Local full-thickness excision for sessile adenoma and cT1-2 rectal cancer: long-term oncological outcome

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Abstract

Purpose We analyzed all patients who underwent local transanal surgery at our institution to determine oncological outcomes and perioperative risk.

Methods In 1997, we developed a prospective protocol for rectal tumors: transanal local full-thickness excision was considered curative in patients with benign adenoma and early cancers. In this analysis, 404 patients were included. To analyze survival, only those patients exposed to the risk of dying for at least 5 years were considered for the study.

Results The final pathological analysis revealed that 262 (64.8%) patients had benign lesions, whereas 142 had malignant lesions. Postoperative complications were recorded in 12.6%. At the median time of 21 months, 14% of the adenomas and 12% of cancers had recurred, half of which were surgically resected. The overall 5-year survival rate was 94%.

Conclusion With similar outcomes and significantly lower morbidity, we found local surgery to be an adequate alternative to radical surgery in selected cases of early rectal cancer.

Keywords Transanal endoscopic microsurgery · Local surgery · Rectal cancer · Rectal adenoma · Oncological outcome · Rectal surgery

Introduction

The excision of rectal adenoma is accepted worldwide as rectal adenoma is a premalignant condition. Moreover, unexpected rectal cancer may be encountered incidentally in the resected specimen despite preprocedural diagnostics [1]. As such, the removal of rectal adenomas relieves symptoms and lowers the incidence of carcinomas. When possible, these lesions are best treated with snare polypectomy; however, they will need surgery in some cases.

Local rectal surgery was considered only for benign tumors with interest in local excision for rectal cancers beginning only in earnest after Morson et al. [2] published their experience of the conventional transanal approach in 1977, which demonstrated a low rate of local recurrence in early distal tumors when excised intact with negative margins.

In 1983, the transanal endoscopic microsurgery (TEM) system was introduced as a technique to ease local rectal surgery [3]. The first results published by TEM pioneers have shown it to be technically superior to the conventional peranal approach, with significantly lowers recurrence rates and an ability to access the entire rectum [4, 5]. The TEM technique gained widespread support during the latter years of the last century and renewed the interest in local rectal surgery among surgeons. Due to this renewed interest [6], an innovation race began, and in a few years, different systems appeared, each one claiming some advantage over the rest [7, 8].

In this sense, as its use becomes popular, considering Morson’s criteria for local excision and recalling the value of the experience of the surgical team are essential
to ensure an optimal outcome. We conducted a prospective study on the TEM technique for sessile rectal adenomas and early rectal cancer; the primary aims of this study were perioperative morbidity and long-term oncological survival. The protocols and first oncological results (1997–2006) have been reported previously [9, 10]. Such protocols and the prospective recording data have remained the same.

In this study, we performed a final analysis of all patients with rectal lesions who underwent local surgery with a curative intent according to the strategy established in 1997 at our institution, a high-volume TEM academic center. The aim was to outline the perioperative risk and long-term oncological outcome of this strategy and to guide surgeons and patients in the shared decision-making process.

Materials and methods

This study included all patients entered into our prospective database because of a rectal lesion who underwent local surgery. The inclusion criteria according to our protocol were as follows: adult patients with benign adenoma unsuitable for endoscopic resection and stage I low-risk (LR) rectal cancer. In cases of high-risk (HR) pT1 or pT2, adjuvant radiotherapy would be offered as an alternative to radical surgery. The protocol was approved in due time by our Institutional Ethics Committee.

Preoperative evaluation

After detailed history taking, physical examination was complemented by digital rectal assessment and rigid rectoscopic examination to estimate the location and distance from the anal verge. We only selected TEM with a curative intent for tumors located in the extraperitoneal region of the rectum that could be removed with sufficient free margins.

Endorectal ultrasonography (ERUS) was performed to stage the neoplasms. Moreover, preoperative evaluation included full colonoscopy to rule out synchronous lesions and obtain samples for histopathological evaluation.

For patients with biopsy-proven adenocarcinoma, the study was complemented with carcinoembryonic antigen (CEA) determination, chest X-ray, and abdominopelvic computed tomography (CT). Moreover, pelvic magnetic resonance imaging (MRI) was used from 2003 onward.

After this diagnostic workup, patients with benign lesions were scheduled for local surgery. Those with cancer were presented to a dedicated multidisciplinary team. Before the procedure, patients were counseled in detail about the benefits and risks involved, and written informed consent was obtained.

Surgery, pathology, and treatment options

All patients underwent full bowel preparation and received short-term antibiotic prophylaxis. General anesthesia was used in all cases. All procedures were performed by two senior surgeons (VAD and JMRR)—both were former trainees at Professor Büess’ training center in Tübingen (Germany). TEM was performed using equipment from Richard Wolf (Knittlingen, Germany). A more detailed description of the instruments and technique has been reported previously [11]. The traditional transanal approach, using conventional instruments (Hill Ferguson or Parks retractors), and direct visualization were indicated for the lowest lesions, which were tumors located between the dentate line and the first rectal valve. The institutional strategy for all these lesions is full-thickness excisions with grossly negative 1-cm peripheral margins. During the early years of TEM in our institution, suturing the defect was an option; however, after the results of our randomized study, this step was no longer routinely performed, and the decision was based upon the surgeon’s preference [12].

Resected specimens were pinned on a cork plate, measured, and sent to the pathology department for examination. Surgical excision was considered complete after confirmation of full-thickness excision and free circumferential margins (≥1 mm) on microscopic evaluation.

Rectal cancer was defined as HR if any of the following characteristics were mentioned in the pathology report: poor differentiation, lymphatic or venous invasion, and a clear resection margin of <1 mm. According to the final pathological report (Fig. 1), the patients were grouped as follows:

Group A: Benign or pT1 LR lesions. TEM alone was considered curative, and no further treatment was required.

Group B: pT1 HR or pT2 LR. In these cases, after being fully informed about the merits and disadvantages of both treatment modalities, the patients were offered either salvage surgery or adjuvant radiotherapy (5040 cGy in 28 fractions).

Follow-up

The patients were followed up at the outpatient clinic and underwent physical examination, rigid proctosigmoidoscopy, and ERUS for the first time at 4 weeks, every
3 months thereafter for 2 years, every 6 months up to the 5th postoperative year, and yearly thereafter. For patients with malignant neoplasms, the follow-up was complemented by the evaluation of serum CEA levels and regular thoracoabdominal CT. Moreover, the follow-up regimen included full colonoscopy 1 and 3 years after local surgery.

**Statistical analysis**

The statistical analysis was descriptive and is indicated using means and standard deviations. Differences between groups were determined using the Mann–Whitney U-test and chi-square test. Overall and cancer-specific survival curves were estimated using the Kaplan–Meier method. The log-rank test was used to examine differences in outcomes. Multivariate analysis was performed using the Cox proportional hazards model. Differences with p-values < 0.05 were considered statistically significant. All analyses were performed using R (R Foundation for Statistical Computing, Vienna, Austria).

**Results**

In the study period between January 1997 and December 2017, 404 patients were enrolled who underwent local surgery with curative intent (Fig. 1). Of these, 237 (58.7%) were men, with a mean age of 68 years (range, 20–92 years). With regard to preoperative clinical staging, 322 (79.7%) patients had adenoma, and 82 (21.3%) had stage I rectal cancer. The median upper distance from the anal verge was 9.7 cm, and the mean size of the lesions was 3.7 cm (Table 1).
Surgical procedure and histopathological examination

Of the 404 patients enrolled in this study, TEM was performed in 367 (91%), with the traditional transanal approach being performed in the remaining 36 (9%) cases; a deep full-thickness excision was performed in all cases. A peritoneal defect was noted intraoperatively in six cases; the suturing of the defect in one of the cases required abdominal laparoscopic assistance. The tumor was extracted fractioned in 10 (2.5%) cases due to technical difficulties. At the end of the operation, the defect was left open in 259 (64%) patients.

The median operation time was 78 min (range: 50–90 min). The final surgical pathological analysis (Table 1) revealed that 262 (64.8%) patients had benign lesions and 142 (35.2%) had malignant lesions (97, pT1; 37, pT2; and 8, pT3). Table 2 shows the relationship between preoperative ERUS and the final pathological report. The overall accuracy of preoperative ERUS was 77% (64% for malignant T1 lesions). Of 45 patients thought to have T2 lesions, 20 (44%) were misdiagnosed (12 overstaged and 8 understaged).

As reported previously, preoperative biopsy and ERUS could not appropriately differentiate between benign lesions and early cancer or between the levels of wall invasion or grading, both of which are of particular interest in the decision-making process. In any case, according to our proposal strategy, only 9 (2%) of the 404 patients were incorrectly included for local surgery (1 with pT2 HR and 8 with pT3).

According to our policy, all these subjects underwent immediate radical surgery, as did three patients from group B after the final shared decision-making process.

Regarding margins, in 21 patients (5.2%), the dissection was considered microscopically incomplete or doubtful because the normal circumferential margin was smaller than 1 mm, whereas there were no patients whose deep margins were compromised.

No statistical differences were observed between adenomas and carcinomas in terms of histological findings according to age, gender, tumor size, distance to the anal verge, or location (Table 1).

Postoperative complications

Postoperative complications were recorded in 51 (12.6%) of the 404 patients, some of whom had more than one complication. Bleeding was the most common early complication (Table 1), occurring in 32 (8%) cases. Nine patients with bleeding needed repeat TEM for hemostasis (two of them also required transfusion).

Postoperatively, one patient (0.25%), a 76-year-old man, underwent the Hartmann procedure on the fourth postoperative day because of intraabdominal sepsis owing to an undetected leakage. Despite this, the patient died 20 days after the reoperation.

Table 1 Pathological and operative characteristics of the patients

| Variable                        | All (n = 404) | Adenoma (n = 262) | Carcinoma (n = 142) | P-value |
|---------------------------------|---------------|-------------------|---------------------|---------|
| Mean age, years (SD)           | 68 (11.9)     | 67.8 (12.1)       | 68.5                | 0.99    |
| Male sex (%)                   | 237 (58.7)    | 153 (58.4)        | 84 (59.1)           | 0.97    |
| Mean lesion size, cm (SD)      | 3.68 (1.60)   | 3.73 (1.63)       | 3.58 (1.55)         | 0.48    |
| Mean upper distance from anal verge, cm (SD) | 9.7 (3.9)   | 9.6 (4.0)        | 9.8 (3.5)           | 0.44    |
| Defect closure (%)             | 145 (35.9)    | 86 (32.8)         | 59 (41.6)           | 0.10    |
| Tumor fragmentation (%)        | 10 (2.5)      | 6 (2.3)           | 4 (2.8)             | 0.10    |
| Mean duration of surgery, min (SD) | 78 (45.7)  | 76.7 (46.6)      | 80.3 (43.9)         | 0.16    |
| *Postoperative complications (%) | 51 (12.6)   | 37 (14.1)        | 14 (9.9)            | 0.28    |
| Postoperative bleeding (%)     | 32 (7.9)      | 22 (8.4)          | 10 (7.0)            | 0.76    |
| Positive margin (%)            | 21 (5.2)      | 18 (6.9)          | 3 (2.1)**           | 0.06    |
| Mean length of stay, days (SD) | 4.4 (4.05)    | 4.5 (4.6)         | 4.2 (2.8)           | 0.54    |

*Some patients had more than one complication
**According to our protocol, patients with cancer with positive margins were considered high risk and received adjuvant radiotherapy

Table 2 Ultrasound vs. definitive histological report

| Variable | All (n = 404) | Benign (n = 262) | pT1 (n = 97) | pT2 (n = 37) | pT3 (n = 8) |
|----------|---------------|------------------|--------------|--------------|-------------|
| uT0      | 302           | 254              | 48           | –            | –           |
| uT1      | 57            | 4                | 37           | 16           | –           |
| uT2      | 45            | 4                | 12           | 21           | 8           |

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Recurrence and survival status

As the main outcomes were long-term recurrence and survival after local surgery, data in this study were based on the full 5-year follow-up. After the first postoperative year, 41 (10%) of the 404 patients were lost to follow-up: one postoperative death and 40 patients (26 with adenomas and 14 with cancer) for reasons unrelated to the surgery. As we analyzed the oncological outcomes of local surgery, we excluded the 12 patients who underwent immediate radical surgery, understanding local surgery as biopsy that appropriately and accurately staged the patient.

Of the remaining 351 patients, 314 (216 adenomas and 98 malignant tumors) met the minimal established follow-up period.

Adenoma recurrence  A total of 31 (14%) of 216 patients with benign lesions demonstrated recurrence at a median duration of 21 months (interquartile range [IQR], 15–28 months). Of the 31 patients, 22 were managed with the new TEM technique, and nine were treated with snare polypectomy. Recurrence for the second time was observed in eight patients (median time, 15 months; IQR, 14–24 months), and recurrence for the third time was observed in one case (12 months after the second). Recurrence was not statistically related to gender, age, margin affected, fragmentation, or defect closure; it seems to be related to the dysplasia grade (Table 3).

No recurrence was observed in patients who underwent surgery by conventional transanal approach.

Carcinoma recurrence and survival  Of the 98 patients who underwent local excision of malignant lesions with a curative

| Table 3 | Risk of recurrence of adenomas and carcinomas |
|---------|---------------------------------------------|
| **Variable** | **Adenomas*** | **Carcinomas*** | **OR (univariate)** |
| Gender-Male | 0.69 (0.34–1.39, p = 0.301) | 0.77 (0.31–1.94, p = 0.579) | 1.05 (0.65–1.71, p = 0.840) |
| Age | 0.98 (0.95–1.00, p = 0.080) | 0.99 (0.95–1.04, p = 0.791) | 1.00 (0.98–1.02, p = 0.774) |
| Tumor size | 1.19 (1.00–1.41, p = 0.050) | 0.86 (0.61–1.23, p = 0.415) | 0.98 (0.84–1.14, p = 0.818) |
| Fragmentation | 1.58 (0.22–11.61, p = 0.651) | 0.00 (0.00–Inf, p = 0.998) | 2.26 (0.52–9.72, p = 0.257) |
| Non clear margins | 2.27 (0.79–6.49, p = 0.126) | 3.65 (0.84–15.93, p = 0.085) | 0.46 (0.10–1.44, p = 0.225) |
| Closure of the defect | 0.58 (0.25–1.35, p = 0.205) | 0.71 (0.27–1.89, p = 0.489) | 1.38 (0.85–2.25, p = 0.225) |
| Postop. complication | 1.23 (0.37–4.05, p = 0.732) | 0.00 (0.00–Inf, p = 0.998) | 0.63 (0.20–1.64, p = 0.372) |
| Low-mod. dysplasia | 0.35 (0.13–0.92, p = 0.034) | – | – |
| High dysplasia | 0.80 (0.34–1.90, p = 0.620) | – | – |
| pT2 | 0.79 (0.23–2.71, p = 0.703) | – | – |

*p Cox regression

**Odds ratio univariate logistic regression

| Table 4 | Protocol failures (n = 98) |
|---------|---------------------------|
|          | Age  | Gender | Site of recurrence | Months to recurrence | Procedure (PR) | Status |
| pT1 low risk | 73   | Male   | Local              | 15                 | AAP (pT1N0)    | Free from disease |
| pT1 low risk | 46   | Male   | Local              | 39                 | LAR (pT2N0)    | Free from disease |
| pT1 low risk | 60   | Female | Local              | 30                 | AAP (pT2N1)    | Free from disease |
| pT1 low risk | 69   | Female | Local              | 19                 | AAP (pT2N0)    | Free from disease |
| pT1 low risk | 49   | Female | Periaortic node    | 24                 | Lymphadenectomy| Death           |
| pT1 low risk | 70   | Male   | Liver              | 36                 | Hepatectomy    | Free from disease |
| pT1 low risk | 83   | Male   | Liver              | 42                 | Adjuvant therapy | Death       |
| pT1 low risk | 57   | Female | Local              | 36                 | AAP (pT2N1)    | Death           |
| pT1 high risk* | 69   | Male   | Local              | 12                 | AAP (pT3N1)    | Death           |
| pT2*        | 61   | Female | Local              | 15                 | LAR (pT2N1)    | Free from disease |
| pT2*        | 60   | Male   | Local              | 12                 | AAP (pT3N1)    | Death           |
| pT2*        | 68   | Female | Liver              | 24                 | Hepatectomy    | Death           |

AAP abdominoperineal resection, LAR low anterior resection, PR pathological report

*Patients with adjuvant radiotherapy
intent and had a minimum follow-up of 5 years, 66 (67.4%) were classified into group A and 32 (32.6%) into group B (Fig. 1). During the follow-up, seven patients with a pathological report of pT1 presented a rectal benign lesion (severe dysplasia), which was excised using the new TEM technique.

Table 4 shows protocol failures. Eight of the 98 patients with cancer (Table 4; Fig. 1) presented local cancer recurrence (five from group A and three from group B), at the median duration of 16.5 months (IQR, 14–31 months). In all cases, radical resection was possible; however, three patients died of cancer. Without local recurrence, one patient presented with periaortic lymph node involvement (died from the disease) and three had liver metastases (only one of them was disease-free after partial hepatectomy). The overall cancer-related mortality was 6.1%; three of the 66 patients from group A (4.5%) and three of the 32 from group B (9.4%) died. The 5-year disease-free survival curve from both groups is displayed in Fig. 2.

Discussion

Endoscopic techniques have improved over time, and a significant proportion of rectal adenomas are now being resected using endoscopic mucosal resection. TEM was originally developed to be complementary to endoscopic mucosal resection and is particularly useful for treating large villous adenomas, for which it remains indicated. Given the low associated morbidity and lack of mortality compared with radical surgery, a proposal has been made to extend this indication to cases of rectal cancer with low probability of lymph node involvement and local recurrence. Although early rectal cancer is relatively uncommon in the West, the generalization of screening programs has indicated that nearly 50% of tumors detected are stage I (T1–2 N0) tumors [13].

Total mesorectal excision (TME) provides the best long-term prognosis for rectal cancer, with low rates of local recurrence and excellent long-term survival. However, this accomplishment is not without an important degree of postoperative morbidity and compromised quality of life [14]. Moreover, permanent stoma rates of up to 37% have been reported [15]. Indeed, balancing the level of surgical morbidity and mortality for all stages of resectable rectal cancer against a satisfactory oncological outcome is a challenge, although, based on current evidence, it appears that TME could be considered overtreatment in some early rectal cases [10, 16]. In this regard, current clinical guidelines agree that, for LR pT1 rectal cancer, local excision is deemed sufficient, whereas for HR pT1 or pT2, adjuvant (chemo) radiotherapy may be an alternative to TME within a clinical trial setting or for patients unfit for surgery [17]. As such, the key point is to perform an accurate preoperative staging, a difficult task that still relies mainly on two imaging tests, namely, ERUS and pelvic MRI scan. ERUS remains the gold standard for evaluating the depth of wall penetration [18], and many clinicians believe that ERUS contributes widely to the management of patients with early disease. However, recent findings have shown that ERUS is not a reliable technique for distinguishing between adenoma and T1 and has an important rate of inaccuracy for determining T1 and T2 [19, 20]. Unfortunately, MRI does not provide any advantages in this regard, and overstaging tends to occur: MRI results are impressive in advanced disease but
less accurate in defining early invasion [20, 21]. All this is of paramount importance as overstaging rectal tumors by ERUS or MRI may result in a decision to use radical instead of local surgery, thus denying patients with early disease a potentially curative and more minor operation.

In our series, 322 of 404 tumors had biopsy of adenoma. From a theoretical viewpoint, all these would be suitable for a mucosectomy or partial-thickness excision. Sixty (19%) of them were cancers, and the full-thickness excision technique helped avoid a second local surgery or, even worse, TME. In this context, some authors have highlighted that patients with rectal sessile tumors without invasive carcinoma on biopsy and without malignant characteristics in the judgment of an experienced colorectal surgeon might not benefit from preoperative imaging before undergoing transanal local surgery [22].

Taking a closer look at the 82 biopsy-proven cancers is interesting as 16 uT1 were already pT2 (Table 2) and were, according to the guidelines, undertreated by local surgery. In these cases, additional treatment (completion TME surgery or adjuvant chemoradiotherapy and close surveillance) should be considered in the shared decision-making process. A recent study indicated that there is no oncological loss from performing local excision before completion of surgery; however, there may be an increased risk for a permanent stoma [23].

In contrast, 11 uT2 cases were already pT1 LR; therefore, these cases would have had unnecessary radical surgery (TME or abdominoperineal resection with permanent colostomy) if we had followed the guidelines.

At the time, we proposed our protocol—postoperative radiotherapy—was the standard for managing rectal cancer and was recommended after local excision of T1 with poor histological features and T2 [24, 25]. Indeed, we used it as a routine procedure in some cases with only minor problems, all of which were treated conservatively. Nowadays, there is an increasing tendency to use neoadjuvant chemotherapy or radiation therapy, followed by TEM, an issue due to the lack of accuracy in preoperative staging.

TEM is a surgical technique linked to few complications, with postoperative bleeding being the most common (0.5–4.1% of cases) [26, 27]. Additional risks communicated to patients include anal incontinence, rectal stenosis, and rectovaginal fistula. Overall, our complication rate was 12%, which is similar to those reported in previous studies on TEM in the literature (5–21%) [28, 29]. However, this technique is not free from mortality, and one patient in our series died (0.2%); this rate is similar to that reported by other authors [30]. Thus, morbidity after TEM is significantly lower than that reported after radical surgery; however, recurrence is its Achilles heel.

Pigot et al. [31] demonstrated that, in large rectal tumors, the risk of recurrence of benign polyps was 10%, whereas if a malignancy was identified, the risk increased to 20%. The risk factors for adenoma recurrence include size, previous piecemeal excision, and positive resection margin [32]. Moreover, unsutured management of the defect has also been identified as a risk factor for recurrence [33]. In our experience, after a minimum surveillance period of 5 years, the recurrence rate of adenomas was 14%. We could not statistically demonstrate any independent factor for recurrence; however, the dysplasia grade seemed to be an independent risk factor. In line with previous reports, leaving a full-thickness rectal defect open seems to be safe and does not show any difference in complication or recurrence rates [12, 34].

After the local treatment of rectal cancer, ensuring the early detection of recurrent disease is of paramount importance. Based on our data, the most intense surveillance should be performed within the first 3 years. As recommended by some authors, locally excised rectal cancers should have specific surveillance guidelines, including periodic pelvic MRI and proctoscopy [35].

Accurately determining the 5-year survival is difficult after radical surgery for stage I rectal cancer as this should consider both cancer-related and postoperative mortality. Moreover, although perioperative patient management has improved recently, the rectal cancer population has aged. In any case, the accepted range is 90–95% [36, 37]. Recently published studies have presented similar rates of survival after local excision of pT1 and pT2 plus adjuvant therapy [38, 39]. In our fully controlled patients, we encountered six cancer-related deaths, thus providing a survival rate of 94% (95.5% for pT1 and 90% for pT2 plus radiotherapy).

Minimally invasive instrumentation is continually evolving, and local rectal excision can currently be performed using the transanal approach, TEM equipment, transanal minimally invasive surgery [40], or even robotic surgery [41]; whatever the technique, surgeons must be part of a multidisciplinary specialized team prepared to discuss any particular case and translate this debate to patients to incorporate their opinions into the decision-making process. Patients should be engaged in a partnered dialog in which the actual risks and benefits of treatment options are presented.

This study has several limitations. First, this was a retrospective analysis of prospective data from a consecutive series of patients who underwent local surgery over a prolonged period. Results could be compromised due to inherent technical evolution.

Conclusion

With similar outcomes and significantly lower morbidity, we found local surgery (alone or adding radiotherapy) to be an adequate alternative to radical surgery in selected cases of early rectal cancer (pT1–pT2). Patients should be involved in the decision-making process and should know the actual risks and benefits of the treatment options.
Authors’ contributions

Study conception and design: JMRR and VA.
Acquisition of data: JMRR, VA, MAG, and JV.
Analysis and interpretation of data: JMRR, VA, MAG, TM, LA, and JV.
Drafting of manuscript: JMRR and MAG.
Critical revision of the manuscript: JMRR, MAG, VA, TM, LA, and JV.
All authors have read and approved the final version of the manuscript to be submitted.

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Declarations

Ethics approval

This is a retrospective study regarding a standard treatment for rectal tumors at our hospital. According to our regional Ethics Committee, ethical approval was unnecessary.

Consent to participate

Informed consent was obtained from all the individual participants included in the study.

Competing interests

JMRR shares a rectoscope patent from Richard Word GmbH. MAGD, VAD, TMT, AG, and JV have no conflicts of interest to disclose.

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References

1. Bronzwaer MES, Musters GD, Barendse RM et al (2018) The occurrence and characteristics of endoscopically unexpected malignant degeneration in large rectal adenomas. Gastrointest Endosc 87:862–871.e1. https://doi.org/10.1016/j.gie.2017.09.046
2. Morson BC, Bussey HJ, Samoorian S (1977) Policy of local excision for early cancer of the colorectum. Gut 18:1045–1050. https://doi.org/10.1136/gut.18.12.1045
3. Buess G, Theiss R, Günther M, Hutterer F, Pichlmaier H (1985) Endoscopic surgery in the rectum. Endoscopy 17:31–35. https://doi.org/10.1055/s-2007-1018451
4. Said S, Stippel D (1995) Transanal endoscopic microsurgery in large, sessile adenomas of the rectum. A 10-year experience. Surg Endosc 9:1106–1112. https://doi.org/10.1007/BF00188997
5. Mayer J, Mortensen NJ (1995) Transanal endoscopic microsurgery: a forgotten minimally invasive operation. Br J Surg 82:435–437. https://doi.org/10.1002/bjs.1800820403
6. Rattner D, Kalloo A (2006) ASGE/SAGES working group on natural orifice transluminal endoscopic surgery. Surg Endosc 20:329–333. https://doi.org/10.1007/s00464-005-3006-0
7. Ramirez JM, Elia M, Cordoba E, Gracia JA, Aguilella V (2016) Current controversies in transanal surgery for rectal cancer. Surg Laparosc Endosc Percutan Tech 26:431–438. https://doi.org/10.1097/SLE.0000000000000357
8. Albert MR, Atallah SB, deBeche-Adams TC, Izzar S, Larach SW (2013) Transanal minimally invasive surgery (TAMIS) for local excision of benign neoplasms and early-stage rectal cancer: efficacy and outcomes in the first 50 patients. Dis Colon Rectum 56:301–307. https://doi.org/10.1097/DCR.0b013e31827ca313
9. Ramirez JM, Aguilella V, Gracia JA et al (2009) Local full-thickness excision as first line treatment for sessile rectal adenomas: long-term results. Ann Surg 249:225–228. https://doi.org/10.1097/SLA.0b013e318190496f
10. Ramirez JM, Aguilella V, Valencia J et al (2011) Transanal endoscopic microsurgery for rectal cancer. Long-term oncologic results. Int J Colorectal Dis 26:437–443. https://doi.org/10.1007/s00384-011-1312-9
11. Arribas Del Amo D, Ramirez Rodriguez JM, Aguilella Diago V, Elia Guedea M, Palacios Fanlo MJ, Martinez Diz M (2000) Cirugía endoscopica transanal en los tumores de recto. Rev Esp Enferm Dig 92:526–535
12. Ramirez JM, Aguilella V, Arribas D, Martinez M (2002) Transanal full-thickness excision of rectal tumours: should the defect be sutured? a randomized controlled trial. Colorectal Dis 4:51–55. https://doi.org/10.1046/j.1463-1318.2002.00293.x
13. Logan RF, Patrick J, Nickerson C et al (2012) Outcomes of the Bowel Cancer Screening Programme (BCSP) in England after the first 1 million tests. Gut 61:1439–1446. https://doi.org/10.1136/gutjnl-2011-300843
14. Grumann MM, Noack EM, Hoffmann IA, Schlag PM (2001) Comparison of quality of life in patients undergoing abdomino- operineal extirpation or anterior resection for rectal cancer. Ann Surg 233:149–156. https://doi.org/10.1097/00000658-200100000-00001
15. Lindgren R, Hallböök O, Rutegård J, Sjödahl R, Matthiessen P (2011) What is the risk for a permanent stoma after low anterior resection of the rectum for cancer? A six-year follow-up of a multicenter trial. Dis Colon Rectum 54:41–47. https://doi.org/10.1007/D01097-008013e3181fd2948
16. Lezoche G, Guerrieri M, Baldarelli M et al (2011) Transanal endoscopic microsurgery for 135 patients with small nonadvanced low rectal cancer (T1-T2, n0): short- and long-term results. Surg Endosc 25:1222–1229. https://doi.org/10.1007/s00464-010-1347-9
17. Bostlap WAA, van Oostendorp SE, Klaver CE et al (2018) Organ preservation in rectal cancer: a synopsis of current guidelines. Colorectal Dis 20:201–210. https://doi.org/10.1111/codi.13960
18. Gao Y, Hu JL, Zhang XX et al (2020) Accuracy of endoscopic ultrasound in rectal cancer and its use in transanal endoscopic microsurgery. Minim Invasive Ther Allied Technol 29:90–97. https://doi.org/10.1080/13645706.2019.1585373
19. Zorcolo L, Fantola G, Cabras F, Marongiu L, D’Alìa G, Casula G (2009) Preoperative staging of patients with rectal tumors suitable for transanal endoscopic microsurgery (TEM): comparison of endorectal ultrasound and histopathologic findings. Surg Endosc 23:1384–1389. https://doi.org/10.1007/s00464-009-0349-y
20. Oien K, Forsmo HM, Röslé C, Nyland K, Waage JE, Pfeffer F (2019) Endorectal ultrasound and magnetic resonance imaging for staging of early rectal cancers: how well does it work in practice? Acta Oncol 58:S49–S54. https://doi.org/10.1080/0284186X.2019.1569259
21. Ashraf S, Hompes R, Slater A et al (2012) A critical appraisal of endorectal ultrasound and transanal endoscopic microsurgery and decision-making in early rectal cancer. Colorectal Dis 14:821–826. https://doi.org/10.1111/j.1463-1318.2011.02830.x

22. Letarte F, Drolet S, Laliberté AS, Bouchard P, Bouchard A (2019) Transanal endoscopic microsurgery for rectal villous tumours: can we rely solely on preoperative biopsies and the surgeon’s experience? Can J Surg 62:445–459

23. Lossius WJ, Stornes T, Myklebust TA, Endreseth BH, Wibe A (2020) Completion surgery vs. primary TME for early rectal cancer: a national study. Int J Colorectal Dis 35(2):429–35

24. Coco C, Magistrelli P, Netri G et al (1995) Combined modality therapy in low risk (T2N0) rectal cancer. Rays 20:156–164. https://doi.org/10.1503/rays.012416

25. Minsky BD (1995) Conservative treatment of rectal cancer with local excision and postoperative radiation therapy. Eur J Cancer 31A:1343–1346. https://doi.org/10.1016/0959-8049(95)00157-e

26. Guerrieri M, Baldarelli M, de Sanctis A, Campagnacci R, Rimini M, Lezoche E (2010) Treatment of rectal adenomas by transanal endoscopic microsurgery: 15 years’ experience. Surg Endosc 24:445–449. https://doi.org/10.1007/s00464-009-0585-1

27. Ondhia M, Tamvakeras P, O’Toole P et al (2019) Transanal endoscopic microsurgery for rectal lesions in a specialist regional early rectal cancer centre: the Mersey experience. Colorectal Dis 21:1164–1174. https://doi.org/10.1111/cdsi.14730

28. Tsai BM, Finne CO, Nordenstam JF, Christoforidis D, Madoff RD, Meltgren A (2010) Transanal endoscopic microsurgery resection of rectal tumours: outcomes and recommendations. Dis Colon Rectum 53:16–23. https://doi.org/10.1007/DCR.0b013 e3181bd6ee

29. O’Neill CH, Platz J, Moore JS, Callas PW, Cataldo PA (2017) Transanal endoscopic microsurgery for early rectal cancer: a single-center experience. Dis Colon Rectum 60:152–160. https://doi.org/10.1097/DCR.0b013e3181bbd8ee

30. Serra-Aracil X, Labró-Ciurans M, Rebasa P et al (2019) Morbidity after transanal endoscopic microsurgery: risk factors for postoperative complications and the design of a 1-day surgery program. Surg Endosc 33:1508–1517. https://doi.org/10.1007/s00464-018-6432-5

31. Pigot F, Bouchard D, Mortaji M et al (2003) Local excision of large rectal villous adenomas: long-term results. Dis Colon Rectum 46:1345–1350. https://doi.org/10.1007/s10350-004-6748-1

32. Morino M, Allaix ME, Caldart M, Scozzari G, Arezzo A (2011) Risk factors for recurrence after transanal endoscopic microsurgery for rectal malignant neoplasm. Surg Endosc 25:3683–3690. https://doi.org/10.1007/s00464-011-1777-z

33. Chan T, Karimuddin AA, Raval MJ, Phang PT, Tang V, Brown CJ (2020) Predictors of rectal adenoma recurrence following transanal endoscopic surgery: a retrospective cohort study. Surg Endosc 34:3398–3407. https://doi.org/10.1007/s00464-019-07114-0

34. Hahnloser D, Cantero R, Salgado G, Dindo D, Rega D, Delrío P (2015) Transanal minimal invasive surgery for rectal lesions: should the defect be closed? Colorectal Dis 17:397–402. https://doi.org/10.1111/codi.12866

35. Kwakye G, Curran T, Uegami S et al (2019) Locally excised T1 rectal cancers: need for specialized surveillance protocols. Dis Colon Rectum 62:1055–1062. https://doi.org/10.1097/DCR.000000000001439

36. Howlader N, Na KM, Miller D, et al (2020) SEER cancer statistics review, National Cancer Institute. Bethesda M. SEER Data Submission. https://seer.cancer.gov/csr/1975_2017/. Accessed 15 January 2021

37. Joachim C, Macni J, Drame M et al (2019) Overall survival of colorectal cancer by stage at diagnosis: data from the Martinique Cancer Registry. Medicine 98:e16941. https://doi.org/10.1097/MD.0000000000016941

38. Junginger T, Goenner U, Hitzler M, Trinh TT, Heintz A, Wollscheid I (2019) Local excision followed by early radical surgery in rectal cancer: long-term outcome. World J Surg Oncol 17:168. https://doi.org/10.1186/s12957-019-1705-6

39. Lai IL, You JF, Chern YJ et al (2019) Survival analysis of local excision vs total mesorectal excision for middle and low rectal cancer in pT1/pT2 stage and intermediate pathological risk. World J Surg Oncol 17:212. https://doi.org/10.1186/s12957-019-1763-9

40. Lee L, Burke JP, deBeche-Adams T et al (2018) Transanal minimally invasive surgery for local excision of benign and malignant rectal neoplasia: outcomes from 200 consecutive cases with midterm follow up. Ann Surg 267:910–916. https://doi.org/10.1097/SLA.0000000000002190

41. Baker EJ, Waters PS, Peacock O et al (2020) Robotic transanal minimally invasive surgery—technical, oncological and patient outcomes from a single institution. Colorectal Dis 22:1422–1428. https://doi.org/10.1111/codi.15045

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