

Review

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Open or laparoscopic resection: does approach matter?

Ebru Esen¹, Cihangir Akyol²

¹Department of General Surgery, Health Sciences University Konya Training and Research Hospital, Konya 42090, Turkey.

²Department of General Surgery, Ankara University School of Medicine, Ankara 06230, Turkey.

Correspondence to: Dr. Cihangir Akyol, Department of General Surgery, Ankara University School of Medicine, Ankara, 06230 Turkey. E-mail: cihangirakyol@gmail.com

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Abstract

In colon cancer surgery, laparoscopic resection is a safer and more feasible method than open resection; however, despite its increasing popularity in recent years, laparoscopic approaches for the treatment of rectal cancer have not become a standard therapy option, due to the technical difficulties in gaining access to the deep and narrow pelvis and the steep learning curve. Multiple randomized trials found that short-term oncological outcomes and perioperative mortality and morbidity were comparable between laparoscopic and open rectal surgery, whereas comparative data between the two approaches. Comparative data between the two approaches on long-term oncological outcomes remain limited. In this review, we summarize the current status of laparoscopic surgery in rectal cancer in the light of recent studies.

Keywords: Laparoscopy, rectal cancer, oncological outcome, physiological outcome

INTRODUCTION

Colorectal cancer is one of the most commonly diagnosed cancers worldwide and is responsible for approximately 750,000 cancer-related deaths annually^[1]. Approximately 30% of colorectal adenocarcinomas originate from the rectum. In a multidisciplinary approach that combines chemotherapy with radiotherapy for the treatment of colorectal cancer, surgery remains the primary treatment option. The most significant improvement in rectal surgery was the widespread implementation of the total mesorectal excision (TME) technique, first described by Heald *et al.*^[2] in 1982, which led to a reduction in locoregional recurrence rates from 25% in the 1980s to under 4% today^[1].



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The first successful use of laparoscopy in colorectal surgery was by Jacobs *et al.*^[3], published in 1991. Laparoscopic surgery has numerous benefits, such as shorter length of hospitalization, reduced postoperative pain, and improved recovery^[4-6]. Although many studies showed that the outcomes of laparoscopic and open colon surgery were similar^[6,7-10], similar comparative outcomes have not been clearly demonstrated in laparoscopic rectal surgery. Concerns regarding laparoscopic rectal surgery are port-site and abdominal wall metastases and local oncological clearance^[11-15]. In addition, laparoscopic rectal surgery has a challenging learning curve because of the deep and narrow pelvis and its assist-dependent procedure^[16].

Current data comparing long-term oncological outcomes between open and laparoscopic rectal surgery are insufficient; therefore, laparoscopy is not accepted as a gold standard in rectal surgery. This review aims to summarize the oncological and physiological outcomes with laparoscopic and open rectal surgery based on the results of recent studies.

Importance of TME

Significant improvements were observed in oncological outcomes with TME since its introduction by Heald *et al.*^[2] in 1982 and subsequent standardization in rectal cancer surgery. With the TME technique, the locoregional recurrence rate of 25% in the 1980s has been successfully reduced to 4% currently. Nagtegaal and van Krieken^[17] reported that the local recurrence rate of 36% with incomplete mesorectal excision was decreased to 20% with complete TME. Kapiteijn *et al.*^[18] compared the outcomes of conventional rectal surgery and TME and found that both local control and survival were improved in the TME group.

TME should be routinely performed to improve oncological results in both laparoscopic and open rectal surgery. Laparoscopic TME is a difficult technique to implement in the deep and narrow pelvis and has a steep learning curve. Several studies reported that at least 50 laparoscopic TME should be performed to achieve proficiency and consistent results^[19-21], and the conversion rate decreases between 151 and 200 cases. Male sex and T staging of cancer are major risk factors affecting the learning curve^[14]. The most important concerns regarding laparoscopic TME are postoperative morbidity and oncological outcomes. One of the most important steps for the correct implementation of TME is dissection of the mesorectum from the parietal and visceral fascia. Laparoscopy provides visualization of this plan and neurovascular structures through a magnified and clean vision.

Short-term oncological outcomes

The use of TME for rectal cancer has led to many favorable results. Blunt dissection commonly performed in the pelvis before the TME era often resulted in inadequate resection of the mesorectum. Quirke *et al.*^[22] reported lateral surgical margin positivity in 14 of the 52 patients who achieved surgical cure and a local recurrence of 85% in those with positive margins. In contrast, in 1998, Heald *et al.*^[23] reported 5- and 10-year local recurrence rates of only 3% and 4%, respectively, among 405 patients who underwent curative resection with TME; the 5- and 10-year disease-free survival rates were 80% and 78%, respectively, in this cohort. In a recent study by Maurer *et al.*^[24], where the patients were followed for a minimum of 7 years, TME reduced rectal cancer recurrence from 20.8% to 5.9%.

Local recurrence is closely associated with several objectively measurable oncological parameters such as completeness of TME, involvement of the circumferential surgical margin (CRM), and number of harvested lymph nodes (HLNs). Prospective randomized trials included Colorectal Cancer Laparoscopic or Open Resection (COLOR) II trial, Conventional versus Laparoscopic-assisted Surgery in Patients with Colorectal Cancer (MRC CLASICC) trial, Open versus laparoscopic surgery for mid-rectal or low-rectal cancer after neoadjuvant chemoradiotherapy (COREAN) trial, ACOSOG Z6051 trial, Australian Laparoscopic Cancer of the Rectum (ALaCaRT) trial; retrospective studies, and meta-analyses evaluated the oncological outcomes of open and laparoscopic rectal surgery. In retrospective studies, laparoscopic rectal surgery was reported to be a generally safe and feasible procedure^[25,26].

In the randomized COLOR II trial including 1103 patients with rectal cancer, although the duration of laparoscopic surgery was longer than that of open surgery (240 min *vs.* 188 min), blood loss was significantly less (200 mL *vs.* 400 mL), and the length of hospital stay was shorter (8 days *vs.* 9 days)^[27]. There were no significant differences in the rate of CRM positivity, number of HLNs, or distal surgical margins between the two groups.

In the CLASSIC trial that included 27 UK centers and 381 patients with rectal cancer were randomized to open ($n = 128$) and laparoscopic ($n = 253$) surgery groups^[6]. The rate of conversion to open surgery was 34%, whereas perioperative morbidity did not differ between the two groups. There was a nonsignificant increase in CRM positivity in the laparoscopic anterior resection group compared with the open surgery group (12% *vs.* 6%), suggesting a slight increase in the risk of recurrence. The 3- and 5-year follow-up studies of all rectal cancer patients revealed that there were no differences in local or distant recurrence rates between the laparoscopic and open surgical groups^[28,29].

In the COREAN trial including 340 patients with locally advanced rectal cancer (T3N0-2) from three centers were randomized to open ($n = 170$) and laparoscopic surgery ($n = 170$) groups, and all patients received neoadjuvant chemoradiotherapy^[30]. The rate of conversion to open surgery was 1.2%, and no differences between the two groups were observed in terms of postoperative morbidity, mortality, CRM positivity, or TME quality.

The ACOSOG Z6051 trial recruited stage IIA or III rectal cancer patients with a tumor ≤ 12 cm from the anal verge after neoadjuvant therapy. The trial was powered to detect the noninferiority of laparoscopic surgery^[31]. Conversion to open surgery occurred in 11.3% of the patients. The authors demonstrated that there were no differences in radial or distal margin positivity or complete or near-total TME between the laparoscopy and open surgery groups.

The design of ALaCaRT trial was similar to that of ACOSOG Z6051, recruiting T1-3 and N0-2 rectal cancer patients with a tumor ≤ 15 cm from the anal verge to assess the noninferiority of laparoscopic surgery^[10]. Although the length of laparoscopic surgery was longer, the blood loss was less in this group. There is no difference in the completeness of TME between the laparoscopic and open surgery groups (82% *vs.* 89%), CRM positivity was observed in 7% and 3% of the laparoscopy and open surgery group patients, respectively ($P = 0.06$), and the rate of conversion to open surgery was 9%. In this study, the laparoscopy group, especially those with large T3 tumors, failed to meet the noninferiority criteria. The controversy of this study with COREAN and COLOR II trials raised the question of whether there were any indications for laparoscopy in lower rectal cancers and locally advanced disease.

A prospective nonrandomized study by Lujan *et al.*^[32] including 4405 patients from 72 centers who were divided into the laparoscopic ($n = 1387$) and open surgery ($n = 3018$) groups showed that the laparoscopy group had less hospitalization time, blood loss, and postoperative morbidity compared with the open surgery group. There was no significant difference in the number of HLNs between the two groups (laparoscopy *vs.* open, 14.5 *vs.* 14.7). The CRM and the distal margin involvement were significantly better in the laparoscopic group ($P < 0.05$), but the completeness of TME was significantly better in the open surgery group ($P < 0.05$).

In a two-center prospective study by Ströhlein *et al.*^[33] laparoscopic surgery was associated with faster recovery and shorter hospital stays than open surgery. There is a significant difference in the number of HLNs between the laparoscopic and the open surgical groups (13.5 *vs.* 16.9; $P = 0.001$); however, no differences local recurrence or metachronous metastasis were observed between the two groups.

In summary, these trials demonstrated that there were no differences in local tumor clearance, number of HLNs, or tumor recurrence rates between the two surgical approaches in patients with rectal cancer.

Table 1. Randomized trials comparing oncological outcomes with laparoscopic and open surgery

Study	No. of patients (L/O)	Follow-up (months)	Local recurrence (months) (L/O) (%)	Overall survival (months) (L/O) (%)	Port site recurrence (%)
Braga <i>et al.</i> ^[35]	83/85	54	4/5.2	No difference	NA
Jayne <i>et al.</i> ^[28]	253/128	56	9.4/7.6	60/53 (5 years)	2.4
Green <i>et al.</i> ^[36]	253/128	63	No difference	83/66 months (median overall survival)	NA
Ng <i>et al.</i> ^[34]	40/40	76	2.8/8.9	86/91 (5 years)	0
Ng <i>et al.</i> ^[37]	51/48	90	5/11	75/77 (5 years)	0

L: laparoscopy group; O: open surgery group; NA: not available

Laparoscopic TME for cancer is technically feasible, with acceptable complication rates and short-term oncological outcomes that are comparable with those of open surgery.

Long-term oncological outcomes

The few randomized trials comparing long-term outcomes after laparoscopic and open TME consistently reported that laparoscopic and open TME were associated with similar oncological outcomes^[28,34-37]. A summary comparison of oncological outcomes between laparoscopic and open TME in randomized comparative trials are presented in Table 1^[38].

Ng *et al.*^[37] investigated patients with rectal cancer who underwent laparoscopic ($n = 51$) or open abdominoperineal ($n = 48$) resection in a single-center prospective randomized trial. In this trial with a median follow-up duration of 90 months, the 5-year survival rates were 75.2% and 76.5% in the laparoscopic surgery and the open surgery groups, respectively. Another randomized trial in 2014, again by Ng *et al.*^[34], found that the 5-year survival rates were 86% in the laparoscopic surgery group and 91% in the open surgery group during a median follow-up of 76 months. However, the number of patients receiving neoadjuvant treatment was not stated in neither of the studies; both of which included a relatively small number of patients. However, the results of both studies supported that the oncological outcomes of laparoscopic and open TME were comparable.

Bonjer *et al.*^[9] published the long-term results of the COLOR II trial in 2015. At the end of the 3-year follow-up, the disease-free survival rates of the laparoscopic and open surgery groups were 74.8% and 70.8%, respectively, and there was no significant difference in overall survival between the laparoscopic and the open surgery groups (86.7% and 83.6%, respectively). These results indicated that laparoscopic surgery was a suitable and valid method in rectal cancer that did not invade the surrounding tissues.

In the CLASSIC trial cohort, the 3-year overall survival rate of the laparoscopic surgery group was not worse than that of the open surgery group (68.4% and 66.7%, respectively, $P = 0.55$)^[6]. There was also no statistically significant difference in disease-free survival between the two groups (67.7% and 66.3% in open and laparoscopic surgery, respectively). The long-term results reported by Green *et al.*^[36] revealed that the median overall survival of patients who underwent surgery for rectal carcinoma was 73.6 months and that there were no significant differences in the median overall survival (82.7 and 65.8 months) or the disease-free survival (67.1 and 70.6 months, $P = 0.925$) between the open and laparoscopic surgery groups, respectively. Furthermore, there were no differences in local, wound, or port recurrent rates between the two groups. The authors concluded that laparoscopic surgery should be preferred for early functional recovery without adversely affecting long-term survival outcomes.

Evaluation of the 3-year disease-free survival rates of the COREAN trial found no difference between the open and laparoscopic surgery groups (72.5% vs. 79.2%), and neither the 3-year overall survival nor the local recurrence parameters exceeded the 15% noninferiority limit^[39].

A prospective study by Ströhlein *et al.*^[33] reported 5-year local recurrence rates of 6.9% and 9.5% with laparoscopic and open surgery, respectively. Additionally, there were no significant differences in 5-year survival rates based on the disease between the two groups (open vs. laparoscopic; stage I, 75.2% vs. 85.4%; stage II, 73.4% vs. 66.7%; stage III, 51.3% vs. 60.1%). Similarly, Laurent *et al.*^[40] found no significant differences in 5-year local recurrence, disease-free survival, or overall survival rates between the laparoscopy and open surgery groups.

In summary, further randomized clinical trials are necessary for complete elucidation of the feasibility of laparoscopic surgery in rectal cancer. Additionally, the anticipated publication of the long-term results of the ACOSOG Z6051 and ALaCaRT trials should provide further insight regarding the implementation of laparoscopic surgery for rectal cancer.

Sexual and urinary dysfunction associated with laparoscopic surgery

Normal bladder and sexual function is controlled by sympathetic input from the superior hypogastric plexus and parasympathetic input from the pelvic splanchnic nerves, which are susceptible to injury during mesorectal resection. Injury to the sympathetic supply results in bladder instability and ejaculatory difficulties, whereas injury to the parasympathetic supply results in poor detrusor contraction and erectile dysfunction^[41,42].

The incidence of urinary and sexual dysfunction after open TME is significantly high^[43-46]. In laparoscopic TME, preservation of the nerves can be achieved by magnifying the images. In a series of 274 patients reported by Runkel and Reiser^[47], only 1.8% of the patients required prolonged urinary catheterization post-operatively. In other studies, the rate of urinary dysfunction after laparoscopic TME ranged from 6% to 15%^[48-52], and the incidence of dysfunction ranged between 5% and 28% in males who were sexually active before laparoscopic TME^[34,47,51,52].

Asoglu *et al.*^[52] reported that the rate of reduction in sexual function among female patients was 7%. In that comparative study, laparoscopic TME was associated with significantly less sexual dysfunction in both male and female patients, and the rate of urinary dysfunction was similar between the laparoscopic and open TME groups.

In a study on data from 247 patients enrolled in the CLASSIC trial, Jayne *et al.*^[41] reported that the rate of bladder dysfunction was similar between the open and laparoscopic surgery groups; however, the rate of erectile dysfunction was higher in the laparoscopic surgery group, which was attributed to the higher frequency of TME in the laparoscopic surgery group.

In their prospective randomized trial, Ng *et al.*^[34] found that there was no significant difference in urinary or erectile dysfunction between the laparoscopic and open TME groups. In the COREAN trial, however, there were significantly fewer urinary complications in the laparoscopic surgery group^[39]. Relatedly, McGlone *et al.*^[53] compared patients undergoing proctectomy by laparoscopic and open surgeries. Urinary and sexual dysfunction was observed in both surgery groups; however, penetration success in males and sexual activity results in women were found to be better in the laparoscopy group.

Overall, the results of these studies indicate that there was no major difference in urinary or sexual dysfunction between patients undergoing laparoscopic and open rectal surgery and that the main causes of these complications were rectal resection and TME, not the surgical approaches.

DISCUSSION

The development of minimally invasive colorectal surgery has been the greatest technological advance

in colorectal surgery in the past 20 years, with established benefits in short-term outcomes and return to function. Laparoscopic rectal surgery can promote patient recovery, overall outcome, and quality of life. Appropriate training is essential to achieve results that are at least comparable with oncological results. Most importantly, the concerns and controversies regarding oncological outcomes with laparoscopic TME should be resolved with the publication of the results of the studies evaluating long-term survival with this surgical approach.

CONCLUSION

TME, which should be performed to preserve the nerves and ureters, is technically difficult to perform in the pelvis. The surrounding tissues can be visualized more clearly with the laparoscopic approach; however, the angulation of the laparoscopic instruments and endoscopic staples is limited. Therefore, at least 50 laparoscopic rectal surgeries must be performed to achieve proper experience with this technique. The results of the studies published to date reveal that there is no difference in short-term outcomes between the laparoscopic and open approach. The long-term results of the limited number of trials conducted to date reported that the outcomes were similar between the two surgical groups; however, concerns remain regarding the utility of laparoscopy in locally advanced and distal rectal cancer, which should be addressed by evaluating long-term outcomes with additional randomized controlled trials.

DECLARATIONS

Authors' contributions

Both authors contributed to the conception and the design of the review.

Availability of data and materials

Not applicable.

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Conflict of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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