LAPAROSCOPIC AND ENDOSCOPIC
SURGERY IN ONCOLOGY

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TRANSANAL ENDOSCOPIC MICROSURGERY

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Rigid rectoscopy is one of the oldest techniques in endoscopy of the intestinal tract. New techniques were developed with more advanced optics in the beginning of the 20th century.[18] Interventional procedures through rigid rectoscopes under gas dilatation had been limited to simple procedures such as snare resections. Operative rectoscopes were developed with diameters of up to 4 cm, but only were used as mechanical retractors, and conventional instruments were applied for minor surgical procedures inside the rectal cavity.

Surgical procedures in the rectum, such as resection of sessile polyps, mainly have been performed with the use of retractors. Retractors for transanal and transvaginal application first were used during the time of the ancient Romans; advanced technical systems were found in Pompeii. Surgical manipulation inside the rectal cavity using rectractors does have disadvantages: the surgical view is restricted to the area between the branches of the retractors, the blades of the retractor obstruct parts of the rectum, the area located higher than the retractor tends to collapse, again obstructing the view, and the surgical instruments and the hands of the surgeon, restrict direct vision of the operating field. For these reasons, transanal surgical manipulation has been most frequently applied for lesions in the lower third of the rectum. Depending on each situation, parts of the tumor-bearing area of the rectum can be prolapsed towards the anal verge, thereby utilizing the standard technique in more proximal lesions.[15]

Rectal resection is possible by utilizing various modifications of dorsal access such as the sphincter splitting procedure[11] or a modified Kraske procedure.[8] Because both procedures are associated with a high incidence of postoperative complications, they are rarely performed today.[15]

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During the 2-year extended work program, these developmental hurdles had to be realized in order to develop a new working structure:

- The need for hundreds of experimental tests during the developmental process precluded the use of animal experiments for testing each phase. Therefore, specific test models were developed using cow's bowel, tightly connected to the rectoscope. This model eventually evolved into the currently used training model (Fig. 1).
- Simple modifications of prototypes were performed in the laboratory of the experimental department in Cologne (Professor W. Isselhard).

TECHNOLOGY

The Operative Rectoscope

The operative rectoscope is 40 mm in diameter, which compromises the acceptable limit of dilating the anal sphincter and adequate space inside the tube to perform complex surgery.

Two different tubes are available with either a length of 10 cm or 20 cm. At the distal end, the rectoscope tubes have a 45° angle (Fig. 2); the tubes are introduced into the handpiece (see Fig. 2). The handpiece allows introduction of the operative rectoscope with the respective obturator for endoscopic examination of the rectum using the glass window (right of the short obturator). A cold light adapter is integrated into the glass window for optimal illumination during examination.

In preparation for the procedure, the handpiece is connected to a holding device, mounted to the rail of the operating table. This martin arm belongs to the operative system. A double-ball joint allows easy adjustment of

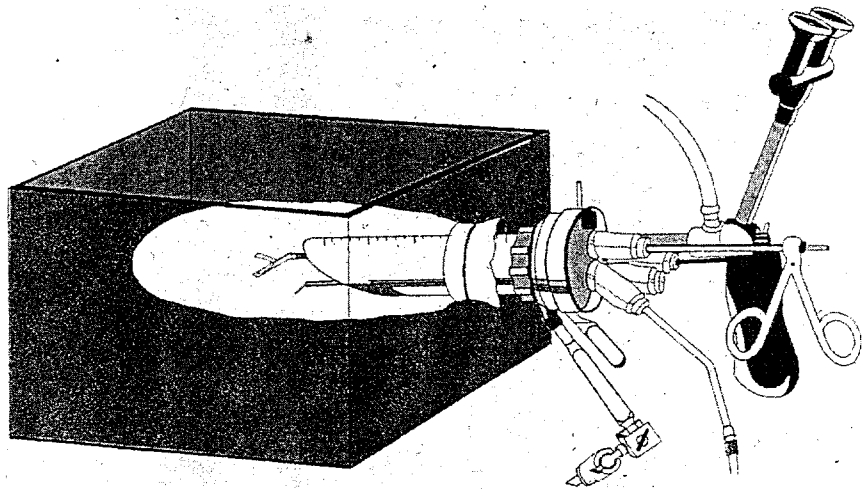

Figure 1. Training model for TEM and for testing of mechanical competence. The cow's bowel is fixed, air-tight, on the operative rectoscope to permit work under gas insufflation.

instrumentation. Therefore, a bayonet-type angulation has been introduced into the system that allows a wider working area, compared with straight instruments. Figure 4 demonstrates the oblique optic and the angular instruments that provide a longer distance between the optic and the working field.

Figure 5 demonstrates the different instruments used during TEM. Specific technical details have been integrated into the needle holder: a small upper jaw fixes the needle in place, while the broader excavated lower jaw brings the needle into an upright position.

The curves in the suction device allow the assistant to guide the suction tube in case of bleeding without extensive mechanical conflict with the operative instruments of the surgeon. The forceps perform two different functions. The tip excavations allow safe grasping of the tissue; however, the jaws are flat so that the needle can be grasped during the suturing process. A silver clip with a central cut is used; instead of the knotting process a monofilament thread is placed into the central cut, tensed, and the clip is fixed to act as a knot substitute.

The Complete Operative System with Simultaneous Use of Three Instruments

The completed system includes several hoses that are connected to the operative rectoscope (Fig. 6). Using three instruments shows a certain spatial conflict in the area of the handles and in the tip of the rectoscope. In practice, the suction device is retracted to the end of the rectoscope and the suction tube is guided to the operative field only in the case of bleeding, when suction and hemostasis are necessary.

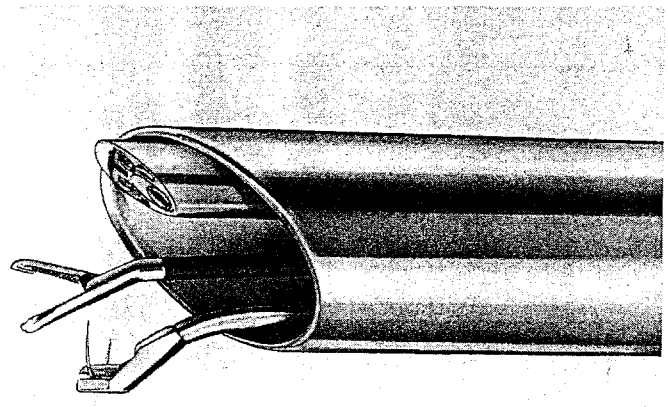

Figure 4. Tip of the operative rectoscope, with the stereoscopic optic above and needle holder and suture grasper below.

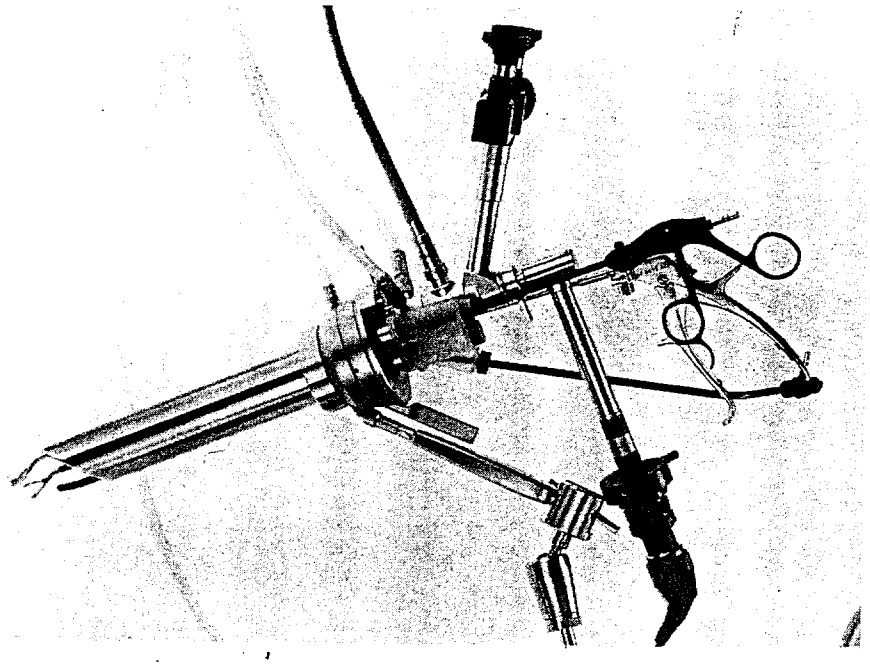

Figure 6. Complete set-up of the operative rectoscope with video camera and part of the tubes adapted.

instrument was to reduce the need for three instruments during the entire dissection process by combining their functions into one instrument (Fig. 7). The four main functions are to cut through the pseudo bipolar cutting needle, coagulate with the tip of the suction device after retracting the cutting needle, rinse alongside the cutting needle, and provide constant suction during the entire process. The electromechanical function of the ERBE TEM instrument is shown in Figure 8.

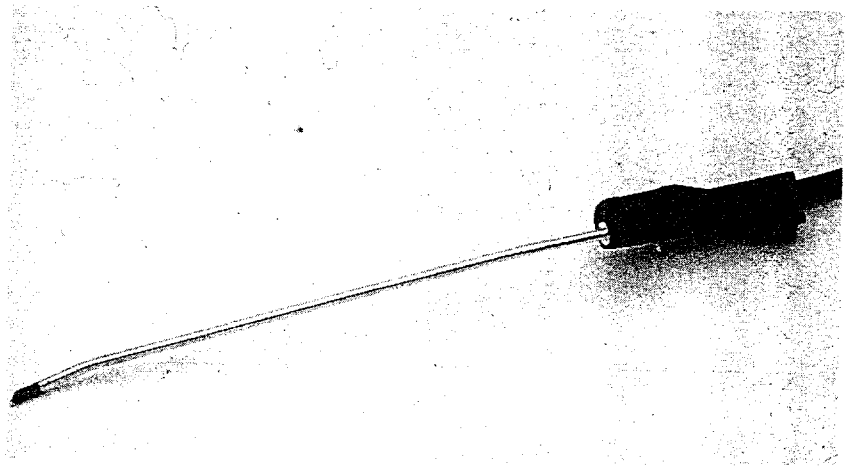

Figure 7. The TEM combination instrument integrating four different functions.

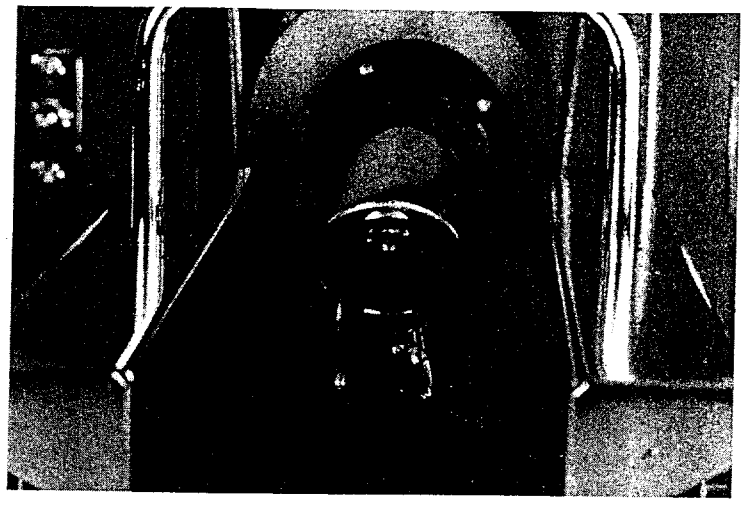

Figure 9. Operative rectoscope intregrated into the training box. The multifunctional TEM instrument and a grasper are introduced.

instruments; subsequently, the triangulation effect that provides spatial information is not available (Fig. 10).

With the stereoscopic optic, the aim was to provide a three-dimensional optic with direct view. This optical system provides a natural stereoscopic view in combination with a high-resolution image. Compared with this superior image, all existing electronically controlled visions systems pale in comparison for brightness, color, and resolution. Furthermore, the stereoscopic system allows precise visualization of tumor spread that is

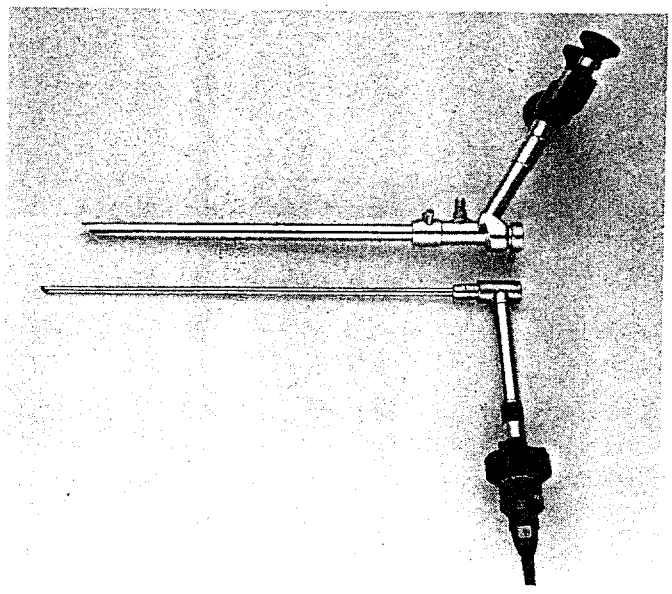

Figure 10. Stereoscopic optic (*top*). Optic for video documentation (*bottom*).

3. T1 low risk tumors[13] from the extraperitoneal portion of the rectum
4. T2 low risk tumors in patients at high risk for conventional surgery or those patients who refuse a colostomy
5. Treatment of tumors with high risk or more advanced tumor stages in combination with radio-chemotherapy and local excision (discussed later in this article)
6. Resection of carcinoids, closure of fistulas, resection of anastomotic stenosis

Preoperative Examination

The most frequent indication is a sessile polyp biopsy suggested as benign. Complete preoperative colonoscopy is mandatory. Information from flexible endoscopy concerning the height and position of the tumor is unreliable, therefore, planning for surgery also should include rigid rectoscopy. Digital examination for clinical staging is performed when tumors can be reached with the palpating finger. During rectoscopy, the lower and upper margin of the tumors and the precise position in the circumference are defined. This information also is important for the proper positioning of the patient on the operating table. Endoluminal ultrasound is mandatory in all patients to ascertain the depth of penetration and thus the stage. In tumors located at the anterior wall in the upper or middle third of the rectum, the location of the peritoneal reflection best is answered by the ultrasound image. Tumors that show signs of infiltration into the submucosa or the rectal wall cephalad to the peritoneal reflection should not be treated by TEM as full-thickness resection could lead to perforation into the peritoneal cavity.

Preoperative Preparation

An informed consent is explained to the patient including the risk of transition to a laparotomy in patients with proximal lesions. In rare cases of suture line dehiscences, postoperative bleeding or sepsis may occur. There is approximately a 1% chance of the need for a temporary colostomy caused by poor healing. Preoperative mechanical bowel preparation and parenteral antibiotics are used.

The Operative Procedure

Positioning of the Patient

The patient is placed in the dependent position, as described during the preoperative examination. This step is necessary because of the angulation of the optics and the specific design of the instruments. When the lateral Simms position is necessary, it is important that the anus is

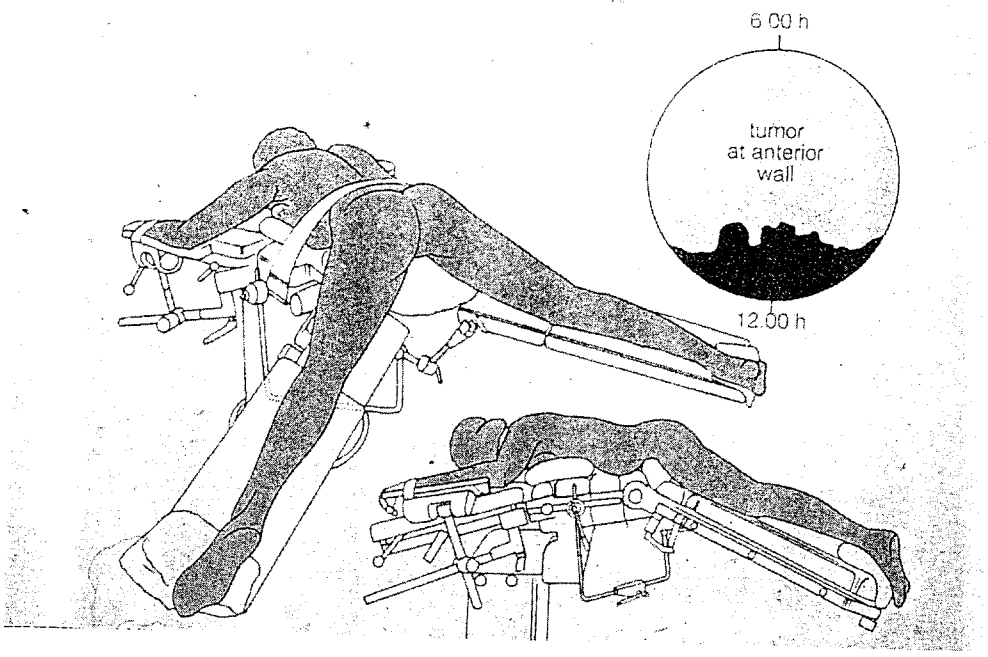

Figure 13. Positioning of the TEM for tumors at the anterior wall. The abdominal wall should be free.

Surgical Procedure for Mucosectomy

The procedure begins by defining the transition zone between the polyp and healthy mucosa using the stereoscopic optic. In tumors that are highly likely to be benign, a 5-mm safety margin is defined in the resection line and marked by coagulation dots. This step is important because during the dissection itself, small bleeders or intestinal fluids can limit the view. The coagulation dots allow a more precise guideline for the resection.

During circular dissection of the mucosal and submucosal planes, care should be taken to avoid incising too deeply into the muscular layer. After circumscribing the lower circumference, the first circular muscle fibers are dissected. Any bleeding vessels are localized with the suction device, after that the vessel is compressed and coagulated. The muscle fibers can be clearly visualized during dissection as demonstrated in Figure 14.

The authors perform mucosectomy in distal benign polyps to ensure that the sphincter function is not impaired by resection of the distal muscle layer. Mucosectomy also is performed for benign anteriorly based tumors at the anterior wall above the peritoneal reflection. In this location, it also is possible to resect parts of the circular muscle layer as a partial wall excision.

Full-Thickness Resection

Full-thickness resection is our standard procedure for all sessile polyps with the exception of the above-mentioned situations. The most ideal

Segmental Resection

Segmental resection is possible with the mucosectomy technique in the upper rectum as is full-thickness resection in the middle rectum. The rectoscope is tilted cephalad so that, by using a straight instrument, the upper wall can be reached, as demonstrated in Figure 16. Segmental resection technically is challenging and should only be performed in centers with extensive experience with the TEM procedure. An example of a 140 cm^2 circular adenoma treated by circumferential segmental resection is shown in Figure 17. Following segmental resection, a hand-sutured, end-to-end anastomosis is performed.

Full-Thickness Resection, Including Perirectal Fat Resection

The authors perform this type of procedure in all patients with histologically proven cancer. The aim is to resect the tumor and some perirectal lymph nodes en bloc (Fig. 18). Dissection of the perirectal fat is difficult for two reasons: first, there is no defined plane for resection; therefore, dissection should be performed near the muscle wall and away from other organs. Dissection of the anterior perirectal fat in women is contraindicated because there is a risk that coagulation on the abdominal wall can induce rectovaginal fistulas. Second, in the perirectal fat, rather large vessels can be found close to tumors, making hemostasis difficult.

Suturing

All defects are closed at the conclusion of the dissection by transverse continuous suture. Before suturing, the area is rinsed thoroughly with

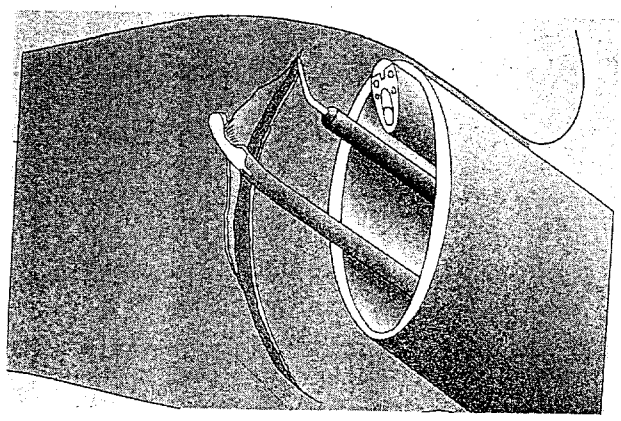

Figure 16. Positioning of the operating rectoscope for segmental resection at the top of the bowel.

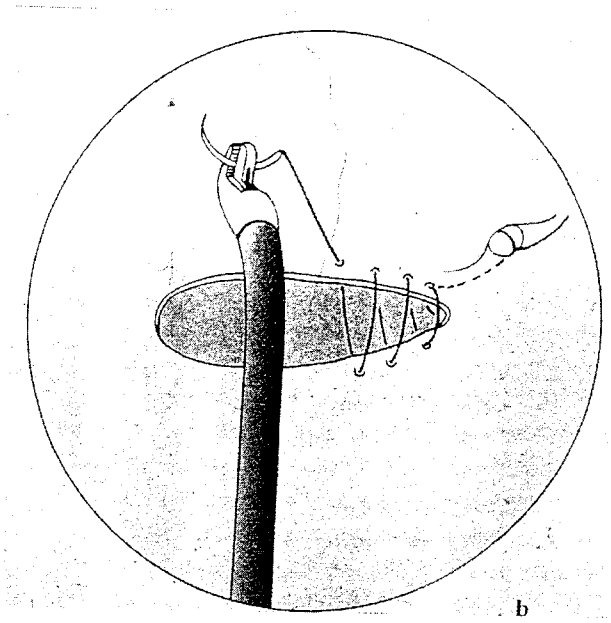

Figure 19. Transverse continuous suture; a silver clip is blocking the thread on the right side.

Postoperative Treatment

Following mucosectomy, all patients are given oral nutrition on the first postoperative day. After full-thickness resection, intravenous infusion is maintained for two days while allowing a clear fluid diet. In larger

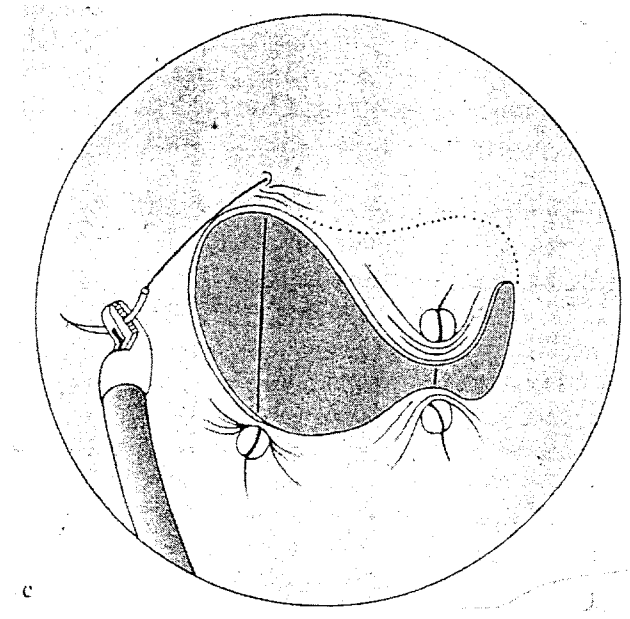

Figure 20. Stay sutures, blocked with silver clip before transverse suturing is performed.

Of the 362 patients with adenoma operated by TEM in Tuebingen between 1989 and 1996, 95% were followed for an average of 34 months. Rectal adenomas away from the scar were seen in 26 patients, classified as new adenoma formation. Six recurrences of adenoma occurred proximal to the resection scar (1.7%). Fifty-four of the 98 patients with a final histologic diagnosis of carcinoma were pT1 low risk, two were pT1 high risk, 25 pT2 low risk, two pT2 high risk, 13 pT3 low risk and two pT3 high risk.[2] In a small group of patients, a low anterior resection or abdominoperineal excision was performed after TEM.[13] The indications for these added procedures were absence of tumor-free margins in the histologic examination, high risk carcinoma, or T2 or T3 low risk carcinoma when curative surgery was intended. Eight of the 56 T1 carcinoma patients were reoperated and two had residual tumor; neither had any associated lymph node metastasis. Eighteen of the 27 T2 carcinoma patients were reoperated, two had residual tumor, and five lymph node metastases. Eight of the 15 T3 carcinoma patients were reoperated, one had residual tumor, and two lymph node metastases.

All patients who underwent TEM were followed closely including rectoscopy 3 and 6 months after the procedure and then annually. Additional cancer recurrence surveillance was employed for patients with carcinoma. Follow-up was complete in 96% of patients with carcinoma and in 94% with adenomas at an average of 24 months.[13] In the carcinoma group, there were two local recurrences of the 48 patients with T1 carcinoma, none in the patients with T2 carcinoma and one of the six patients with T3 lesions. All patients with recurrence underwent radical rectal resection and remained recurrence-free in the follow-up period.

In the Mainz T1 carcinoma group ($n = 60$), at a follow-up of five years after TEM, four of the 13 patients with high risk T1 carcinoma treated with local excision developed recurrences, while none of the low risk patients had recurrence.[1] The follow-up of those T1 carcinoma patients treated only by TEM was compared with a group of 47 patients treated by radical rectal resection. Two (4.2%) patients died after radical resection, whereas there were no deaths after local excision. There were no differences seen with the actuarial five-year survival rate in the low risk T1 carcinoma group between patients treated with local excision (79%) compared with those treated by radical resection (81%; $P = 0.72$).

In 1996, a prospective randomized study compared TEM versus anterior resection in T1 carcinoma patients.[20] In the two therapeutic arms, 24 patients who underwent TEM and 26 treated by anterior resection were included. Survival curves based on a mean follow-up of 45 months in both groups showed no significant differences. One patient died in the radical group from early tumor metastasis while another died in the locally resected group for undetermined reasons. In a subsequent publication, it was noted that one recurrence in the TEM group reportedly was cured by abdominoperineal resection.[21]

Although patients' age and rectal tumor location showed no significant differences when comparing TEM to anterior resection, other parameters such as length of hospitalization, blood loss, operative time, and

have been developed. The most multifunctional instrument includes four different functions supported by automatic activation of an electronically controlled pneumatic drive. Two instruments do show significantly less conflict during mechanical interaction compared with three instruments and the reaction time to bleeding significantly is reduced. When using multifunction instruments, the vessel can be ligated by coagulation within a fraction of a second after the bleeding commences, thereby reducing blood loss, compared with single function instruments. The three dimensional optic allows precise interaction between the two surgical instruments under reliable spatial orientation. The newest modifications allow more flexibility in moving the instruments. In fact, even conventional instruments can be introduced to stop bleeding during the early experience with TEM.

The clinical results for resection of adenomas by TEM are the most promising caused by optimal visualization, clear definition of safety margins, and precise surgical dissection. In cases of sessile adenomas in the rectum, TEM has proven to be the most technically reliable mechanical surgical system.[12] TEM is also, however, one of the most difficult endoscopic procedures because of handling of the instrumentation. Anyone wishing to incorporate this technique into their surgical armamentarium must devote significant time and energy to surmounting a steep learning curve.

Our preference is a full thickness resection even in benign lesions because full thickness resection leads to a stable piece of tissue that does not tear and safety margins can be analyzed clearly by the pathologist. Furthermore, in case an infiltrating cancer is found, deciding safety margins or the completeness of a resection will not be in question. Only in the areas close to the dentate line where the sphincter function should be preserved and the anterior wall higher than 10 cm is mucosectomy indicated routinely. Mucosectomy above the peritoneal reflection has to be very carefully performed to avoid opening the rectal wall towards the free abdomen. After adequate experience in TEM surgery, the peritoneal opening can be closed by continuous suture during the dissection process.

Local excision of an early cancer is the most important indication for TEM. Indications for early cancers have been a matter of controversy in Europe. When TEM initially was started, even local excision of T1 low risk tumors was not permitted and many of the benign tumors that were initially resected finally, resulted in radical treatment when T1 cancer was discovered. In a stepwise expansion of the indications for TEM, T1 low risk cancer has been approved for local excision if healthy margins are evident. In high-risk patients, cancers close to the dentate line, and in patients who refuse rectal excision, and also in T2 cancers, TEM has played a major role.

The clinical results of TEM are favorable and the morbidity and mortality acceptably are low.[12] In T1 low risk cancers, the results of local treatment are excellent. It is mandatory for patients to be reexamined in short intervals to detect any recurrences at an early stage that can be treated by continence-saving surgery. In these cases of early detection, patients with recurrent tumors can be treated by anterior resection. It also may be acceptable to perform TEM for T2 low risk tumors in high-risk patients. Indications in more advanced tumors and in high-risk cancers are under

10. Lezoche E, Feliciotti F: Long term results of laparoscopic rectal resections. International Symposium Rectal Cancer, Urbino, 2000
11. Mason YY: Surgical access to the rectum—a transsphincteric exposure. Proc R Soc Med 63:91–94, 1970
12. Mentges B, Buess G, Schaefer D, et al: Local therapy of rectal tumors. Dis Colon Rectum 39:886–892, 1996
13. Mentges B, Buess G, Effinger G, et al: Indications and results of local treatment of rectal cancer. Br J Surg 84:348–351, 1997
14. Morschel M, Heintz A, Bussmann M, et al: Follow up after transanal endoscopic microsurgery or transanal excision of large benign rectal polyps. Langenbecks Arch Surg 383:320– 324, 1998
15. Muldoon JP: Treatment of benign tumors of the rectum. Clin Gastroenterol 4:563–570, 1975
16. Raestrup H, Manncke K, Mentges B, et al: Indications and technique for TEM (transanal endoscopic microsurgery). Endosc Surg Applied Technol 2:241–246, 1994
17. Raestrup H, Mailander L, Roth K, et al: Phantom training courses in Tübingen. Min Invas Thera Allied Technol 9(5):311–314, 2000
18. Strauss H: Die Proctosigmoskopie. Leipzig: JA Barth, 1910
19. Westbrook KC, Lang NP, Broadwater JR, et al: Posterior surgical approaches to the rectum. Ann Surg 195:677–685, 1982
20. Winde G, Nottberg H, Keller R, et al: Surgical cure for early rectal carcinomas (T1). Dis Colon Rectum 39:969–976, 1996
21. Winde G, Herwig R, et al: Kontrollierter, randomisierter Vergleich von transanal endoskopischer Mikrochirurgie zu Rektumresektion beim pT1 Karzinom. Endoskopie heute 2:168–172, 1996

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