Hypothesis: Single-port laparoscopic rectal surgery can be performed using the principles of oncologic surgery in institutes experienced in laparoscopy with the advantages of minimally invasive surgery.

Design: Sphincter-saving mesorectal excision in 4 human cases via a single laparoscopic port.

Settings: A university hospital and a private hospital.

Patients: A series of 4 patients who underwent single-port laparoscopic sphincter-saving rectal resection for rectal cancer. Two of them were total and 2 were partial mesorectal excisions.

Interventions: An umbilical incision was made to place the multichannel single port. The sigmoid colon was hung to the left lateral abdominal wall using an intracorporeal stitch passing through its appendices epiploicae to achieve medial dissection and vascular ligation. The mesorectum was sharply dissected down to the pelvic floor. Endoscopic linear roticulating staplers were used to divide the rectum and proximal colon. A specimen was retrieved using an extraction bag through the umbilicus. Anastomosis was performed using a circular stapler, or pull-through hand-sewn anastomosis was performed.

Main Outcome Measures: Duration of the operation, length of hospital stay, surgical complications, wound size, and histopathologic data.

Results: There were no perioperative or postoperative complications. Mean operative time was 347 minutes (range, 240-480 minutes). Mean hospital stay was 4.25 days (range, 4-5 days). Mean wound size was 3.5 cm (range, 3-4 cm). Mean number of harvested lymph nodes was 15 (range, 8-28).

Conclusions: With the help of sophisticated surgical technology and techniques, single-port laparoscopic surgery for rectal cancer will be feasible while also maintaining oncologic principles and patient safety.

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Abdominal surgery has never been the same since the first laparoscopic cholecystectomy.1 Laparoscopic surgery has gained extensive acceptance during the past 2 decades. Open surgery was abandoned in many areas because of the clear benefits of the laparoscopic approach, such as less postoperative pain, fewer wound complications, better cosmesis, and a reduction in convalescence time. Laparoscopic management of several abdominal diseases is the criterion standard (Nissen fundoplication, cholecystectomy, and others).2,3 Moreover, challenging abdominal procedures, such as restorative proctocolectomy, hepatic lobectomy, and donor nephrectomy, can be safely performed using laparoscopic methods.4,6

The advantages of minimally invasive surgery (MIS) have urged surgeons toward more sophisticated methods, such as natural orifice transluminal surgery (NOTES), which has already become an attractive scarless surgical method among surgical options.7,8 Although technological improvement could not sufficiently support the surgeons in NOTES, as they did in laparoscopic procedures, surgeons have improved their surgical skills before NOTES. The umbilicus (known as an embryologic orifice) was used as an access point for a lesser scar surgery. Transumbilical single-access surgery, known as embryologic NOTES, has increased with experience.5

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Video available online at www.archsurg.com

First, Remzi et al10 and Bucher et al11 published their single-port laparoscopic right colectomy case reports. Leroy et al12 later
We report our preliminary experience with 4 patients who underwent laparoscopic mesorectal excision via a single port. Patient characteristics are given in Table 1. No pathologic findings were detected during physical examination except in the case of digital rectal examination. A tumoral mass was palpated on the posterior rectal wall in patient 1 and on the anterior wall of the lower rectum in patient 2. No palpable mass was detected in patients 3 and 4 on digital rectal examination. All the patients underwent rigid rectoscopy, colonoscopy, pelvic magnetic resonance imaging, and abdominopelvic computed tomography. Only 1 patient underwent endosanal ultrasonography. Colonoscopic biopsy revealed adenocarcinoma in all 4 patients. In all cases, no abnormality was observed on biochemical analysis, tumor markers were within normal limits, and no distant organ metastasis was detected preoperatively.

CONSENT

The patients fully consented to the operation and signed a detailed informed consent form. They were informed that they were to be our first cases to undergo this specific procedure. We explained to the patients that, as an initial procedure, this technique would bring them no benefit other than reducing wound size compared with the laparoscopic procedure. Furthermore, they were fully aware that we would need to use additional ports or would convert to open surgery in the event of intraoperative difficulty or complications.

SURGICAL PROCEDURE

The patients underwent a standard bowel preparation protocol comprising a fiber-free diet for 2 days and sodium phosphate soda 1 day before surgery. All the patients received general anesthesia with antibiotic and venous thrombosis prophylaxis. Patients were placed in the lithotomy position. A standard laparoscopic technique was used, as reported in an earlier article. We used a single-port access technique to perform single-port laparoscopic low anterior resection (SP-LLAR).

SP-LLAR With Mesorectal Excision

The surgeon and an assistant were positioned on the right of the patient. A second assistant was positioned to the left. Multiport-channel single ports (TriPort; Advanced Surgical Concepts, Dublin, Ireland; and SILS Port, 12 mm; Covidien AG, Norwalk, Connecticut) were used in these 4 patients. The multiport-channel single port was first placed at the umbilicus via an open technique (Figure 1B). All the surgical procedures, including vessel ligation, mobilization, transection, and Anastomosis, were performed intracorporeally. A 10-mm flexible laparoscope with a flexible 0° tip using the high-definition endo eye system (HDTV EXERA II; Olympus KeyMed, Southend on Sea, United Kingdom) was used initially to allow the simultaneous use of two 5-mm instruments. The routine exploration was guided by use of the laparoscope.

The next stage was to expose the operation field after placing the patient in the 30° Trendelenburg with 15° right lateral tilt position. The omentum and the transverse colon were placed beneath the diaphragm and over the liver by using 2 articulating endograspers (Roticulator Endo Grasp with Lock; Covidien AG). An atraumatic 2-0 silk suture with a straight needle was inserted into the abdominal cavity percutaneously. The sigmoid colon was elevated to the left lateral abdominal wall using an intracorporeal stitch passing through its appendices epiploicae. The stitch was tightened above the skin. With this maneuver, it was possible for the inferior mesenteric vein and Treitz ligament to be exposed. In the first patient, an additional stitch for hanging the left colon was required for exposure. The peritoneum was incised at the level of the promontorium above the bifurcation of the iliac artery by using Ultracision (Harmonic Ace; Ethicon Endo-Surgery Inc, Cincinnati, Ohio). The right ureter and gonadal vessels were exposed during the medial to lateral dissection. We tried to protect the Toldt fascia to save these structures.

The dissection was continued superiorly to the level of the inferior mesenteric artery and was ligated at its origin (Figure 1C). The inferior mesenteric vein was also highly ligated by use of 5-mm polymer endoclips (Hem-o-Lok; Weck
Closure Systems, Research Triangle Park, North Carolina). Special attention was given to preserving the inferior mesenteric and hypogastric plexuses. The hanging stitches of the sigmoid colon were cut, the sigmoid colon was freed from the anterior abdominal wall and retracted to the right side of the patient, and its lateral attachments were dissected using curved shears (Harmonic Ace; Ethicon Endo-Surgery Inc) to reach the previously dissected medial area; this resulted in full mobilization of the sigmoid mesocolon from Toldt fascia. Before starting the dissection of the mesorectum, a nylon tape was placed inside the abdominal cavity via a single port. This tape was tightened intracorporeally over the sigmoid colon and its mesentery with the help of the roticulating endodissector (Roticulator Endo; Covidien, AG) and the endograsper. A suture-passing device (Suture Grasper; Proxy Biomedical, Galway, Ireland) was inserted percutaneously from the lower abdominal quadrant to hang the sigmoid colon and its mesentery, keeping up the nylon tape. This hanging maneuver was repeated to create a better working space behind the rectosigmoid mesocolon. We used 2 or 3 hanging nylon tapes in each case. These nylon tapes were used to manipulate the colon laterally or medially by changing the percutaneous insertion point of the suture-passing device. Then the mesorectum was sharply dissected down to the pelvic floor posteriorly (Figure 1D). Waldeyer rectorectal fascia was cut in all patients irrespective of whether total mesorectal excision (TME) or partial mesorectal excision (PME) was used to effectively manipulate the rectum and mesorectum. With the advantage of a larger posterior anatomical dissection space, the lateral dissection of the rectum was more easily performed. The rectum was freed from its lateral attachments before an anterior mesorectal excision was made. Anterior mesorectal dissection was continued below the vesicula seminalis in the male patient and the posterior wall of the vagina in the female patient in cases of TME. The dissection was kept close to keep the mesorectum intact. During mesorectal excision, the curved shears and the roticulating endohears (Roticulator Endo Mini-Shears; Covidien AG) were used to facilitate sharp dissection. The rectum enveloped within the fascia propria recti was completely removed in TME patients. In patients who underwent PME, the fascia propria recti was incised 5 cm below the tumor. The rectum was prepared using the Harmonic Ace before being transected. Before transection of the distal part of the rectum, the lateral attachments of the left colon and of the splenic flexure were freed (Figure 2A). In the patient who underwent SP-LLAR with TME, the rectum was transected approximately at the level of the puborectal ring. Before using an endoscopic linear roticulating stapler (Endo GIA Universal; Covidien AG), the abdominal cavity was desufflated and the TriPort was changed with the SILS Port (Figure 3A). Two 5-mm trocars and a 15-mm trocar were inserted into the abdominal cavity via the single port. Pneumoperitoneum was reestablished. A rigid 5-mm 30° laparoscope

Figure 1. External views of the abdomen. A, Patient view on postoperative day 3. B, Transumbilical multichannel single port. C, High ligation of the inferior mesenteric artery. D, Posterior view of the total mesorectal excision.
with an integrated camera (EndoEYE; Olympus, Orangeburg, New York) and a 5-mm endograsper were inserted. Endoscopic linear roticulating staplers with green cartridges were used to transsect the rectum. To transsect the rectum, the average number of cartridges used was 4 for TME and 6 for PME (Figure 2B). The previously ligated inferior mesenteric vein was found, and the left mesocolon was divided along with the inferior mesenteric pedicle using the Harmonic Ace and the endoclips to have a sufficient oncologic pedicle. After completion of the proximal mesocolon dissection, the proximal surgical margin was transected using an endoscopic linear roticulating stapler. The resected specimen was placed in an extraction bag (Endo Catch II, 15 mm; Covidien AG) that was inserted through the 15-mm trocar of the SILS port. The extraction bag was retrieved using the single port after desufflation of the abdominal cavity.

The proximal colon was pulled to the outside of the abdomen through the umbilical incision under the direct visualization of a 10-mm flexible laparoscope. The colon was prepared for insertion of the anvil of the circular stapler. A purse-string suture was placed and tightened over the proximal end of the colon, and the colon was returned to the abdominal cavity (Figure 2C). The single port was repositioned, and two 5-mm trocars and one 10-mm trocar were inserted through this single port. Pneumoperitoneum was reestablished. A transanally inserted circular stapler (CDH 29; Ethicon Endo-Surgery Inc) was used to perform an intracorporeal anastomosis (Figure 2D). The anvil of the stapler was joined to the shaft of the stapler, taking care to avoid any entrapment of the adjacent organs within it. Before firing the stapler, the tension of the anastomosis and the course of the left colon were checked to avoid any twisting. Anastomosis was performed, and afterward the donuts were checked; they were complete. No drain was placed, and no diverting stoma was performed.

**Single-Port Laparoscopic Transabdominal Transanal Resection With TME**

The surgical procedure was the same as that for SP-LLAR except for the division of the proximal and distal parts of the specimen and creation of the anastomosis. After TME was completed, the abdomen was desufflated. The umbilicus was covered with a sterile drape, and the patient was placed in the jackknife position. The anal canal was exposed with a self-holding retractor (Lone star Retractor; Lone Star Medical Products Inc, Houston, Texas). Full-thickness transanal excision was started at the level of the dentate line anteriorly to reach the posterior wall of the vagina. After the rectovaginal septum was dissected, the pelvic space of the abdomen, which was previously dissected, was reached, and circumferential anorectal division was completed. The specimen was retrieved transanally until
the previously prepared proximal mesocolon was exposed. 3-0 Polygla
tin 910 sutures (Vicryl; Ethicon Inc, Somerville, New Jersey) were pl
aced on the distal anal mucosa and submucosa circumferentially. Af
fter the specimen was resected, the full-thickness bites were passed from
the proximal colon, and these sutures were tied. To avoid any rotation of
the anastomosis, care was taken to locate the colonic mesentery on the
right side of the patient. After completion of the pull-through anasto
mosis, the patient was placed in the supine position. The sterile drape
was removed, skin asepsis with povidone iodine was performed, and the
trocars of the single port were inserted; pneumoperitoneum was then
established. The tension and course of the anastomosis were checked
under laparoscopic vision. The single port was retrieved, and the incision
was closed. The summary of the surgical procedure is presented with the video (available at http://www.archsurg.com).

Histopathologic Evaluation

After the mesorectal surface had been marked with ink, the speci
men was sliced at approximately 3- to 5-mm intervals. All lymph
nodes were sent for microscopic examination. Histopathologi
cal evaluation of the mesorectal fascia was evaluated using
a standardized procedure described by Quirke et al.14 Variables
recorded included the number of lymph nodes har
vested and the longitudinal and radial margins of the excision.
Tumor staging classification in accordance with the American Joint Committee on Cancer was used to record the pathologic
stage of the tumor.

RESULTS

Three patients underwent SP-LLAR and 1 patient under
went single-port laparoscopic transabdominal trans
anal resection. Sphincter-saving laparoscopic TME was
performed for the 2 lower rectal tumors, and PME was
performed for the 2 upper rectal tumors. The anastomo
ses were performed intracorporeally in 3 patients, whereas
a pull-through hand-sewn anastomosis was performed
in 1 patient. All the operations were completed without
any complications. Mean operative time was 347 min-
utes (range, 240-480 minutes). Mean length of the post
operative stay was 4.25 days (range, 4-5 days). The av-
erage wound size was 3.5 cm (range, 3-4 cm). The histo
pathologic data are given in Table 2. The meso
rectum of the specimens was macroscopically intact in
each case (Figure 3B). All the patients were allowed a clear
diet on postoperative day 1. There were no postopera
tive complications in any of the patients.

COMMENT

Total mesorectal excision has become the criterion stan
dard surgical method for the treatment of rectal can
cer.15-18 Many researchers19-22 agree that laparoscopic TME
is a safe and feasible approach. Case series regarding laparo
scopic TME procedures show that it is as safe as an open
procedure.22 Patients experience the advantages of MIS,
such as a faster recovery period, better cosmetic results,
early return to work, less pain, and shorter hospital stays.
Although the same principles were followed in laparo
scopic and open procedures, intra-abdominal adhe
sions were less often observed after the laparoscopic op
erations. Furthermore, laparoscopic procedures are less
traumatic owing to small incisions.

The advantages provided by MIS have gained wide ac
ceptance, and important technological advances have been
made and technical equipment has improved to achieve
scars surgery. Nevertheless, the instruments available
on the market are still inadequate, which is an im
portant limitation for surgeons who want to perform scar
less procedures, such as NOTES. With the development of
surgical instruments and optical devices, serious im
provements seem likely.

With approval of the oncologic safety of laparo
scopic resections for the treatment of colorectal cancers
in randomized controlled trials,16,23 new devices and in
struments (single port, multichannel port, articulating
struments, etc) have encouraged surgeons to use more
sophisticated techniques, such as single-port laparo
scopic cholecystectomy and colectomy.10,11,24

The present study is an attempt to share our initial experi
ence of performing single-port laparoscopic management
of rectal cancer. After a review of the literature, ours are the first cases, to our knowledge, of SP-LLAR for rectal cancer to be reported in human beings. We per
formed SP-LLARs on 4 patients and encountered some
Technical difficulties. However, patient safety and onco
logic adequacy were foremost among our concerns. Ex
cept for operative time, all the variables in this study were
comparable with those of the laparoscopic and open sur
gical techniques. The longer operative time can be ex
plained by the learning curve of the novel single-port tech
nique. All the instruments we used were actually designed
for laparoscopic operations except for multichannel ports
and the flexible laparoscope. With the introduction of
stronger articulating graspers, the operative time will be shorter. Another issue is the difficulty in dividing the rectum using endoscopic linear staplers. Roticulating and flexible endoscopic staplers should be developed to address this problem and to improve operation times.

Within the limits of our initial experience and observations, we propose the following: (1) umbilical and fascial incisions should be at least 3 cm long to manipulate the instruments easily, (2) articulation of the instruments can provide larger exposure of the area to be dissected, (3) elevation of the sigmoid colon using percutaneously inserted stitches can be helpful for retraction, (4) the flexible 10-mm laparoscope can help in visualization of the operation field in different directions while allowing the surgeon an adequate angle, and (5) an additional 5-mm laparoscope is strongly advised when transecting the colon and rectum using endoscopic linear staplers. Transecting the rectum using endoscopic linear staplers was the most difficult and time-consuming part of the operation using conventional rotulating staplers.

The umbilical incision can be a probable risk factor for incisional hernia. However, right lower quadrant, left lower quadrant, and suprapubic incisions have been used to retrieve the specimen in laparoscopic colorectal procedures.\(^5\),\(^13\),\(^21\),\(^22\) To avoid abdominal incisions, Franklin et al.\(^23\) and Palanivelu et al.\(^26\) reported an innovative transvaginal specimen extraction technique for laparoscopic colorectal procedures. Thus, the umbilical incision, which is performed for working and also retrieving the specimen, can be the disadvantage of this technique. Hsu\(^27\) believed that the degree of pain is related to the length of the incision and also concluded that the incisions created for trocars, especially through the rectus muscle, are actually quite painful. In this technique, there is no trocar site through the rectus muscle, but there is still an umbilical incision.

There were no perioperative or postoperative complications in these cases, and patient satisfaction was excellent. The body images of the patients were preserved. Overall, fewer working ports were needed (only 2 ports) in SP-LLAR, whereas there were more than 3 in laparoscopic procedures. Operative time was longer in SP-LLAR. With these exceptions, there are no differences between SP-LLAR and LLAR regarding patient safety and oncologic adequacy.

In conclusion, during the evolution of MIS, it has been shown that tumor clearance using the laparoscopic approach is equal to that of conventional surgery. The application of laparoscopy in oncologic colorectal surgery, with sophisticated surgical technology and techniques, is a less invasive surgical procedure. Single-access laparoscopic TME is a reliable technique that benefits patients with rectal cancer. We shared our patients' SP-LLAR data, this being the first time such data have been made available. The results were satisfactory and comparable with those of other resection methods. Randomized prospective trials are required to compare the results of this novel but feasible technique with those of laparoscopic or open techniques.

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Author Contributions: Study concept and design: Hamzaoglu, Karahasanoglu, Baca, and Kahya. Acquisition of data: Karatas and Aytac. Analysis and interpretation of data: Hamzaoglu, Karahasanoglu, Baca, Karatas, Aytac, and Kahya. Drafting of the manuscript: Hamzaoglu, Karahasanoglu, Baca, and Aytac. Critical revision of the manuscript for important intellectual content: Hamzaoglu, Karahasanoglu, Baca, Karatas, Aytac, and Kahya.

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Table 2. Histopathologic Data

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<td>Age, y</td>
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<td>61</td>
<td>53</td>
<td>51</td>
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<tr>
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<td>Tumor size, cm</td>
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<td>Low</td>
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<td>I</td>
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<td>T2N0M0</td>
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</table>

Abbreviation: NA, not available.
\(^a\)Tumor staging in accordance with the American Joint Committee on Cancer.
\(^b\)Mesorectal fascia was assessed in accordance with Quirke grading.\(^14\)
REFERENCES


