Chapter

Local Excision for the Management of Early Rectal Cancer

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Abstract

Transanal endoscopic microsurgery (TEM) is a minimally invasive technique introduced in the 1980s to overcome the technical difficulties in the management of low rectal tumors. The TEM system includes a dedicated rigid rectoscope and platform with a dedicated expensive instrumentation. The transanal minimally invasive surgery (TAMIS) technique was introduced to overcome these limitations. Transanal surgery consists of three main steps: exposure of the lesion, tumor excision, and defect closure. Traditional indications are benign adenomas and selected T1 rectal cancers. However, when combined with neoadjuvant chemoradiotherapy (n-CRT), the indications may be extended to patients with selected T2-T3 rectal cancers responsive to n-CRT. Intraoperative complications may be difficult to deal with, but peritoneal entry is adequately managed by endoluminal direct closure of the defect by expert surgeons. Concerning the indications for defect closure, there is no evidence of better results to prevent complications such as bleeding; the indication for defect closure should be evaluated according to multiple variables. The management of other complications is safe and does not affect TEM's oncological and functional outcomes. Transanal excision of rectal tumor is a safe and effective alternative to conventional resection to avoid the low anterior resection syndrome, with comparable oncological results and with the advantages of an organ-sparing strategy for better patients' QoL.

Keywords: early rectal cancer, local excision, transanal endoscopic microsurgery, TEM, transanal minimally invasive surgery, TAMIS, complication, prevention, managements

1. Introduction

Transanal endoscopic microsurgery (TEM) is a minimally invasive technique introduced in 1983 by Professor G. Buess [1]. By merging endoscopy with microsurgery [2], Buess developed this natural orifice instrumentation and technique to overcome the technical difficulties that are inherent in the management of low rectal tumors, avoiding an invasive surgical procedure such as low anterior resection but with disease-free margins, unlike traditional local excision techniques. Before the development of TEM, the available methods for the management of rectal tumors included abdominal invasive surgery, in the form of anterior or posterior approach,

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and traditional transanal local excision techniques. In the anterior approach, the anatomic and technical difficulties restricted the surgeon; the posterior approaches were extremely radical with significant morbidity and mortality. These methods included the York Mason para-sacrococcygeal trans-sphinteric approach [3] for middle rectal tumors and the trans-coccygeal Kraske approach [4] for upper rectal lesions. Both the posterior techniques had high rates of complications: wound infection, fistulae, chronic pain, fecal incontinence, stenosis, high incidence of permanent stoma [5, 6]. Traditional transanal local excision techniques had several disadvantages such as poor exposure and lighting, with consequently increased risk of local recurrence. These techniques included the Parks transanal [7] approach and its variations according to Francillon [8] and Faivre [9]. In the Parks' procedure [7] after positioning of Parks' retractor, adrenaline submucosal injection was performed to raise the submucosa from the muscle plane, then two sutures were placed for traction, the mucosa was marked at about 1 cm from the tumor with diathermy, and it was excised following the muscle plane until complete tumor removal, with subsequent closure of the defect. According to the Francillon's technique [8], several stitches were positioned on healthy mucosa at about 1 cm from the tumor, and their traction acted like a "parachute," whereby the rectal wall harboring the tumor could be excised together with adjacent perirectal fat. Finally, in the Faivre technique [9], a flap of ano-rectal mucosa hosting the tumor was created and excised.

Buess, together with Richard Wolf Medical Instruments Division, developed a specific rectoscope and dedicated instrumentation to accomplish a revolutionary, highly technological, and new technique of rectal tumors excision by a transanal organ sparing minimally invasive approach but preserving oncological radicality, due to a magnified binocular 3D vision and excellent lighting [10].

2. TEM instrumentation and technique

The TEM system consists of a beveled rigid rectoscope of 4 cm in diameter and available in two sizes: 12 cm – short – or 20 cm – long – (**Figure 1**), depending on the preoperative location of the rectal lesion.

The rectoscope is fixed to the operating table with a multidirectional bearing, the Martin's Arm, and a constant pneumorectum is obtained by an insufflation unit providing carbon dioxide insufflation, suction, and irrigation (**Figure 2**).

The removable faceplate of the rectoscope has a port system to accommodate long curved instruments, the suction and coagulation cannula, and for placing the stereoscope with gas sealing (**Figure 3**). Through the stereoscope the surgeon obtains a magnified, three-dimensional vision of the rectal lesion with high-intensity lighting.

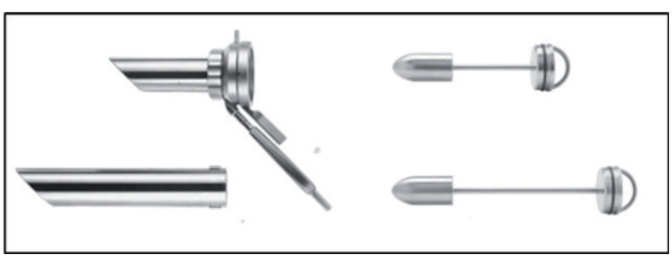

Figure 1.
Rectoscope © Richard Wolf GmbH. All rights reserved.

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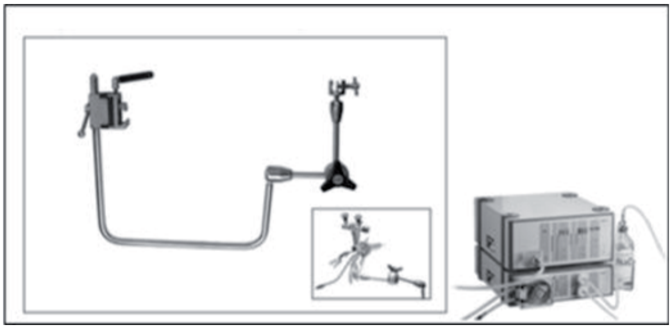

Figure 2.
Martin's Arm and insufflation system

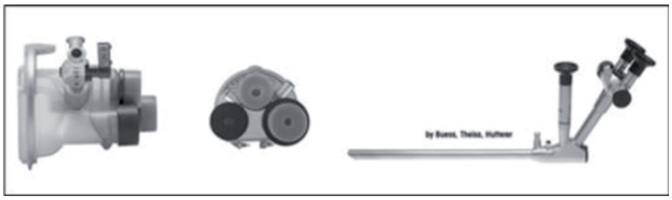

Figure 3.
Port System and Stereoscope

The stereoscope can also be connected to a laparoscopic video unit, for procedure recording and teaching purposes.

Given the instrumentation design, the lesion must always be located in the inferior part of the operative visual field. Therefore, a precise preoperative assessment of the rectal tumor position is of upmost importance because the patient's position on the operative table depends on the localization of the rectal lesion: for anteriorly located lesions, a prone jack-knife position (**Figure 4**) is required, whereas a lithotomy position is needed for posterior lesions (**Figure 5**). These positions may have to be coupled with a lateral tilt of the operative table on one side or the other in case of lesions that are located on the lateral rectal wall. The patient's position and the instrumentation settings may sometimes have to be changed during the procedure; therefore, an excellent supporting working team is fundamental.

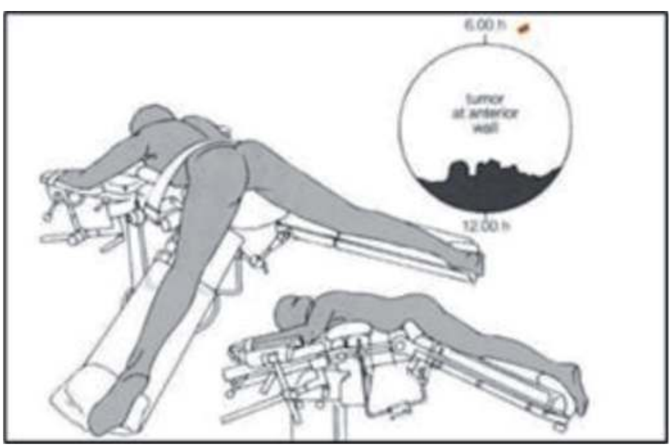

Figure 4.
The prone jack-knife position for anterior lesions.

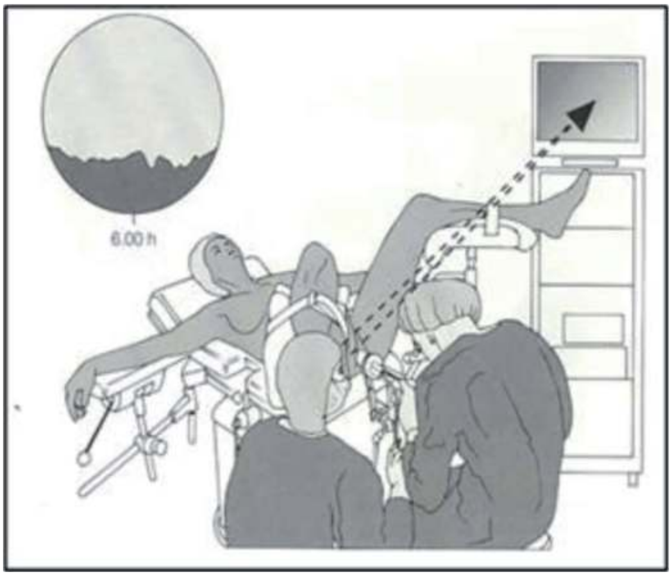

Figure 5.
The lithotomy position for posterior lesions.

Once the correct patient position and lesion exposure are obtained, the surgeon gets a magnified view of the distended rectum and can take advantage of a wide set of angled instruments (monopolar grasping forceps, scissors, needle holder, hook, silver clip applier, suction/irrigation, and coagulation cannula) to excise the lesion with adequate margins. The surgeon may therefore perform a full-thickness resection of the rectal lesion including the perilesional mesorectal fat, if necessary, and to close the residual defect with a running suture.

3. TAMIS instrumentation and technique

With the increase in laparoscopic experience, some limitations of TEM, such as costs, need for specific technical training, dedicated equipment, and instrumentation, encouraged the development of the transanal minimally invasive surgery (TAMIS) platform in 2009 [11]. TAMIS needs only a single-incision laparoscopic surgery port (SILSTM Port, Covidien, Mansfield, MA) that is first lubricated and then introduced into the anal canal (**Figure 6**). Through the SILS port, a standard

Figure 6.
SILS™ port and modified laparoscopic instrument for TAMIS ©Medtronic.

bidimensional laparoscope and instrumentation are inserted into the rectum, and pneumorectum is achieved with a conventional laparoscopic insufflator. Therefore, TAMIS provides similar, although not equivalent, visibility as TEM without the need for expensive and specialized equipment.

Furthermore, TAMIS enables dissection from different angles in multiple quadrants, avoiding the changes in patient's position that may sometimes be required during TEM: all resections in TAMIS can be done in the lithotomy position. Initially TAMIS was employed only for local excision of distal rectal lesions, but it is reported to be a feasible option also for higher lesions with satisfactory outcome [12]. So, nowadays TAMIS is considered to be a valuable alternative to TEM, with technical advantages and same prognosis for full-thickness local excision of rectal lesions [13, 14].

4. Surgical technique

The essential steps for both TEM and TAMIS are similar. They include: operative field exposure, tumor excision, and defect closure.

The first step is the positioning of the rectoscope or of the SILS Port, then the lesion is identified, and the rectoscope or SILS port is fixed in place in the correct position. CO_2 insufflation is then started to create pneumorectum until reaching an endoluminal pressure of 8–10 mmHg.

Once the lesion is identified, the line of excision is circumferentially marked by electrocautery with at least a 5–10 mm safety margin from the lesion, and dissection then starts at its caudal margin. Tumor resection can be performed by monopolar hook, ultrasonic instruments, or electrothermal bipolar energy devices. Dissection is carried around the lesion until the yellow adipose tissue of the mesorectum is identified and reached for a full-thickness resection. Full-thickness resection with adequate safety margins is performed routinely, with preservation of sphincter muscles (**Figure 7**). Full-thickness resection could be the cause of inadvertent entry into the peritoneal cavity. Should this occur, a laparoscope can be inserted into the abdominal cavity during TAMIS or in a TEM performed in lithotomy position, for better control of the peritoneal repair. If TEM is performed in the prone position, the patient will have to be turned in lithotomy position for diagnostic laparoscopy. After tumor removal, a suction-irrigation cannula is used for irrigation of the residual cavity and to check the hemostasis. Bleeding is controlled by monopolar or radiofrequency coagulation.

Following the tumor excision, the residual defect in the rectal wall can either be closed or be left opened. In the literature, no difference between these two techniques

Figure 7.
Step-by-step dissection technique for full-thickness excision and residual defect.

is reported in terms of intraoperative results and final outcome [15]. Our personal preference is to close the defect, as previously reported [16, 17]. The closure can be performed with one or more interrupted or continuous sutures, with Lapraty (Ethicon®) preformed knots and with dedicated silver clips. In case of large defects, the closure can be carried out first by placing a single interrupted or figure of eight suture in the middle of the defect to draw the margins closer. At this stage, the endoluminal pressure can be reduced to facilitate suturing the margins of the defect with either single stitches or, preferably, with a running suture. The suture line should be closed without excessive tension not to cause tissue ischemia. Once the suture is completed, it is necessary to make sure that the rectal lumen has not been inadvertently closed. A suction-irrigation device is helpful in the final correct visualization of the suture.

5. Indications

Traditional indications of TEM and TAMIS are benign lesions and selected T1 rectal tumors, defined by Buess as sessile rectal adenomas and pT1 stage low-risk adenocarcinomas [1, 2].

5.1 Benign adenomas

The standard procedure for the management of benign adenomas with size and morphology that do not allow a complete endoscopic removal is now considered a full-thickness excision by TEM. In these patients, TEM may avoid the morbidity of major surgery with a low recurrence rate [2, 18].

Nowadays, however, with appropriately selected indications, endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD) can be suitable alternative to surgery for subinvasive rectal tumor. In case of R1 endoscopic removal at final pathology, a subsequent salvage endoluminal loco-regional resection by TEM can be obtained aimed at achieving R0 resection [19].

5.2 Selected T1 rectal adenocarcinomas

In case of rectal cancer, a number of factors should be considered to set the indications for tumor excision by TEM. These factors include physical examination findings, preoperative imaging, and histopathological characteristics [20–22].

Preoperative staging examinations include:

- total colonscopy and rigid rectoscopy with biopsies of the lesion to evaluate distance and circumferential position of the lesion;
- digital examination to evaluate mobility or fixity of the tumor;
- endorectal ultrasound scan;
- magnetic resonance imaging (MRI) with 3 mm sections of abdomen and pelvis;
- Total body computed tomography (CT).

Several studies concluded that in carefully selected low-risk T1 patients, TEM had a similar local recurrence rate than total mesorectal excision [23]. Criteria to set the indications for tumor excision by TEM are summarized in **Table 1**.

TEM and TAMIS are also effective for patients' management after R1 polypectomy, after either EMR or ESD [24], avoiding total mesorectal excision, which would be an overtreatment. The oncological outcomes of transanal minimally invasive procedures in these patients are equal to more invasive surgery, with R0 status in all cases, low morbidity, and 0% mortality rate at a minimum 12 months follow-up [19].

5.3 Extended indications in rectal tumors: TEM after neoadjuvant chemoradiotherapy

Neoadjuvant chemoradiotherapy (n-CRT) is recommended by the European Society of Medical Oncology (ESMO) in cases of: advanced disease (T3c/T3d and over), MRI-predicted circumferential radial margin (CRM) (<1 mm), and lymph node involvement at MRI [25]. These characteristics of the tumor define the risk of local recurrence and metastatic disease, so the goal of n-CRT is to downsize or downstage the tumor and to avoid disease progression. Short-course neoadjuvant radiation therapy involves 25 Gy administered in doses of 5 Gy daily in 1 week, followed by surgery 1 week after completing neoadjuvant therapy; in 1997, the Swedish Rectal Cancer Study Group found a significant reduction in local recurrence rates between irradiated and control group [26]. Neoadjuvant long-course chemoradiation therapy described by Marks et al. [27] includes an overall administration of 50, 40 Gy in 28 fractions over 5 weeks, with concurrent continuous intravenous infusion of 5-FU. The radiation is administered in the areas of the anus, rectum, mesorectum, regional and iliac lymph nodes. Surgery is performed between 45 and 55 days after completion of chemoradiotherapy.

The standard treatment for T2–T3 rectal cancer after neoadjuvant chemoradiotherapy (n-CRT) is low anterior resection (open or laparoscopic approach) with total mesorectal excision (TME) [28, 29]. However, some studies report that combination of n-CRT with TEM is feasible in T2 and T3 rectal cancers [30, 31]. In a prospective randomized controlled trial, at a 5-year follow-up in selected post n-CRT patients with T2 rectal cancers, the local recurrence rates, the disease-free survival, and distant metastases rates showed no statistical difference in patients receiving TEM or TME [32]. Furthermore, the combination of n-CRT with TEM showed also advantages in preserving patients' anal function and in lower disruption of patients' quality of life [33–35].

Anatomic	Histologic	Staging
• <40–50% circumference of rectum • <3 cm in size • Mobile, not fixed • Within 20 cm from the anal verge	• T1 • Sm1 or Sm2 • Absence of tumor budding • Absence of lymphovascular invasion • Moderate to well-differentiation	• cT1N0 without neural /lymphovascular infiltration

Sm: submucosal layer invasion [21].

Table 1.
Criteria of inclusion for TEM.

Nevertheless, despite extensive mesorectal fat dissection during endoluminal loco-regional resection (ELRR) by TEM, in these patients the N parameter may remain incompletely defined, which may be a cause of concern. In the literature, an original modified sentinel lymph node procedure called nucleotide-guided mesorectal excision (NGME) [36] is described, which can improve the lymph node harvest during endoluminal resection by TEM/TAMIS and consequently obtain a better staging accuracy. During NGME, injection of 99 m-technetium-marked nanocolloid is performed in the peritumoral submucosa before starting the procedure. After specimen removal, the residual cavity is probed with a gamma camera in order to survey any residual radioactive area. In case of positivity, these areas are excised by TEM/TAMIS.

TEM may also be used when the focus is on palliation, if a curative treatment is impossible, in > T3 tumors in patients with unresectable metastases.

5.4 Other indications

Other types of rectal tumors can also be treated with TEM or TAMIS approaches, such as neuroendocrine tumors, leiomyoma, gastrointestinal stromal tumors [25, 23].

TEM can also be used for treatment of iatrogenic fistulae after general surgery and gynecological or urological procedures, such as after prostatectomy or for management of recto-vaginal and recto-urinary fistulae [37–39]. Benign rectal strictures can also be treated by TEM [40, 41].

6. Complications management

6.1 Intraoperative complications

6.1.1 Peritoneal entry

Accidental peritoneal entry during full-thickness TEM excision was in the past considered a serious complication requiring an aggressive management by conversion to standard laparotomy anterior resection (LAR) and fecal diversion [18, 42, 43]. More recently, larger transanal minimally invasive resection series showed a rate of peritoneal entry ranging from 0 to 32% [44, 45]. Proposed risk factors for accidental peritoneal opening include full-thickness TEM excision of lesions located in the upper rectum and in the anterior and lateral rectal wall [46–48]. These papers also demonstrated that for a surgeon with appropriate skills in transanal surgery, peritoneal entry during TEM can be safely closed transanally with direct defect sutures without the need for abdominal exploration [45, 46] and was not followed by increased postoperative morbidity [45, 48, 49]. As previously demonstrated in large TEM series, [47, 48], the occurrence of peritoneal entry was not associated with increased risks of infectious or other postoperative complications, or longer hospital stay. Several series have also demonstrated that peritoneal entry during TEM resection of rectal cancer was not associated with worse oncologic outcomes [48, 49]. Peritoneal entry during TAMIS has not been as frequently reported as during TEM procedures. In a TAMIS systematic review of 390 patients published in 2014, only four cases of inadvertent peritoneal opening have been documented during dissection of low rectal lesions, and only one required laparoscopic assistance for closure of the defect [50]. TAMIS experience for resection of upper rectal lesion is still limited in the literature, and among recent TAMIS series, the rate of peritoneal entry ranged from 0 to 10% [51–53]. However, a total of seven cases of peritoneal entry during TAMIS for upper rectal tumors have been described, six of which required conversion to laparoscopy or laparotomy. A recently published systematic review of 12 series of TEM procedures, including 4395 patients report that the rate of perforation into the peritoneal cavity was 5.1%, and conversion to an abdominal approach was required in 0.8% of cases [54]. Risk factor analysis identified anterior [46, 47] and upper rectal [45] tumor locations as significant risk factors for peritoneal entry. Also female sex during excision of anteriorly located lesions has been advocated as a risk factor due to the lower reflection of the anterior peritoneum in the female pelvis. Some authors state that in experienced hands, the majority of peritoneal defects could be closed transanally with significant decrease in conversion rate [49]. It is important to note that the definition used for peritoneal entry across different series is really heterogeneous, including: "major leakage of CO2 into the abdominal cavity resulted in significant technical difficulties" [55], "visible entrance into the peritoneal cavity" [46], "direct visualization of the defect during surgery" [45], while many studies do not explicitly state how they defined peritoneal entry [47, 48].

Transanal endoscopic direct closure of peritoneal defects appears to be feasible in more than 90% of cases, but it requires a significantly longer operating time (207.5 vs. 131.5 min) [55] from the increased technical complexity due to the loss of pneumorectum, producing a limited endoluminal vision and a troublesome reach of the peritoneal defect by the surgical instruments [49]. Authors experienced in both TEM and TAMIS transanal tumor excision have also suggested to shift to the TEM platform in case of peritoneal entry during TAMIS dissection, particularly for anterior and upper rectal lesions, to better manage the transanal peritoneal suture. This is due to the advantage offered by the rigid and longer rectoscope that is included in the TEM platform, which maintains the rectal wall stented allowing to suture the defect without the need for conversion [55]. In conclusion, peritoneal entry during local excision of a rectal tumor is a recognized intraoperative complication that can be adequately managed by endoluminal direct closure of the defect, not affecting the short- and long-term oncological results. However, extensive surgeon experience in transanal minimally invasive resection is required, together with the ability to use different transanal platforms. In the decision-making process for patient selection, the risk factors for peritoneal entry should be evaluated, considering the upper and anterior location of the lesion as an increased risk factor for this complication.

6.2 Postoperative complications

6.2.1 Bleeding, suture dehiscence, and pelvic abscess: to close or not to close the defect?

Postoperative rectal bleeding after TEM or TAMIS is the most frequently reported complication with a variable incidence ranging between 1.7% and 10.8% [56–58]. Nevertheless, in the literature the definition of rectal bleeding as a complication is heterogeneous, because the presence of a wound inside the rectum, whether completely sutured, partially sutured, or left open, causes variable blood emission after contact with the stools and with increasing internal pressure inside the rectum during defecation. This is a common occurrence, and it may be considered normal within the process. Therefore, rectal bleeding should be considered a cause of concern when the amount of blood loss produces anemia requiring blood transfusions and those requiring surgical revision, considering that more than 50% of post TEM/TAMIS bleeding episodes are self-limited. Some authors observed that bleeding is more consistent if it is associated with suture line dehiscence in patients with defect closure, and it is more frequent in patients whose defect was left open [59, 60]. Other authors instead did not observe a correlation between defect closure and risk for postoperative bleeding [15, 44]. Postoperative bleeding seems to be significantly reduced following the use of ultrasonic dissection during local excision, as compared with diathermy (1.1% vs. 6.3%) [44, 61]. According to Lee et al., postoperative bleeding was less common in sutured defects [12]. A retrospective analysis of 220 patients with full-thickness excision and 210 patients with partial-thickness excision showed an incidence of 30-day complications analogous for open and closed defects after full-thickness (15% vs. 12%, $p = 0.432$) and partial-thickness excisions (7% vs. 5%, $p = 0.552$). Although full-thickness excision in patients with open defects had a higher rate of clinically relevant postoperative bleeding complications (9% vs. 3%, $p = 0.045$) [62].

Use of hemostatic agents at the end of the resection is commonly part of the clinical practice; however, no focused trials have been published reporting its effectiveness in prevention of postoperative bleeding. In patients with consistent bleeding, usually endoscopic hemostatic techniques (argon, clipping, adrenaline injection), or TEM/TAMIS revision with defect suturing (or resuturing) may be effective in managing this complication without the need for creation of a diverting stoma or resorting to an anterior resection procedure [54, 57, 59].

The suture line dehiscence rate after full-thickness TEM and TAMIS is not negligible, and in the literature, it ranges between 2% and 22.7% [16, 17, 44, 63, 64]. Its clinical presentation may range from paucisymptomatic cases to a variable symptoms' collection including rectal pain, bleeding, fever, and development of a pelvic abscess. Endoscopy is the primary investigation to assess the presence of suture line dehiscence, whereas transanal ultrasound, MRI, and CT scan should be reserved to the patients suspected for having developed a pelvic abscess. Many factors have been considered responsible for suture line dehiscence: tumor size and location [44], type of resection (full thickness), depth of excision, degree of tension on the suture line [16], type of suture (multiple interrupted sutures or single running suture) [60], previous neoadjuvant therapy [63, 64], and rectal wall ischemia [17]. Lateral or anterior location of the tumor associated with a defect size of 2 cm or more seems related to an increased risk of postoperative bleeding and pelvic collection with sepsis [56]. Bignell et al. reported that for lesions sited within 2 cm from the anal verge, an increased rate of complications occurs [44]. The risk of postoperative complications after neoadjuvant chemoradiotherapy was also reported by several authors [63, 64]. The high rate of suture line dehiscence in irradiated patients who underwent TEM/TAMIS could be a consequence of the detrimental effects of radiotherapy on the tissue, (free radical formation, DNA damage, tissue fibrosis, vascular thrombosis), with a consequently higher risk of suture line dehiscence and infection [65]. Moreover, in TEM irradiated patients, both sutured wound edges were previously irradiated, presenting all listed detrimental causes of damage, therefore the risk of wound complication is increased [63]. Some authors [16] suggested the degree of tension on the suture line and perirectal collection formation as primary causes for suture line dehiscence. This is particularly relevant in relation to extended endoluminal resection partially including perirectal fat, in which not only defect closure is mandatory to avoid pelvic contamination but the lack of tissue around the rectal wall resection becomes a "locus minoris resistentiae" where fluids collect increasing the suture line tension. With the aim of avoiding perirectal fluid collection, these authors proposed to stuff the rectal ampulla with two iodoform gauzes and to place a transanal Foley catheter with its tip well above the suture line for postoperative gas evacuation to be kept in place for 48 h. The rationale is to prevent overdistention of the rectal ampulla and at the same time obtain a moderate pressure to obliterate the remaining perirectal cavity. A wider residual cavity is subject to collection of larger amounts of fluids, which may lead to infection. This infected collection may spontaneously drain through the suture line, which in turn may lead to wound separation. The described technical details have reduced the dehiscence rate in the authors' series from 12 to 0% for wide endoluminal resection independently of tumor location and previous radiation treatment.

Pelvic abscess occurs due to intraoperative seeding of bacteria aided by dissection into the retroperitoneum and diffusion from carbon dioxide insufflation. Extension of infection from the anal region into the retroperitoneum has been reported in the literature. Bacterial seeding may cause presacral and perirectal abscess that can extend into the perineal space or to the retroperitoneum along the psoas muscle. Its clinical presentation includes pelvic and anal pain, fever, increased inflammatory markers up to sepsis. Diagnosis requires radiological confirmation by CT scan or MRI to evaluate the extension of the infectious process and the involvement of pelvic and retroperitoneal structures. The occurrence of suture line dehiscence in full-thickness excision is considered a risk factor for pelvic abscess development. Bignell et al. series of 262 patients who underwent TEM for lesions located within 2 cm from the dentate line was associated with a higher incidence of pelvic sepsis ($p < 0.02$). Surprisingly, no statistical correlation between defect closure and pelvic abscess was found [44]. Many patients with pelvic sepsis were managed with diverting colostomy aimed at reducing perineal contamination [44, 63, 66]. Interventional radiology (IR) development, together with the extension of indications for percutaneous drainage, has progressively replaced the need for surgical revision in a large part of retroperitoneal and pelvic collections. Generally, retroperitoneal abscess management strategies include conservative treatment with antibiotics in association with radiologically guided percutaneous drains, versus traditional surgical exploration with abscess drainage and eventually fecal diversion [44, 63, 64, 66, 67]. The need for protective stoma should be evaluated and considered particularly in relation to the abscess extension and patients' septic state. Small retroperitoneal abscesses (less than 3 cm in diameter) in a hemodynamically stable patient may be effectively treated with an extended course of antibiotics alone. However, larger abscesses or unresolving smaller abscesses must be drained either by percutaneous drain placement or by surgical exploration and drainage. Microbiological examination is required to shift from empirical antibiotic therapy to a tailored one. Surgery offers several advantages over IR drainage, including the ability to fully explore the anatomy and extent of the infection as well as the ability to remove fistulous tracts [68]. However, surgery does carry more significant risks, delays, and morbidity. Resolution and recurrence are similar between the surgical and IR approaches [68].

Concerning the issue of defect closure indications, several studies have directly compared the outcomes of leaving the defect open versus suture closure, reporting variable results. The first randomized controlled trial (RCT) on this subject, with short follow-up at 30 days [15], showed postoperative bleeding to be the only complication encountered, and both techniques were judged to be equally safe. This result was confirmed by a large multicenter comparative study in which the rectal defects were left open in 47% of patients, without increased complications [52]. However, a more recent study has postulated that open management of the rectal defect after TEM may be associated with a higher postoperative complications rate (19% vs. 8.4% $p = 0.03$)

but also with lower readmission rates (4.7 vs. 12.4%, $p = 0.01$) [60]. Brown et al. also underlined the importance of performing defect closure as a surgical training modality to achieve rectal wall suturing skills, because involuntary opening of the peritoneum during transanal excision does require such technical skills to manage this complication without conversion.

Another topic of concern has been the association of TEM defect management and increased postoperative pain. This was reported by a 2011 study, stating that postoperative pain after defect suture closure was associated with a high readmission rate and a high incidence of wound dehiscence [69]. However, a more recent multicenter RCT has refuted these results, reporting no difference in postoperative pain between sutured or open defect management [70]. In conclusion, there is no evidence that closure of the defect will prevent complications, both approaches being equally safe. Nevertheless, the decision to close or not the defect, particularly after full-thickness excision, should be evaluated according to multiple parameters, including tumor position and size, extension and depth of resection, and surgeon's technical skills.

6.2.2 Rectovaginal fistula (RVF)

Rectovaginal fistula after transanal excision is a rare iatrogenic complication, but a particularly challenging one to treat. In the literature it has been reported in a few series with an incidence rate of 0.5%–2.3% [62, 66]. It usually occurs after excision of anteriorly located lesions in women. The integrity of the rectovaginal septum should be monitored during surgery, and a vaginal examination is performed in case of doubt. Vaginal fistulas can result also from suture line dehiscence after defect closure of anterior lesion with development of a perirectal collection draining through the vaginal orifice, due to the poor vascularization and fragility of the rectovaginal septum, to the higher intraluminal rectal pressure and to the even higher pressure exerted on it during defecation. These fistulas are difficult to treat, requiring in many cases multiple reinterventions, starting with creation of a temporary stoma and subsequent repair of the fistula, which may be subject to failure. Typical clinical presentations include vaginal passage of air, stool, purulent drainage, or ill-smelling discharge, often associated with urinary infection. Diagnosis includes digital recto-vaginal bimanual examination, vaginoscopy and proctoscopy, transanal blue methylene test, or transanal injection of iodine contrast agent followed by conventional X-ray or CT scan and MRI. Across the years, different techniques have been proposed for the surgical management of this complication: skin flaps, muscle flaps, musculocutaneous flaps, intestinal flaps, and the Martius flap, including subcutaneous tissue and bulbocavernosus muscle from one of the labia minora, and graciloplastica. The success rates ranged from 62–92% for patients not previously treated by radiotherapy and not affected by inflammatory bowel disease [71–77]. Among the unusual indications for TEM, there is also the possibility to close the fistula orifice after fecal diversion by a deferred transanal approach, as described by some authors in small series with good results [78–80].

6.2.3 Pneumoretroperitoneum

Under physiologic conditions, rectal intralumenal air pressure ranges between 5 and 25 cm H2O, but during transanal procedures, the intralumenal pressure increases due to gas insufflation [81]. Common to all cases of pneumo-mediastinum and pneumo-retroperitoneum, the pathophysiological mechanism begins with gas migrating from the pelvis to the retroperitoneum and then to the cervical spaces, passing through the diaphragmatic hiatus, the posterior mediastinum, following the course of tracheal and esophageal walls, and then through any space delimited by skull, diaphragm, and both anterior and posterior cervical fasciae (the so-called Godinsky's space) or the retropharyngeal space [81]. Air migration might be limited in overweight and obese subjects, as fat fills in all anatomical spaces. In patients who underwent general anesthesia, it is very important to exclude other causes of extralumenal gas, such as esophageal or tracheobronchial perforations that may occur intraoperatively during nasogastric tube positioning or endotracheal intubation. In most cases, treatment may be conservative with restricted diet, intravenous antibiotics administration, and close observation [12, 82–85], although some authors prefer to treat this condition by fecal diversion [86, 87]. The presence of perirectal fluid and gas collection aerosol dissemination of bacteria and the subsequent risk of cardiac and respiratory infection or generalized sepsis must be considered in evaluating the opportunity of operative management. Frequent clinical symptoms reported in the literature are fever, pain, and subcutaneous emphysema, together with other less frequent symptoms such as dyspnea, dysphagia, or positive Kernig's sign. Fever seems to be a recurrent finding especially during the first postoperative day, without specific correlation with a septic state in patients who do not present with fluid collection or abscess [12, 82–85]. Fever could be related to transient aerosol dissemination of enteric bacteria trough the fascial spaces. Asymptomatic fever with no clinical evidence of infectious site has been described also in patients not presenting with pneumoretroperitoneum or subcutaneous emphysema, showing a self-limited trend with resolution within 2–3 days [50, 54, 66, 88].

6.2.4 Urinary complications

Urinary complications are the second most frequent short-term complication after bleeding and have been reported in 5–10.8% of patients after transanal surgery [12, 54, 57, 66]. Urinary retention is a common complication after transanal procedures, especially in anterior resection, mainly occurring in male patients. Often it is classified as a Clavien-Dindo [89] grade II sequel, and it is easily managed by placement of a transurethral catheter [12, 54, 57, 66]. Reasons may be related to different factors: the anterior location of the excised lesion, preexisting prostatic hypertrophy, spinal anesthesia, and premature removal of the bladder catheter.

6.2.5 Rectal stenosis

Rectal stenosis is relatively infrequent complication after transanal excision of rectal lesions, poorly reported in the literature with an incidence rate of 1.5–5.8% [44, 90–93]. Rectal stenosis is associated with fecal urgency and incontinence, and it has a negative impact on the patients' quality of life [64]. In a recently published series of 761 patients undergoing TEM, the overall stenosis rate was 3.2%; analyzing the correlation between tumor size and subsequent stenosis development, the authors did not find postoperative stenosis in tumors measuring less than 5 cm in diameter, but it appeared in 6.8% of very large tumors (5–9 cm) and in 13.9% of ultralarge tumors (>10 cm) [93]. Altaf et al. report an incidence of stenosis of 5.8% following transanal surgery, but it did not become obstructive in any patient [91], therefore not requiring endoscopic treatment. Bignell et al. reported a 1.5% rate of rectal stenosis underlining that none of the patients received neoadjuvant therapy before surgery, but 50% of them underwent four quadrants lesion's excision [44].

The etiology of stenosis following anterior resection and total mesorectal excision is multifactorial, and it includes postoperative leaks and pelvic sepsis. It is also widely believed that ischemia plays an important role in stenosis formation. On the contrary, transanal excision is not associated with major alteration of blood supply; therefore, it appears that the only factor that may play a role is mucosal ischemia in association with the extension of the dissection. Several authors agree on the fact that circumferential excision or resection of lesions measuring more than 5 cm in diameter is the main risk factor for rectal stenosis, independently from the distance of the tumor from the anal verge or from neoadjuvant radiotherapy [44, 90, 91]. Once stenosis has occurred, there are several treatment options that have been already described in the setting of rectal stenosis following anterior resection. These options include surgical resection, transanal strictureplasty, balloon or surgical dilatation, and stenting [90, 92, 94]. In the literature, the majority of cases of rectal stenosis following transanal surgery can be easily treated by endoscopic balloon dilatation or with a day-case procedure under general anesthesia using Hegar's dilators by single or multiple sessions [56, 90, 92, 94]. Surgical resection of the stenotic tract or fecal diversion should be reserved only to those patients who are refractory to endoscopic conservative treatment.

6.3 Functional outcomes

Despite the large diffusion of TEM and TAMIS for organ-sparing tumor resection in rectal cancer, several issues have been investigated to assess the safety of both techniques concerning the postoperative functional outcomes. This is due to the risk that rectal and anal stretching produced by the introduction of a wide proctoscope or platform during surgery, as well as partial organ resection reducing rectal compliance, might be the cause of postoperative functional disorders such as fecal incontinence, urgency, and soiling, with subsequent impairment of the patient's quality of life (QoL). A recently published systematic review including 29 studies reporting the functional results following TEM or TAMIS surgery and including almost 1300 patients reveals that several studies reported some deterioration in manometric scores after both TEM and TAMIS and suggested worsening function, at least in some items of the used scores, including de novo incontinence development in some patients. However, globally the QoL does not seem to be significantly impaired after either procedure [95]. After tumor resection, continence was recovered or improved in several series following both TEM [33, 96–100] and TAMIS [101, 102]. On the contrary, worsening of fecal continence scores was reported by some studies assessing TEM functional outcomes [102–106]. Sphincter damage caused by anal dilation during surgery with the rigid TEM rectoscopes or platforms that are 4 cm in diameter [107, 108] has been advocated as a risk factor for postoperative incontinence, as well the surgical duration [108]. Moreover, partial rectal wall resection reduces rectal compliance, which might also result in later development of fecal symptoms as incontinence and urgency [33]. However, it should be underlined that some studies, including the authors' previous series [33, 100], reported that postoperative incontinence after TEM was transient in many patients and improved at long term postoperative follow-up [97, 107, 109, 110, 111]. All these changes in anorectal physiology are mainly detected within the first 30 postoperative days and seem to significantly improve at 1 year after surgery; hence, they might not be clinically relevant to the patients in the long run [33, 104]. Mora Lopez et al. [104] found that only closer distance to the anal verge seemed to affect continence. Other reported risk factors for fecal incontinence included male gender, age at surgery, surgical time, extended resection, and full-thickness resection [103, 105, 110]. Khoury et al. [112] found that continence can be also affected by repeated TEM procedures, as the result of multiple anal sphincter complex traumas. There are very few available studies that included patients who underwent chemoradiotherapy before TEM [35, 64, 110, 113] and TAMIS [108], hence no conclusive data are available, although worsening functional outcomes have been reported in this group of patients as compared with those who underwent transanal surgery alone [35, 110, 113]. A possible explanation for worse results in irradiated patients can be postulated due to radiotherapy impairment of muscles and nerve fiber integrity and reduced rectal wall elasticity [114, 115]. This was reported by the authors [35] and Ghiselli et al. [110] after TEM surgery and by Clermonts et al. after TAMIS procedures [108]. In conclusion, TEM and TAMIS can be considered safe in terms of long-term functional outcomes, with only transient impairment of fecal continence and worsening QoL, showing almost complete anorectal physiology recovery within 1 year from surgery. Nevertheless, the duration of surgery together with tumor features (location, stage, and size) can be considered as a risk factor for deterioration of functional results together with combination of radiation treatment.

7. Conclusion

Transanal excision of rectal tumors is a valid, safe, and reproducible alternative to conventional anterior resection for the treatment of early rectal cancer, showing comparable oncological results with the advantages of an organ-sparing surgical strategy favorably impacting on overall patients' QoL as compared with low anterior resection. Encouraging results have been obtained also in the treatment of locally advanced tumors in association with n-CRT, although randomized controlled trials with long-term follow-up and shared protocols are still needed to definitely asses the role of TEM and TAMIS in non-early rectal cancer. Globally, the morbidity rate of both techniques is lower than after anterior resection, and their main complications including postoperative bleeding, suture line dehiscence, and urinary complications can be safely managed in most cases without conventional surgical revision or fecal diversion. The functional outcomes are also satisfactory, with mainly transient disturbance of anorectal physiology and progressive functional recovery. In conclusion, transanal excision techniques must be rightfully included in the armamentarium of the technical skills of any colorectal surgeon for the multimodality treatment of rectal cancer.

Conflict of interest

The authors declare no potential conflicts of interest with respect to research, authorship, and/or publication of this manuscript.

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References

[1] Buess G, Theiss R, Hutterer F, Pichlmaier H, Pelz C, Holfeld T, et al. Die transanale endoskopische Rektumoperation - Erprobung einer neuen Methode im Tierversuch [Transanal endoscopic surgery of the rectum - testing a new method in animal experiments]. Leber, Magen, Darm. 1983;**13**(2):73-77

[2] Buess GF, Mentges B. Transanal endoscopic microsurgery (TEM). Minimally Invasive Therapy. 1992;**1**(2):101-109. DOI: 10.3109/13645709209152931

[3] Mason AY. Surgical access to the rectum - A transsphincteric exposure. Proceedings of the Royal Society of Medicine. 1970;**63**(Suppl. 1):91-94

[4] Kraske P. Zur extirpation hochsitzenden mastdarmkrebs verhandl deutch gesellsch. Verhandlungen der Deutscht Gesellsch Chir. 1885;**14**:464-474

[5] Thompson BW, Tucker WE. Transsphincteric approach to lesions of the rectum. Southern Medical Journal. 1987;**80**(1):41-43. DOI: 10.1097/00007611-198701000-00010

[6] Onaitis M, Ludwig K, Perez-Tamayo A, Gottfried M, Russell L, Shadduck P, et al. The Kraske procedure: A critical analysis of a surgical approach for mid-rectal lesions. Journal of Surgical Oncology. 2006;**94**(3):194-202. DOI: 10.1002/jso.20591

[7] Parks AG, Stuart AE. The management of villous tumours of the large bowel. The British Journal of Surgery. 1973;**60**(9):688-695. DOI: 10.1002/bjs.1800600908

[8] Francillon J, Moulay A, Vignal J, Tissot E. L'exérèse par voie basse des cancers de l'ampoule rectale. Technique "du parachute" [Excision of carcinomas of the rectal ampulla via the inferior route. The parachute technic]. La Nouvelle Presse Médicale. 1974;**3**(21):1365-1366

[9] Faivre J. Abord proctologique des tumeurs villeuses du rectum. L'electro-resection transanale par Lambeau tracteur. Ann Gastroenterol Hepathol. 1979;**15**:313-318

[10] Buess G, Hutterer F, Theiss J, Böbel M, Isselhard W, Pichlmaier H. Das System für die transanale endoskopische Rectumoperation [A system for a transanal endoscopic rectum operation]. Chirurg. 1984;**55**(10):677-680

[11] Atallah S, Albert M, Larach S. Transanal minimally invasive surgery: A giant leap forward. Surgical Endoscopy. 2010;**24**(9):2200-2205. DOI: 10.1007/s00464-010-0927-z

[12] Lee L, Burke JP, deBeche Adams T, Nassif G, Martin-Perez B, Monson JRT, Albert MR, Atallah SB. Transanal minimally invasive surgery for local excision of benign and malignant rectal Neoplasia: Outcomes From 200 consecutive cases with midterm follow up. Annals of Surgery 2018;267(5):910-916. doi: 10.1097/SLA.0000000000002190

[13] Van den Eynde F, Jaekers J, Fieuws S, D'Hoore AM, Wolthuis AM. TAMIS is a valuable alternative to TEM for resection of intraluminal rectal tumors. Techniques in Coloproctology. 2019;**23**(2):161-166. DOI: 10.1007/s10151-019-01954-7

[14] Quaresima S, Balla A, Franceschilli L, La Torre M, Iafrate C, Shalaby M, et al. Transanal minimally invasive surgery

for rectal lesions. JSLS: Journal of the Society of Laparoendoscopic Surgeons. 2016;**20**(3):e2016.00032. DOI: 10.4293/JSLS.2016.00032

[15] Ramirez JM, Aguilella V, Arribas D, Martinez M. Transanal full-thickness excision of rectal tumours: Should the defect be sutured? A randomized controlled trial. Colorectal Disease. 2002;**4**(1):51-55. DOI: 10.1046/j.1463-1318.2002.00293.x

[16] Paganini AM, Balla A, Quaresima S, D'Ambrosio G, Bruzzone P, Lezoche E. Tricks to decrease the suture line dehiscence rate during endoluminal loco-regional resection (ELRR) by transanal endoscopic microsurgery (TEM). Surgical Endoscopy. 2014;**29**(5):1045-1050. DOI: 10.1007/s00464-014-3776-3

[17] Lezoche E, Guerrieri M, Paganini AM, Feliciotti F. Transanal endoscopic microsurgical excision of irradiated and nonirradiated rectal cancer. A 5-year experience. Surgical Laparoscopy & Endoscopy. 1998;**8**(4):249-256

[18] Demartines N, von Flüe MO, Harder FH. Transanal endoscopic microsurgical excision of rectal tumors: Indications and results. World Journal of Surgery. 2001;**25**(7):870-875. DOI: 10.1007/s00268-001-0043-2

[19] Quaresima S, Balla A, D'Ambrosio G, Bruzzone P, Ursi P, Lezoche E, et al. Endoluminal loco-regional resection by TEM after R1 endoscopic removal or recurrence of rectal tumors. Minimally Invasive Therapy and Allied Technologies. 2016;**25**(3):134-140. DOI: 10.3109/13645706.2016.1145125

[20] Doornebosch PG, Zeestraten E, de Graaf EJ, Hermsen P, Dawson I, Tollenaar RA, et al. Transanal endoscopic microsurgery for T1 rectal cancer: Size matters! Surgical Endoscopy. 2011;**26**(2):551-557. DOI: 10.1007/s00464-011-1918-4

[21] Robek O, Čan V, Svoboda T, Hemmelová B, Kala Z, Hrivnák R. Transanální endoskopická mikrochirurgie (TEM) naše zkušenosti [Transanal endoscopic microsurgery (TEM) our experience]. Rozhledy v Chirurgii. 2016;**95**(1):33-39

[22] Lin GL, Qiu HZ, Xiao Y, Wu B, Meng WC. Transanal endoscopic microsurgery for rectal intraepithelial neoplasia and early rectal carcinoma. Zhonghua Wei Chang Wai Ke Za Zhi. Jan 2008;**11**(1):39-43. Chinese. PMID: 18197492

[23] Xue X, Lin G. Transanal endoscopic microsurgery: Exploring its indications and novel applications. A narrative review. Videosurgery and Other Miniinvasive Techniques. 2022;**17**(1):95-103. DOI: 10.5114/wiitm.2021.108811

[24] Tytherleigh MG, Warren BF, McC Mortensen NJ. Management of early rectal cancer. The British Journal of Surgery. 2008;**95**(4):409-423. DOI: 10.1002/bjs.6127

[25] Glynne-Jones R, Wyrwicz L, Tiret E, Brown G, Rödel C, Cervantes A, et al. Rectal cancer: ESMO clinical practice Guidelines for diagnosis, treatment and follow-up. Annals of Oncology. 2017;**28**:iv22-iv40. DOI: 10.1093/annonc/mdx224

[26] Swedish Rectal Cancer Trial, Cedermark B, Dahlberg M, Glimelius B, Påhlman L, Rutqvist LE, Wilking N. Improved survival with preoperative radiotherapy in resectable rectal cancer. The New England Journal of Medicine. 1997 Apr 3;**336**(14):980-987. DOI: 10.1056/NEJM199704033361402.

Erratum in: The New England Journal of Medicine. 1997 May 22;**336**(21):1539. PMID: 9091798

[27] Marks G, Mohiuddin M, Masoni L. The reality of radical sphincter preservation surgery for cancer of the distal 3 cm of rectum following high-dose radiation. International Journal of Radiation Oncology, Biology, Physics. 1993;27(4):779-783. DOI: 10.1016/0360-3016(93)90449-6

[28] Hospers GA, Punt CJ, Tesselaar ME, Cats A, Havenga K, Leer JW, et al. Preoperative chemoradiotherapy with capecitabine and oxaliplatin in locally advanced rectal cancer. A phase I–II multicenter study of the dutch colorectal cancer group. Annals of Surgical Oncology. 2007;14(10):2773-2779. DOI: 10.1245/s10434-007-9396-6

[29] Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, et al. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): Multicentre, randomised controlled trial. The Lancet. 2005;365(9472):1718-1726. DOI: 10.1016/s0140-6736(05)66545-2

[30] Borschitz T, Wachtlin D, Möhler M, Schmidberger H, Junginger T. Neoadjuvant chemoradiation and local excision for T2-3 rectal cancer. Annals of Surgical Oncology. 2007;15(3):712-720. DOI: 10.1245/s10434-007-9732-x

[31] Lezoche E, Baldarelli M, Lezoche G, Paganini AM, Gesuita R, Guerrieri M. Randomized clinical trial of endoluminal locoregional resection versus laparoscopic total mesorectal excision for T2 rectal cancer after neoadjuvant therapy. The British Journal of Surgery. 2012;99(9):1211-1218. DOI: 10.1002/bjs.8821

[32] Lezoche G, Baldarelli M, Mario, Paganini AM, De Sanctis A, Bartolacci S, Lezoche E. A prospective randomized study with a 5-year minimum follow-up evaluation of transanal endoscopic microsurgery versus laparoscopic total mesorectal excision after neoadjuvant therapy. Surgical Endoscopy. 2007;**22**(2):352-8. DOI:10.1007/s00464-007-9596-y

[33] D’Ambrosio G, Paganini AM, Balla A, Quaresima S, Ursi P, Bruzzone P, et al. Quality of life in non-early rectal cancer treated by neoadjuvant radio-chemotherapy and endoluminal loco-regional resection (ELRR) by transanal endoscopic microsurgery (TEM) versus laparoscopic total mesorectal excision. Surgical Endoscopy. 2015;**30**(2):504-511. DOI: 10.1007/s00464-015-4232-8

[34] D'Ambrosio G, Balla A, Mattei F, Quaresima S, De Laurentis F, Paganini AM. Quality of life after endoluminal loco-regional resection (ELRR) by transanal endoscopic microsurgery (TEM). Annali Italiani di Chirurgia. 2015;**86**(1):56-60

[35] Biviano I, Balla A, Badiali D, Quaresima S, D'Ambrosio G, Lezoche E, et al. Anal function after endoluminal locoregional resection by transanal endoscopic microsurgery and radiotherapy for rectal cancer. Colorectal Disease. 2017;**19**(6):O177-O185. DOI: 10.1111/codi.13656

[36] Quaresima S, Paganini AM, D'Ambrosio G, Ursi P, Balla A, Lezoche E. A modified sentinel lymph node technique combined with endoluminal loco-regional resection for the treatment of rectal tumours: A 14-year experience. Colorectal Disease. 2017;**19**(12):1100-1107. DOI: 10.1111/codi.13768

[37] Kanehira E, Tanida T, Kamei A, Nakagi M, Iwasaki M, Shimizu H. Transanal endoscopic microsurgery for surgical repair of rectovesical

fistula following radical prostatectomy. Surgical Endoscopy. 2014;**29**(4):851-855. DOI: 10.1007/s00464-014-3737-x

[38] Bochove-Overgaauw DM, Beerlage HP, Bosscha K, Gelderman WA. Transanal endoscopic microsurgery for correction of rectourethral fistulae. Journal of Endourology. 2006;**20**(12):1087-1090. DOI: 10.1089/end.2006.20.1087

[39] D'Ambrosio G, Paganini AM, Guerrieri M, Barchetti L, Lezoche G, Fabiani B, et al. Minimally invasive treatment of rectovaginal fistula. Surgical Endoscopy. 2011;**26**(2):546-550. DOI: 10.1007/s00464-011-1917-5

[40] Kato K, Saito T, Matsuda M, Imai M, Kasai S, Mito M. Successful treatment of a rectal anastomotic stenosis by transanal endoscopic microsurgery (TEM) using the contact Nd:YAG laser. Surgical Endoscopy. 1997;**11**(5):485-487. DOI: 10.1007/s004649900398

[41] Baatrup G, Svensen R, Ellensen VS. Benign rectal strictures managed with transanal resection - A novel application for transanal endoscopic microsurgery. Colorectal Disease. 2010;**12**(2):144-146. DOI: 10.1111/j.1463-1318.2009.01842.x

[42] Cocilovo C, Smith LE, Stahl T, Douglas J. Transanal endoscopic excision of rectal adenomas. Surgical Endoscopy. 2003;**17**(9):1461-1463. DOI: 10.1007/s00464-002-8929-0

[43] Lev-Chelouche D, Margel D, Goldman G, Rabau MJ. Transanal endoscopic microsurgery: Experience with 75 rectal neoplasms. Diseases of the Colon and Rectum. 2000;**43**(5):662-667; discussion 667-8. DOI: 10.1007/BF02235583

[44] Bignell MB, Ramwell A, Evans JR, Dastur N, Simson JN. Complications of transanal endoscopic microsugery (TEMS). A prospective audit. Colorectal Disease. 2009. DOI: 10.1111/j.1463-1318.2009.02071.x

[45] Gavagan JA, Whiteford MH, Swanstrom LL. Full-thickness intraperitoneal excision by transanal endoscopic microsurgery does not increase short-term complications. The American Journal of Surgery. 2004;**187**(5):630-634. DOI: 10.1016/j.amjsurg.2004.01.004

[46] Marks JH, Frenkel JL, Greenleaf CE, D'Andrea AP. Transanal endoscopic microsurgery with entrance into the peritoneal cavity. Diseases of the Colon and Rectum. 2014;**57**(10):1176-1182. DOI: 10.1097/DCR.0000000000000208

[47] Ramwell A, Evans J, Bignell M, Mathias J, Simson J. The creation of a peritoneal defect in transanal endoscopic microsurgery does not increase complications. Colorectal Disease. 2009;**11**(9):964-966. DOI: 10.1111/j.1463-1318.2008.01719.x

[48] Baatrup G, Borschitz T, Cunningham C, Qvist N. Perforation into the peritoneal cavity during transanal endoscopic microsurgery for rectal cancer is not associated with major complications or oncological compromise. Surgical Endoscopy. 2009;**23**(12):2680-2683. DOI: 10.1007/s00464-008-0281-6

[49] Morino M, Allaix ME, Famiglietti F, Caldart M, Arezzo A. Does peritoneal perforation affect short- and long-term outcomes after transanal endoscopic microsurgery? Surgical Endoscopy. 2012;**27**(1):181-188. DOI: 10.1007/s00464-012-2418-x

[50] Martin-PerezB, Andrade-RibeiroGD, Hunter L, Atallah S. A systematic

review of transanal minimally invasive surgery (TAMIS) from 2010 to 2013. Techniques in Coloproctology. 2014;**18**(9):775-788. DOI: 10.1007/s10151-014-1148-6

[51] Albert MR, Atallah SB, DeBeche-Adams TC, Izfar S, Larach SW. Transanal minimally invasive surgery (TAMIS) for local excision of benign neoplasms and early-stage rectal cancer. Diseases of the Colon & Rectum. 2013;**56**(3):301-307. DOI: 10.1097/DCR.0b013e31827ca313

[52] Hahnloser D, Cantero R, Salgado G, Dindo D, Rega D, Delrio P. Transanal minimal invasive surgery for rectal lesions: Should the defect be closed? Colorectal Disease. 2015;**17**(5):397-402. DOI: 10.1111/codi.12866

[53] McLemore EC, Weston LA, Coker AM, Jacobsen GR, Talamini MA, Horgan S, et al. Transanal minimally invasive surgery for benign and malignant rectal neoplasia. The American Journal of Surgery. 2014;**208**(3):372-381. DOI: 10.1016/j.amjsurg.2014.01.006

[54] Serra-Aracil X, Badia-Closa J, Pallisera-Lloveras A, Mora-López L, Serra-Pla S, Garcia-Nalda A, et al. Management of intra- and postoperative complications during TEM/TAMIS procedures: a systematic review. Minerva Surgery. 2021;**76**(4). DOI: 10.23736/S2724-5691.20.08405-9

[55] Molina G, Bordeianou L, Shellito P, Sylla P. Transanal endoscopic resection with peritoneal entry: A word of caution. Surgical Endoscopy. 2015;**30**(5):1816-1825. DOI: 10.1007/s00464-015-4452-y

[56] Kreissler-Haag D, Schuld J, Lindemann W, König J, Hildebrandt U, Schilling M. Complications after transanal endoscopic microsurgical resection correlate with location of rectal neoplasms. Surgical Endoscopy. 2007;**22**(3):612-616. DOI: 10.1007/s00464-007-9721-y

[57] Kumar AS, Coralic J, Kelleher DC, Sidani S, Kolli K, Smith LE. Complications of transanal endoscopic microsurgery are rare and minor: A single institution's analysis and comparison to existing data. Diseases of the Colon and Rectum. 2013;**56**(3):295-300. DOI: 10.1097/DCR.0b013e31827163f7

[58] Tsai BM, Finne CO, Nordenstam JF, Christoforidis D, Madoff RD, Mellgren A. Transanal endoscopic microsurgery resection of rectal tumors: Outcomes and recommendations. Diseases of the Colon and Rectum. 2010;**53**(1):16-23. DOI: 10.1007/DCR.0b013e3181bbd6ee

[59] Marques CF, Nahas CS, Ribeiro U, Bustamante LA, Pinto RA, Mory EK, et al. Postoperative complications in the treatment of rectal neoplasia by transanal endoscopic microsurgery: A prospective study of risk factors and time course. International Journal of Colorectal Disease. 2016;**31**(4):833-841. DOI: 10.1007/s00384-016-2527-4

[60] Brown C, Raval MJ, Phang PT, Karimuddin AA. The surgical defect after transanal endoscopic microsurgery: Open versus closed management. Surgical Endoscopy. 2016;**31**(3):1078-1082. DOI: 10.1007/s00464-016-5067-7

[61] Langer C, Liersch T, Süss M, Siemer A, Markus P, Ghadimi B, et al. Surgical cure for early rectal carcinoma and large adenoma: Transanal endoscopic microsurgery (using ultrasound or electrosurgery) compared to conventional local and radical resection. International Journal of Colorectal Disease. 2003;**18**(3):222-229. DOI: 10.1007/s00384-002-0441-4

[62] Lee L, Althoff A, Edwards K, Albert MR, Atallah SB, Hunter IA, et al.

Outcomes of closed versus open defects after local excision of rectal neoplasms. Diseases of the Colon and Rectum. 2018;**61**(2):172-178. DOI: 10.1097/DCR.0000000000000962

[63] Marks JH, Valsdottir EB, DeNittis A, Yarandi SS, Newman DA, Nweze I, et al. Transanal endoscopic microsurgery for the treatment of rectal cancer: Comparison of wound complication rates with and without neoadjuvant radiation therapy. Surgical Endoscopy. 2009;**23**(5):1081-1087. DOI: 10.1007/s00464-009-0326-5

[64] Coco C, Rizzo G, Mattana C, Gambacorta MA, Verbo A, Barbaro B, et al. Transanal endoscopic microsurgery after neoadjuvant radiochemotherapy for locally advanced extraperitoneal rectal cancer: Short-term morbidity and functional outcome. Surgical Endoscopy. 2013;**27**(8):2860-2867. DOI: 10.1007/s00464-013-2842-6

[65] Stone HB, Coleman CN, Anscher MS, McBride WH. Effects of radiation on normal tissue: Consequences and mechanisms. The Lancet Oncology. 2003;**4**(9):529-536. DOI: 10.1016/s1470-2045(03)01191-4

[66] Serra-Aracil X, Labró-Ciurans M, Rebasa P, Mora-López L, Pallisera-Lloveras A, Serra-Pla S, et al. Morbidity after transanal endoscopic microsurgery: Risk factors for postoperative complications and the design of a 1-day surgery program. Surgical Endoscopy. 2018;**33**(5):1508-1517. DOI: 10.1007/s00464-018-6432-5

[67] Raney A, Raman S. Retroperitoneal abscess after transanal minimally invasive surgery: Case report and review of literature. Journal of Coloproctology. 2017;**37**(4):323-327. DOI: 10.1016/j.jcol.2017.06.007

[68] Capitán Manjón C, Tejido Sánchez A, Piedra Lara JD, Martínez Silva V, Cruceyra Betriu G, Rosino Sánchez A, et al. Retroperitoneal abscesses - Analysis of a series of 66 cases. Scandinavian Journal of Urology and Nephrology. 2003;**37**(2):139-144. DOI: 10.1080/00365590310008884

[69] Perez RO, Habr-Gama A, São Julião GP, Proscurshim I, Neto AS, Gama-Rodrigues J. Transanal endoscopic microsurgery for residual rectal cancer after neoadjuvant chemoradiation therapy is associated with significant immediate pain and hospital readmission rates. Diseases of the Colon and Rectum. 2011;**54**(5):545-551. DOI: 10.1007/DCR.0b013e3182083b84

[70] Brown CJ, Hochman D, Raval MJ, Moloo H, Phang PT, Bouchard A, et al. A multi-centre randomized controlled trial of open vs closed management of the rectal defect after transanal endoscopic microsurgery. Colorectal Disease. 2019;**21**(9):1025-1031. DOI: 10.1111/codi.14689

[71] Mccraw JB, Massey FM, Shanklin KD, Horton CE. Vaginal reconstruction with gracilis myocutaneous flaps. Plastic and Reconstructive Surgery. 1976;**58**(2):176-183. DOI: 10.1097/00006534-197608000-00006

[72] Cardon A, Pattyn P, Monstrey S, Hesse U, de Hemptinne B. Use of a unilateral pudendal thigh flap in the treatment of complex rectovaginal fistula. The British Journal of Surgery. 1999;**86**(5):645-646. DOI: 10.1046/j.1365-2168.1999.01095.x

[73] Gürlek A, Gherardini G, Coban KY, Görgü M, Erdogan B, Evans GR. The repair of multiple rectovaginal fistulas with the neurovascular pudendal thigh flap (singapore flap). Plastic and Reconstructive

Surgery. 1997;**99**(7):2071-2073. DOI: 10.1097/00006534-199706000-00042

[74] Wee JT, Joseph VT. A new technique of vaginal reconstruction using neurovascular pudendal-thigh flaps. Plastic and Reconstructive Surgery [Internet]. 1989;**83**(4):701-709. DOI: 10.1097/00006534-198904000-00018

[75] Monstrey S, Blondeel P, Van Landuyt K, Verpaele A, Tonnard P, Matton G. The versatility of the pudendal thigh fasciocutaneous flap used as an island flap. Plastic and Reconstructive Surgery. 2001;**107**(3):719-725. DOI:10.1097/00006534-200103000-00011

[76] Wexner SD, Ruiz DE, Genua J, Nogueras JJ, Weiss EG, Zmora O. Gracilis muscle interposition for the treatment of rectourethral, rectovaginal, and pouch-vaginal fistulas. Annals of Surgery. 2008;**248**(1):39-43. DOI: 10.1097/SLA.0b013e31817d077d

[77] Ruiz D, Bashankaev B, Speranza J, Wexner SD, Rabau M. Graciloplasty for rectourethral, rectovaginal and rectovesical fistulas: Technique overview, pitfalls and complications. Techniques in Coloproctology. 2008;**12**(3):277-282. DOI: 10.1007/s10151-008-0433-7

[78] D'Ambrosio G, Intini G, Balla A, Quaresima S, Picchetto A, Seitaj A, et al. Recto-Urinary Fistula (RUF) treated by transanal endoscopic microsurgery (TEM). Review of the literature and surgical technique. Annali Italiani di Chirurgia. 2016;**87**:356-361

[79] Vavra P, Dostalik J, Vavrova M, Gunkova P, Pai M, El-Gendi A, et al. Transanal endoscopic microsurgery: A novel technique for the repair of benign rectovaginal fistula. The Surgeon. 2009;**7**(2):126-127. DOI: 10.1016/s1479-666x(09)80031-0

[80] Darwood RJ, Borley NR. TEMS: An alternative method for the repair of benign recto-vaginal fistulae. Colorectal Disease. 2008;**10**(6):619-620. DOI: 10.1111/j.1463-1318.2008.01478.x

[81] Basso L, Pescatori M. Subcutaneous emphysema after associated colonoscopy and transanal excision of rectal adenoma. Surgical Endoscopy. 2003;**17**(10):1677. DOI: 10.1007/s00464-003-4214-0

[82] Farmer KC, Tjandra JJ, Hockenberry S, Fazio VW. Pneumomediastinum following transanal excision of a rectal tumour. ANZ Journal of Surgery. 1993;**63**(7):568-571. DOI: 10.1111/j.1445-2197.1993.tb00456.x

[83] Petros JG, Thanikachalam M, Lopez MJ. Retroperitoneal and abdominal wall emphysema after transanal excision of a rectal carcinoma. The American Surgeon. 1996;**62**(9):759-761

[84] Franken RJ, Moes DE, Acherman YI, Derksen EJ. Free intra-abdominal air without peritoneal perforation after TEM: A report of two cases. Case Reports in Surgery. 2012;**2012**:1-3. DOI: 10.1155/2012/185429

[85] Liang HH, Tu CC, Hung CS, Wei PL, Yen KL, Kuo LJ. "Air bubble" in the head after transanal excision of a rectal carcinoma. The Journal of Emergency Medicine. 2013;**44**(2):e273-e274. DOI: 10.1016/j.jemermed.2012.06.026

[86] Restivo A, Zorcolo L, D'Alia G, Cocco F, Cossu A, Scintu F, et al. Risk of complications and long-term functional alterations after local excision of rectal tumors with transanal endoscopic microsurgery (TEM). International Journal of Colorectal Disease. 2015;**31**(2):257-266. DOI: 10.1007/s00384-015-2371-y

[87] Martins BA, Coura MD, de Almeida RM, Moreira NM, de Sousa JB, de Oliveira PG. Pneumoretroperitoneum and sepsis after transanal endoscopic resection of a rectal lateral spreading tumor. Annals of Coloproctology. 2017;**33**(3):115-118. DOI: 10.3393/ac.2017.33.3.115

[88] Dulskas A, Petrauskas V, Kavaliauskas P, Sapoka V, Samalavicius NE. Short-term clinical and functional results of rectal wall suture defect after transanal endoscopic microsurgery—a prospective cohort study. Langenbeck's Archives of Surgery. 2022. DOI: 10.1007/s00423-022-02476-x

[89] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of a 6,336 patients and results of a survey. Annals of Surgery. 2000;**240**:205-213. DOI: 10.1097/01.sla.0000133083.54934.ae

[90] Liu LR, Yan YC, Shang SW, Yuan YW, Hao HL, Zhai ZJ, et al. Risk factors and treatment of rectal stenosis after transanal endoscopic microsurgery. Colorectal Disease. 2021. DOI: 10.1111/codi.15904

[91] Altaf K, Slawik S, Sochorova D, Gahunia S, Andrews T, Kehoe A, et al. Long-term outcomes of open versus closed rectal defect after transanal endoscopic microscopic surgery. Colorectal Disease. 2021. DOI: 10.1111/codi.15830

[92] Barker JA, Hill J. Incidence, treatment and outcome of rectal stenosis following transanal endoscopic microsurgery. Techniques in Coloproctology. 2011;**15**(3):281-284. DOI: 10.1007/s10151-011-0703-7

[93] Serra-Aracil X, Flores-Clotet R, Mora-López L, Pallisera-Lloveras A, Serra-Pla S, Navarro-Soto S. Transanal endoscopic microsurgery in very large and ultra large rectal neoplasia. Techniques in Coloproctology. 2019;**23**(9):869-876. DOI: 10.1007/s10151-019-02071-1

[94] Garcea G, Sutton CD, Lloyd TD, Jameson J, Scott A, Kelly MJ. Management of benign rectal strictures. A review of present therapeutic procedures. Diseases of the Colon and Rectum. 2003;**46**:1451-1460. DOI: 10.1007/s10350-004-6792-x

[95] Marinello FG, Curell A, Tapiolas I, Pellino G, Vallribera F, Espin E. Systematic review of functional outcomes and quality of life after transanal endoscopic microsurgery and transanal minimally invasive surgery: A word of caution. International Journal of Colorectal Disease. 2019;**35**(1):51-67. DOI: 10.1007/s00384-019-03439-3

[96] Barendse RM, Oors JM, de Graaf EJ, Bemelman WA, Fockens P, Dekker E, et al. The effect of endoscopic mucosal resection and transanal endoscopic microsurgery on anorectal function. Colorectal Disease. 2013:n/a. DOI: 10.1111/codi.12311

[97] Hompes R, Ashraf SQ, Gosselink MP, van Dongen KW, Mortensen NJ, Lindsey I, et al. Evaluation of quality of life and function at 1 year after transanal endoscopic microsurgery. Colorectal Disease. 2015;**17**(2):O54-O61. DOI: 10.1111/codi.12858

[98] Doornebosch PG, Gosselink MP, Neijenhuis PA, Schouten WR, Tollenaar RA, de Graaf EJ. Impact of transanal endoscopic microsurgery on functional outcome and quality of life. International Journal of Colorectal Disease. 2008;**23**(7):709-713. DOI: 10.1007/s00384-008-0442-z

[99] Planting A, Phang T, Raval M, Brown C. Transanal endoscopic microsurgery: Impact on fecal incontinence and quality of life. Canadian Journal of Surgery. 2013;**56**(4):243-248. DOI: 10.1503/cjs.028411

[100] Lezoche E, Paganini AM, Fabiani B, Balla A, Vestri A, Pescatori L, et al. Quality-of-life impairment after endoluminal locoregional resection and laparoscopic total mesorectal excision. Surgical Endoscopy. 2013;**28**(1):227-234. DOI: 10.1007/s00464-013-3166-2

[101] Schiphorst AHW, Langenhoff BS, Maring J, Pronk A, Zimmerman DD. Transanalminimally invasive surgery: Initial experience and short-term functional results. Diseases of the Colon and Rectum. 2014;**57**:927-932. DOI: 10.1097/DCR.0000000000000170

[102] Verseveld M, Barendse RM, Gosselink MP, Verhoef C, de Graaf EJ, Doornebosch PG. Transanal minimally invasive surgery: Impact on quality of life and functional outcome. Surgical Endoscopy. 2015;**30**(3):1184-1187. DOI: 10.1007/ s00464-015-4326-3

[103] Kennedy ML, Lubowski DZ, King DW. Transanal endoscopic microsurgery excision. Diseases of the Colon and Rectum. 2002;**45**(5):601-604. DOI: 10.1007/s10350-004-6252-7

[104] Mora López L, Serra Aracil X, Hermoso Bosch J, Rebasa P, Navarro SS. Study of anorectal function after transanal endoscopic surgery. International Journal of Surgery. 2015;**13**:142-147. DOI: 10.1016/j.ijsu.2014.11.021

[105] Herman RM, Richter P, Wałęga P, Popiela T. Anorectal sphincter function and rectal barostat study in patients following transanal endoscopic microsurgery. International Journal of Colorectal Disease. 2001;**16**(6):370-376. DOI: 10.1007/s003840100325

[106] Kreis ME, Jehle EC, Haug V, Manncke K, Buess GF, Becker HD, et al. Functional results after transanal endoscopic microsurgery. Diseases of the Colon and Rectum. 1996;**39**(10):1116-1121. DOI: 10.1007/BF02081411

[107] Jin Z, Yin L, Xue L, Lin M, Zheng Q. Anorectal functional results after transanal endoscopic microsurgery in benign and early malignant tumors. World Journal of Surgery. 2010;**34**(5):1128-1132. DOI: 10. 1007/s00268-010-0475-7

[108] Clermonts SH, van Loon YT, Schiphorst AH, Wasowicz DK, Zimmerman DD. Transanal minimally invasive surgery for rectal polyps and selected malignant tumors: Caution concerning intermediate-term functional results. International Journal of Colorectal Disease. 2017;**32**(12):1677-1685. DOI: 10.1007/s00384-017-2893-6

[109] Allaix ME, Rebecchi F, Giaccone C, Mistrangelo M, Morino M. Long-term functional results and quality of life after transanal endoscopic microsurgery. The British Journal of Surgery. 2011;**98**(11):1635-1643. DOI: 10.1002/bjs.7584

[110] Ghiselli R, Ortenzi M, Cardinali L, Skrami E, Gesuita R, Guerrieri M. Functional outcomes after TEM in patients with complete clinical response after neoadjuvant chemoradiotherapy. Surgical Endoscopy. 2016;**31**(7):2997-3003. DOI: 10.1007/s00464-016-5321-z

[111] Palmieri L, Corallino D, Manni R, Meoli F, Paganini AM. Quality of life and anorectal function after transanal surgery for rectal cancer. A literature

review. Annali Italiani di Chirurgia. 2019;**90**:138-144

[112] Khoury W, Gilshtein H, Nordkin D, Kluger Y, Duek SD. Repeated transanal endoscopic microsurgery is feasible and safe. Journal of Laparoendoscopic & Advanced Surgical Techniques. 2013;**23**(3):216-219. DOI: 10.1089/lap.2012.0394

[113] Rizzo G, Pafundi DP, Sionne F, D'Agostino L, Pietricola G, Gambacorta MA, et al. Preoperative chemoradiotherapy affects postoperative outcomes and functional results in patients treated with transanal endoscopic microsurgery for rectal neoplasms. Techniques in Coloproctology. 2021;**25**(3):319-331. DOI: 10.1007/s10151-020-02394-4

[114] da Silva GM, Berho M, Wexner SD, Efron J, Weiss EG, Nogueras JJ, et al. Histologic analysis of the irradiated anal sphincter. Diseases of the Colon and Rectum. 2003;**46**(11):1492-1497. DOI: 10.1007/s10350-004-6800-1

[115] Yarnold J, Vozenin Brotons MC. Pathogenetic mechanisms in radiation fibrosis. Radiotherapy and Oncology. 2010;**97**(1):149-161. DOI: 10.1016/j.radonc.2010.09.002