52; 95% CI, 1.10–27.74; p = 0.038) were independently associated with higher odds of permanent stoma formation (Table 4).

Table 4a. Factors associated with anastomotic leakage: univariable and multivariable logistic regression analyses								
	Univariate				Multivariable			
	OR	95%CI		*p* value	OR	95%CI		*p* value
Male	1.82	(0.49-	6.79)	0.375	1.92	(0.51-	7.25)	0.337
Age	1.03	(0.98-	1.08)	0.211	1.03	(0.98-	1.08)	0.188
ASA								
1	Reference							
2	--							
3	--							
clinical stage								
II	Reference							
III	1.39	(0.42-	4.62)	0.595				
Lesion site								
upper	Reference							
middle	0.19	(0.03-	1.08)	0.061				
low	0.39	(0.09-	1.66)	0.200				
Cigarette	1.26	(0.15-	10.78)	0.830				
Alcohol	--							
CAD+ PAOD	--							
CVA	--							
DM	2.56	(0.80-	8.22)	0.114				
blood loss	1.00	(1.00-	1.00)	0.244				
p stage								
0-1	Reference							
2	0.85	(0.19-	3.75)	0.831				
3	1.38	(0.40-	4.78)	0.611				
LN harvested	1.00	(0.94-	1.07)	0.892				
distal cut end (cm)	0.92	(0.68-	1.24)	0.574				
TRG								
0-1	Reference							
2	2.20	(0.41-	11.82)	0.359				
3	2.22	(0.29-	16.73)	0.440				
Group								
SCRT	Reference				Reference			
LCCRT	1.14	(0.37-	3.57)	0.817	1.22	(0.39-	3.86)	0.730

Logisitc regression. *p<0.05, **p<0.01.

Table 4b. Factors associated with permanent stoma: univariable and multivariable logistic regression analyses								
	Univariate				Multivariable2			
	OR	95%CI		*p* value	OR	95%CI		*p* value
Male	2.38	(0.65-	8.65)	0.188	2.69	(0.71-	10.16)	0.144
Age	1.02	(0.98-	1.07)	0.281	1.02	(0.98-	1.07)	0.312
ASA								
1	Reference							
2	0.84	(0.16-	4.30)	0.834				
3	3.20	(0.62-	16.49)	0.164				
clinical stage								
II	Reference							
III	2.74	(0.76-	9.95)	0.125				
Lesion site								
upper	Reference							
middle	0.56	(0.13-	2.43)	0.440				
low	0.28	(0.06-	1.28)	0.101				
Cigarette	1.01	(0.12-	8.47)	0.995				
Alcohol	--							
CAD+ PAOD	9.56	(0.57-	160.31)	0.116				
CVA	1.54	(0.17-	13.62)	0.697				
DM	0.89	(0.24-	3.28)	0.856				
blood loss	1.00	(1.00-	1.00)	0.089				
p stage					Reference			
0-1	Reference				5.38	(1.05-	27.66)	0.044*
2	5.74	(1.14-	29.06)	0.035*	5.52	(1.10-	27.74)	0.038*
3	5.02	(1.02-	24.68)	0.047*				
LN harvested	1.03	(0.97-	1.09)	0.320				
distal cut end (cm)	0.97	(0.75-	1.24)	0.784				
TRG								
0-1	Reference							
2	7.56	(0.91-	62.58)	0.061				
3	7.09	(0.70-	71.97)	0.098				
Group								
SCRT	Reference				Reference			
LCCRT	1.57	(0.53-	4.69)	0.415	1.90	(0.61-	5.87)	0.265

OR, odds ratio; CI, confidence interval. SCRT was the reference category for radiotherapy regimen. *P < 0.05; **P < 0.01.

3.5 oncological outcomes

The median follow-up was shorter in the SCRT group than in the LCCRT group (26.5 vs. 41.7 months, p < 0.001). The three-year overall survival rates were 88.7% in the SCRT group and 89.5% in the LCCRT group (log-rank p = 0.904) (Fig. 2a). The corresponding three-year local recurrence-free survival rates were 84.4% and 80.6%, respectively (log-rank p = 0.790) (Fig. 2b). No statistically significant differences in overall survival or local recurrence-free survival were observed between the groups.

Discussions

In this retrospective study, we collected data from patients with stage II–III rectal cancer who received either SCRT or LCCRT followed by restorative minimally invasive rectal resection. We examined whether the lower total radiation dose delivered with SCRT was associated with fewer postoperative complications, particularly anastomotic leakage and permanent stoma formation. No significant differences in anastomotic leakage or permanent stoma rates were observed between the two groups. After adjustment for potential confounders, LCCRT was not independently associated with either outcome. In contrast, higher post-treatment pathological stage was independently associated with permanent stoma formation. Three-year overall survival and local recurrence-free survival also did not differ significantly between the SCRT and LCCRT groups.

Hauer-Jensen et al. described pelvic radiotherapy–induced endothelial dysfunction, microvascular sclerosis, chronic inflammation, and progressive tissue fibrosis, providing a biological basis for impaired tissue perfusion and healing(8). Although SCRT delivers a lower total radiation dose than LCCRT, its higher dose per fraction may still exert substantial biological effects on late-responding tissues. Consequently, the lower total dose of SCRT may not necessarily result in less microvascular injury or fibrosis, or in improved anastomotic healing. This radiobiological consideration may partly explain why SCRT was not associated with lower rates of anastomotic leakage or permanent stoma formation in our study.

Back et al. developed a multivariable prediction model for stoma status two years after anterior resection in a large population-based cohort. Preoperative radiotherapy was independently associated with a higher likelihood of having a stoma at two years, together with factors including higher clinical T and M categories, lower tumor height, and defunctioning stoma formation(9). These findings highlight the relevance of neoadjuvant treatment and baseline disease characteristics when assessing subsequent stoma status. Our study addressed a different question by comparing SCRT with LCCRT among patients who all received neoadjuvant radiotherapy and underwent restorative minimally invasive rectal resection. Therefore, our findings do not negate the association reported by Back et al.; rather, they indicate that within this irradiated cohort, we did not detect a significant difference in anastomotic leakage or permanent stoma between the two radiotherapy regimens. The LCCRT group included more low rectal tumors (61.0% vs. 40.9%) and numerically more cT4 tumors than the SCRT group (7.6% [8/105] vs. 4.5% [3/66]), and the limited number of events means that a clinically relevant difference cannot be excluded. The two studies also used different stoma outcomes, as Back et al. assessed any stoma at two years, whereas we evaluated permanent stoma over follow-up.

Den Dulk et al. reported that postoperative complications and secondary stoma formation were major barriers to stoma reversal(20). In our study, LCCRT was not independently associated with permanent stoma formation, whereas higher ypStage was a significant risk factor. In the context of the increasing use of different TNT regimens, these findings suggest that SCRT does not offer a detectable advantage over LCCRT in reducing anastomotic leakage or overall postoperative morbidity. Failure to restore bowel continuity appeared to be more closely related to persistent or recurrent disease and the need for ongoing systemic treatment than to the radiotherapy regimen itself. Higher ypStage may reflect a greater residual disease burden and a poorer response to neoadjuvant treatment, thereby reducing the likelihood of subsequent stoma reversal.

Furthermore, three-year OS and LRFS were similar between the SCRT and LCCRT groups, suggesting comparable oncological control during the observed follow-up period. However, the shorter follow-up in the SCRT group precludes firm conclusions regarding long-term equivalence. Therefore, the choice between SCRT and LCCRT should not be based primarily on concerns

regarding anastomotic leakage. Instead, treatment selection should consider tumor stage and location, anticipated treatment response, patient fitness, treatment accessibility, and the overall multidisciplinary treatment strategy.

This study has several limitations. First, its retrospective design introduced the possibility of selection bias and residual confounding. Patients in the LCCRT group more frequently had low rectal tumors and may have had more locally advanced disease. Second, the limited sample size and small number of leakage and permanent stoma events reduced the statistical power to detect modest but clinically relevant differences between the two regimens, as reflected by the wide confidence intervals. Third, the follow-up duration differed between the groups and may have affected the assessment of permanent stoma and long-term oncological outcomes. Finally, detailed long-term radiation-related toxicity and bowel function were not routinely recorded. Future prospective studies should include longer follow-up and validated functional assessments, such as the LARS and Wexner scores, to provide a more comprehensive comparison of the long-term effects of SCRT and LCCRT.

Conclusions

No statistically significant differences in anastomotic leakage or permanent stoma formation were detected between SCRT and LCCRT in patients undergoing minimally invasive rectal resection. Higher ypStage, rather than radiotherapy regimen, was independently associated with permanent stoma formation. The lower total radiation dose delivered with SCRT did not translate into a detectable reduction in postoperative complications; therefore, the choice of radiotherapy regimen should remain primarily guided by oncological considerations. Larger prospective studies with longer follow-up are required to confirm these findings and evaluate long-term functional outcomes.

Declarations

Funding

No external funding was received for this study.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

Ethical approval was obtained from the institutional review board (IRB number: CE24540A), and registered at ClinicalTrials.gov (Identifier: NCT06713824).

Consent

Patient consent was waived due to the retrospective design of this study, which was approved by the Institutional Review Board.

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Figures

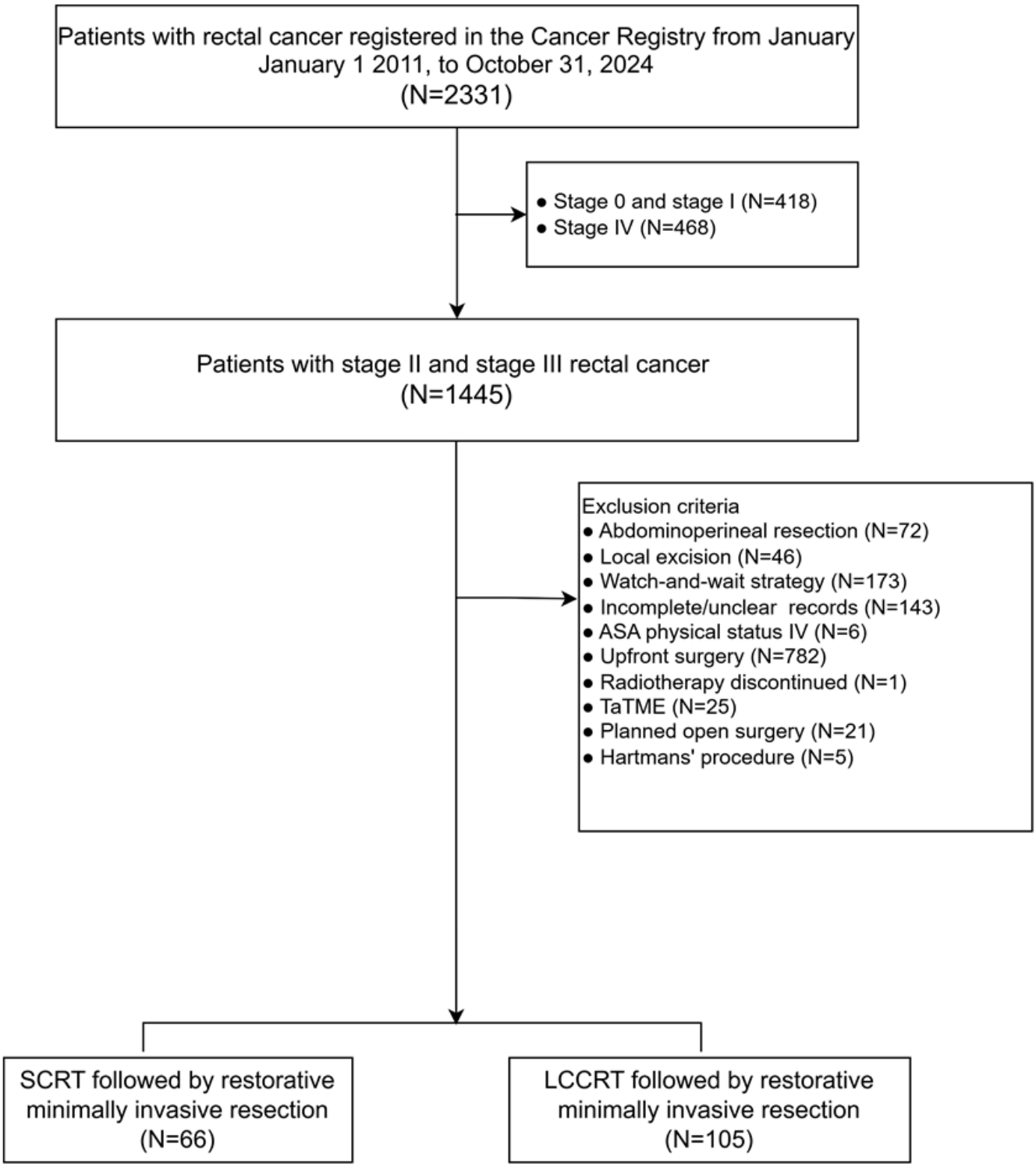
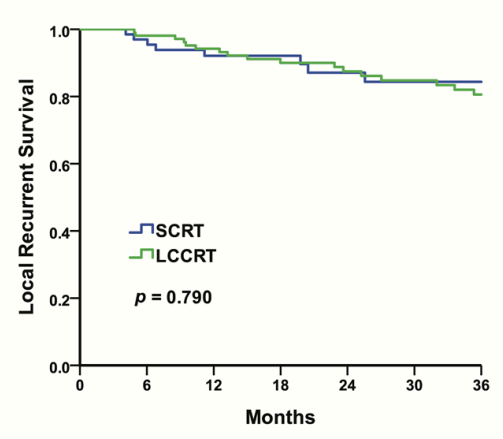


Figure 1

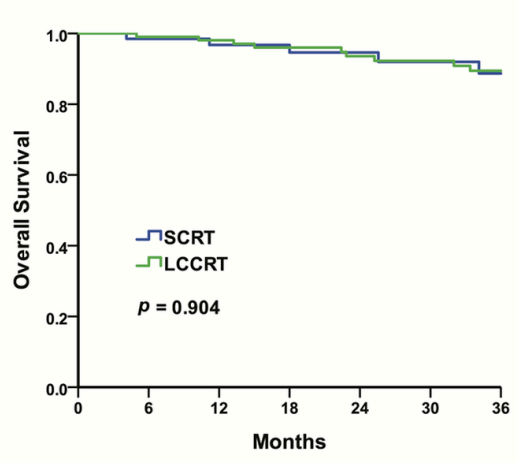
Flow diagram of patient selection and cohort formation. SCRT, short-course radiotherapy; LCCRT, long-course chemoradiotherapy.

Figure 2a



Local recurrence-free survival after SCRT or LCCRT								
	Total	LR/Death	Censored		Survival rate			p for log rank
			n	%	1y	2y	3y	
Group								0.790
SCRT	66	8	58	(87.9%)	92.1%	87.1%	84.4%	
LCCRT	105	17	88	(83.8%)	94.2%	87.5%	80.6%	
Survival estimates were calculated using the Kaplan–Meier method. Between-group differences were assessed using the log-rank test. LR, local recurrence; SCRT, short-course radiotherapy; LCCRT, long-course chemoradiotherapy.								

Figure 2b



Overall survival after SCRT or LCCRT								
	Total	Death	Censored		Survival rate			p for log rank
			n	%	1y	2y	3y	
Group								0.904
SCRT	66	5	61	(92.4%)	96.8%	94.6%	88.7%	
LCCRT	105	9	96	(91.4%)	98.1%	93.6%	89.5%	
Survival estimates were calculated using the Kaplan–Meier method. Between-group differences were assessed using the log-rank test. SCRT, short-course radiotherapy; LCCRT, long-course chemoradiotherapy.								

Figure 2

a. Kaplan–Meier curves for local recurrence-free survival (LRFS) in patients treated with SCRT or LCCRT. The between-group difference was assessed using the log-rank test.

b. Kaplan–Meier curves for overall survival (OS) in patients treated with SCRT or LCCRT. The between-group difference was assessed using the log-rank test.