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REVIEW

Impact of technology on indications and limitations for transanal surgical removal of rectal neoplasms

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Abstract

Transanal surgery has and continues to be well accepted for local excision of benign rectal disease not amenable to endoscopic resection. More recently, there has been increasing interest in applying transanal surgery to local resection of early malignant disease. In addition, some groups have started utilizing a transanal route in order to accomplish total mesorectal excision (TME) for more advanced rectal malignancies. We aim to review the role of various transanal and endoscopic techniques in the local resection of benign and malignant rectal disease based on published trial data. Preliminary data on the use of transanal platforms to accomplish TME will also be highlighted. For endoscopically unresectable rectal adenomas, transanal surgery remains a widely accepted method with minimal morbidity that avoids the downsides of a major abdomino-pelvic operation. Transanal endoscopic microsurgery and transanal minimally invasive surgery offer improved visualization and magnification, allowing for finer and more precise dissection of more proximal and larger rectal lesions without compromising patient outcome. Some studies have demonstrated efficacy in utilizing transanal platforms in the surgical management of early rectal malignancies in selected patients. There is an overall higher recurrence rate with transanal surgery with the concern that neither chemoradiation nor salvage surgery may compensate for previous approach and correct the inferior outcome. Application of transanal platforms to accomplish transanal TME in a natural orifice fashion are still in their infancy and currently should be considered experimental. The current data demonstrate that transanal surgery remains an excellent option in the surgical management of benign rectal disease. However, care should be used when selecting patients with malignant disease. The application of transanal platforms continues to evolve. While the new uses of transanal platforms in TME for more advanced rectal malignancy are exciting, it is important to remain cognizant and not sacrifice long term survival for short term decrease in morbidity and improved cosmesis.

Key words: Transanal surgery; Transanal endoscopic microsurgery; Endoscopic mucosal resection; Transanal total mesorectal excision; Transanal minimally invasive surgery; Robotic transanal surgery; Local excision rectal neoplasms

Core tip: The review summarizes the technology advances and analyzes their impact on the validity of local transanal management of benign *vs* malignant rectal neoplasms. Current data demonstrate that transanal surgery remains an excellent option for benign disease. As transanal platforms continue to evolve, caution should be used when selecting patients with malignant disease. In view of the fact that the alternative of abdominal oncological procedures (laparoscopic, robotic, open) provide high cure rates, it is important to remain cognizant and not sacrifice long term survival for short term benefits (decrease in morbidity and improved cosmesis).

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INTRODUCTION

Rectal neoplasms are frequent and range from simple to highly complex conditions. Decision factors for their optimal management among others include the size and true axial and radial location of the lesion, the level of rectal wall and adjacent organ involvement, but most importantly, whether a definitively non-malignant (*e.g.*, lipoma), a potentially malignant (adenomatous polyp, carcinoid), or a malignant process is suspected or confirmed. Particularly for more advanced and malignant lesions, the standard approach consists of an abdominal low anterior resection; depending on the proximity to the pelvic floor and sphincter complex, it includes a resection of the anus (abdomino-perineal resection) or allows for restoration of the intestinal continuity[1,2]. The advantage of the abdominal total mesorectal excision (TME) is that it assures a lymphadenectomy and-if done correctly-the removal of an intact mesorectal envelope (fascia propria) as the two most relevant factors to reduce the risk of local recurrences. The disadvantages, however, include the magnitude of the surgery as such, the length of recovery, the risk for an anastomotic leak, a not negligible probability to require a temporary or permanent ostomy, and a marked negative functional impact.

As communicated by Parks *et al*[3], conventional transanal excision (TAE) became a widely adopted surgical technique with minimal morbidity for the management of low rectal lesions. Criteria were defined to characterize lesions best suited for TAE: it should be < 3-4 cm in size/diameter, encompass less than 25%-40% of the circumference, be mobile, and be in reach of the finger/anoscope (*i.e.*, no more than 6-8 cm from the anal verge)[1]. This latter aspect represented the biggest technical limitations of conventional transanal surgery, as mid to upper rectal tumors were out of reach secondary to inadequate exposure.

In more recent years, a number of technical developments have evolved to overcome these limitations. Transanal endoscopic microsurgery (TEMS) and later transanal minimally invasive surgery (TAMIS) have allowed for local excision of tumors anywhere in the entire rectum. The improved reach and visualization allows for a finer and controlled dissection which made it possible for surgeons to push the limits of what can be accomplished *via* a transanal route. Resection of larger, more proximal adenomas encompassing more than 40% of the circumference have been carried out with low morbidity and acceptable recurrence rates for benign neoplasms[4-6].

Whether transanal surgery should be applied to malignant disease remains a matter of considerable debate. Even when limiting local excision to early tumors with favorable histology, as described by Willett *et al*[7], a significant rate of local recurrence has been reported[8-10]. Two factors are thought to contribute to this unfavorable outcome: (1) direct implantation of cancer cells into the surgical wound as a result of the direct instrumentation of the tumor; and (2) the lack of a lymphadenectomy even though 7%-10% of T1 tumors are found to have lymph node metastases[1,2]. This latter aspect not only leaves behind nodal tumor tissue, but results in understaging and hence undertreatment of stage Ⅲ disease. Furthermore, salvage therapy after failure of local excision may involve more than what would have been needed initially and potentially require multivisceral resection with increased morbidity and lower overall survival[11,12].

Advances in endoscopy techniques have led to the introduction of endoscopic mucosal resection (EMR). This procedure has demonstrated some efficacy in the resection of larger (> 2 cm) and sessile lesions, characteristics that would have in the past ruled out the possibility of an endoscopic resection[13-16]. Similar to transanal surgery, EMR is not suited to perform a lymphadenectomy and carries a risk of bowel perforation with intraperitoneal bowel segments.

In recent years, some groups have extended the use of TEMS and TAMIS platforms in order to accomplish transanal natural orifice transluminal endoscopic surgery (NOTES) TME[17,18]. In addition, a combination of the da Vinci robotic system (Intuitive Surgical Inc., Sunnyvale, CA, United States) with the TAMIS platform was used to carry out the first series of robotic-assisted transanal surgery for TME[19]. Experience with these approaches remain confined to specialty groups and limited to feasibility case reports[19-22].

The goal of this article is to highlight the various transanal surgical techniques and analyze the available evidence on the validity of local excision of benign and

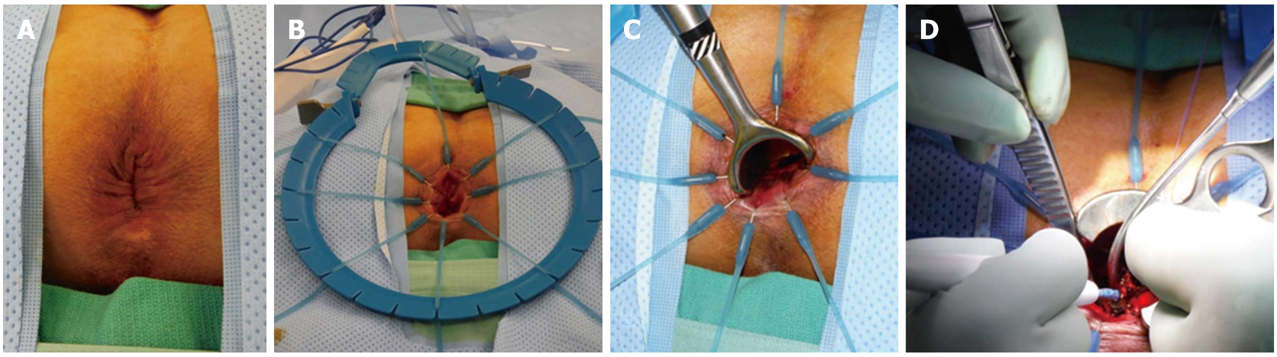

Figure 1 Conventional transanal excision with the patient in prone-jackknife position. A: Anus at beginning of the surgery; B: Placement of Lone Star retractor; C: Additional hand-held retractor optimizes exposure; D: Direct transanal instrumentation under regular view.

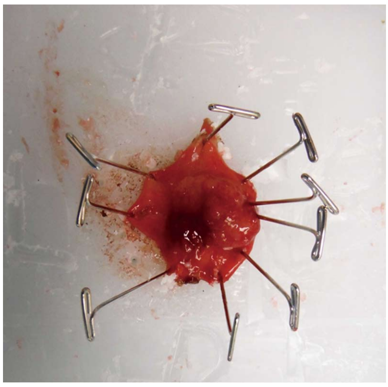

Figure 2 Fixation and orientation of the specimen on a wax board. The tissue is pinned down with needles. L(eft), R(ight), D(istal), and P(roximal) are carved into the wax. The specimen is subsequently placed in formalin for at least 24 h before processing and sectioning it onto slides.

malignant rectal neoplasms.

TAE

TAE can be performed with minimal specialty equipment, but depends on an optimized exposure of the target lesion as well as good hemostasis throughout the procedure. A variety of retractors are available, but in our hands, a Lone Star retractor (Coopersurgical, Inc. Trumbull, Connecticut, United States) to retract/evert the dentate line in combination with a handheld anal retractor has been the most reliable set-up (Figure 1). A circumferential margin of about 1cm is marked out by diathermy around the lesion. A full thickness excision using energy devices is then carried out whereby fragmentation of the specimen should be avoided. Fixation and orientation of the excised lesion on a wax board should then be carefully performed to prevent the tissue from rolling up and allow for proper pathological assessment of the resection margins (Figure 2). The defect should be washed out and either closed transversely with interrupted absorbable stitches or left open.

TAE overall is well tolerated and associated with only minor morbidity. However, there appears to be a significant variability in regards to recurrence rates after local excision of rectal adenomas ranging from 3%-40% in published series[23-26]. In a 10 year single institution review of 26 transanally excised adenomas, Hoth *et al*[27] reported a 38% recurrence rate over an average follow-up period of 25 mo. In a larger series of 117 patients with an average follow-up of 55 mo, Sakamoto *et al*[28] demonstrated an overall 30% recurrence rate for rectal adenomas. The authors postulated that the high recurrence rate was the result of inadequate exposure leading to incomplete excision[28]. A more recent and even larger study by Pigot *et al*[29] on a cohort of 207 patients undergoing TAE for rectal villous adenomata yielded better outcomes. The authors claimed to obtain improved intra-operative visualization by creating a cutaneo-mucus flap handle to allow for gentle traction, hence allowing for complete excision of the rectal adenoma with a recurrence rate of only 3.6%. Overall, the data on conventional TAE demonstrate higher than expected recurrence rates even for benign rectal adenomas; nonetheless, this surgical approach remains widely accepted for management of benign rectal pathologies in very distal location and close proximity to the sphincter structures.

Unquestionably, similarly high local recurrence rates would seem much more concerning in the management of malignant rectal tumors. Some 20 years ago, Willett *et al*[7] completed one of the earlier comparisons of standard resection with transanal local excision for low T1/T2 rectal cancer. This study was one of the first to suggest that in patients with favorable cancer histology (well differentiated, no venous or lymphovascular involvement), transanal surgery might be an acceptable alternative to standard resection. Fifty-six patients who had undergone transanal surgery were compared to 69 patients subjected to an abdomino-perineal resection (APR). Transanal surgery in 28 patients with favorable cancer histology resulted in a 5 year disease-free survival of 87% and a local control rate of 96%, whereas the other 28 patients with unfavorable cancer histology only achieved a 57% and 68%, respectively. In contrast, APR in 49 patients with favorable tumor histology resulted in 5 year disease-free survival and local control rates of 91%

Table 1 Single center comparison of transanal excision and standard resection for T1 rectal cancer

Ref.	Year	Follow-up (yr)	*n*		5 yr local recurrence		5 yr overall survival	
			TAE	SR	TAE	SR	TAE	SR
Mellgren *et al*[31]	2000	4.4-4.8	69	30	18%[1]	0[1]	72%	80%[1]
Nascimbeni *et al*[32]	2004	9.2	70	74	6.6%	2.8%	72%[1]	90%[1]
Bentrem *et al*[30]	2005	4.3	151	168	15%[1]	3%[1]	89%	93%
Nash *et al*[33]	2009	5.6	137	145	13.2%[1]	2.7%[1]	87%[1]	96%[1]

[1]Statistically significant. TAE: Transanal excision; SR: Standard resection.

Table 2 National cancer registries comparison of transanal excision and standard resection for T1 rectal cancer

Ref.	Year	Follow-up (yr)	*n*		5 yr local recurrence		5 yr overall survival	
			TAE	SR	TAE	SR	TAE	SR
Endreseth *et al*[37]	2005	2-8.1	35	256	12%	6%[1]	70%[1]	80%[1]
You *et al*[42]	2007	6.3	601	493	12.5%	6.9%[1]	77%	82%
Ptok *et al*[40]	2007	3.5	85	359	5.1%[1]	1.4%[1]	84%	92%
[2]Folkesson *et al*[38]	2007	NA	256	1141	7%	2%[1]	87%	93%
Hazard *et al*[39]	2009	3.9	573	3040	NA	NA	71%	84%
[2]Saraste *et al*[41]	2013	NA	448	3246	11.2%	2.9%	81%	92%

[1]Statistically significant; [2]Mix of T1 and T2 tumors. SR: Standard resection; TAE: Transanal excision; NA: Not available.

and 91%, compared to 79% and 89%, respectively, in 20 patients with unfavorable tumor histology.

Since then, several single institution case series have been published that compared transanal local excision to standard resection in T1 rectal cancers[30-33]. These results are summarized in Table 1. Overall, there is a significantly increased 5 year local recurrence rate with transanal surgery (7%-18%) compared to standard resection (0%-3%). The 5 year overall survival in the transanal local excision group was also noted to be substantially lower (72%-87%) than in the standard resection groups (80%-96%). The most recent of these studies by Nash *et al*[33] found a 20% incidence of lymph node metastasis in the standard resection group despite the tumor histological profile being similar between the 2 groups. This high prevalence of lymph node metastasis for early T tumors is about double the expected number from previously published reports[34-36]. At 7 years, cancer related deaths were 17% in the TAE group compared to 6% in patients undergoing a standard oncological resection. The differences in both local recurrence and 5 year overall survival were not only statistically significant but clinically alarming enough for the authors to conclude that transanal surgery even in early rectal cancer offered inferior oncological outcomes and should be restricted to patients that are unable to undergo standard resection[33].

In addition to single institution case series, national cancer registries have recently reported results comparing transanal surgery to standard resection[37-42]. These results are summarized in Table 2. Such registries have the benefit of a much larger sample size at the expense of a lack of detail and standardization (surgical techniques, data incorporation and surveillance protocols). Even though two of the studies included a mix of T1 and T2 rectal tumors in their analysis[38,41], there still appear to be higher than expected local recurrence rates for transanal surgery (5.1%-12.5%) compared to standard resection (1.4%-6.9%). Though not reaching statistical significance, there was a clear trend towards improved overall survival in patients undergoing standard resection (80%-93%) *vs* transanal surgery (70%-87%). An insufficiently analyzed factor contributing to the lower survival in the transanal excision group could be the inherent selection bias prevalent in registry data whereby patients might have been directed towards local excision if they had relevant comorbidities and limited operability.

While there is little doubt about the substantially increased local recurrence rates after transanal surgery compared to standard resection, a key question is whether these recurrences are salvageable with further surgical or adjuvant chemoradiation. Data on this topic are limited to single institution reviews[43]. Data from Memorial Sloan Kettering Cancer Center suggested that a substantial fraction of patients with local recurrences only could be managed with salvage surgery, but that only 30% of these were alive at 6 years[43]. In the most recent data analysis from MD Anderson Cancer Center over an 18 year period, You *et al*[44] demonstrated that recurrent rectal cancer (initial T1-T3 disease) appeared at a median interval of 1.9 years. The majority of patients (87%) were candidates to undergo salvage therapy with an R0 resection being attained in 80% of these patients. However, salvage therapy was associated significant morbidity: sphincter preservation was possible in only a third; a third underwent multi-visceral resection with a perioperative morbidity of 50%. In addition, 5 year

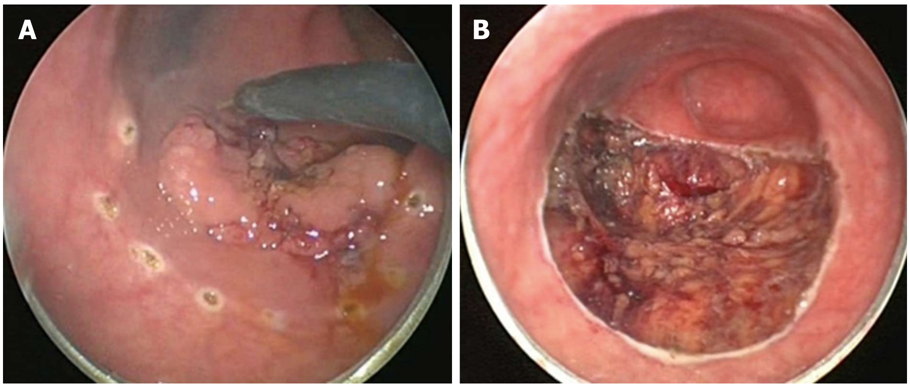

Figure 3 Transanal endoscopic microsurgery-internal view demonstrating an excellent exposure of the lesion. A: Sessile lesion being marked with a dotted line at about 1 cm around the border of the lesion; B: View after full thickness excision with exposed mesorectal fat.

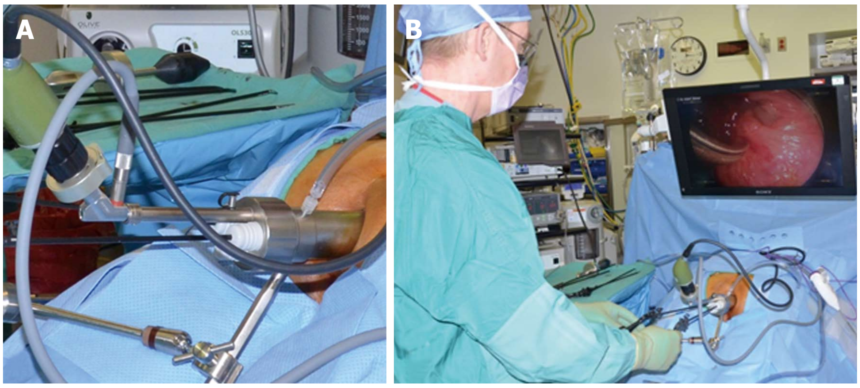

Figure 4 Transanal endoscopic microsurgery-external view. A: Close-up to working anoscope with air insufflation, camera port, and 3 working ports; B: Surgeon and monitor position during procedure with a patient in prone-jackknife position.

overall survival after salvage therapy was significantly lower at 68% compared to the reported 80%-90% survival rate that should be expected in stage 1-2 rectal cancers. Earlier data from other institutions mirror the MD Anderson experience: all demonstrating lower 5 year overall survival in salvage therapy (53%-59%) despite attaining an R0 resection in most cases (79%-97%)[11,12,45].

TEMS

TEMS was originally developed by Buess *et al*[46] in Germany in the early 1980s. This transanal platform which is offered by different vendors includes video optics and an improved visibility due to creation of a pneumorectum (Figure 3). It consists of a 4 cm diameter proctoscope with a variable length of 7.5 to 20 cm allowing for visualization of the entire rectum. An airtight seal is maintained between the proctoscope and the anus allowing for pressure-controlled rectal insufflation with CO_2. The faceplate of the proctoscope has 4 ports allowing for the insertion of the camera and three other working instruments (Figure 4). The ends of the operating instruments are angulated to improve their range of motion in the tight rectal space. The entire unit is fixed to the operating table and stabilized *via* an articulating arm. The procedure is facilitated by positioning the patient such that the target lesion is in the dependent position. Obstacles of this technology are its substantial initial cost to purchase the specialty equipment as well as a steep learning curve[47,48].

As with TAE, there is overall minimal perioperative morbidity associated with TEMS[49-51]. However, given the larger size of the operating proctoscope in relation to traditional handheld anal retractors, a negative impact (stretch injury) on the sphincter would not come as a surprise. In fact, some studies analyzed the effect of TEMS on anorectal function[52-57]; lower sphincter pressures were observed but the squeeze pressures ultimately improved by 1 year after TEMS[57]. Similarly, in study with a 5 year follow up after TEMS, Allaix *et al*[52] demonstrated a return of manometric values to pre-operative levels after 1 year. Utilizing sequential Fecal Incontinence Severity Index (FISI) and Fecal Incontinence Quality of Life scores, Cataldo *et al*[53] and Doornebosch *et al*[54] did not note a decrease in either one after TEMS. The current evidence suggests that TEMS does not have any long lasting deleterious effect on anorectal function.

With the introduction of TEMS, larger and more proximal rectal adenomas are now amenable to local surgical excision. Local recurrence rates after adenoma

Table 3 Recurrence after transanal endoscopic microsurgery resection of benign rectal adenoma

Ref.	Year	Follow-up (yr)	*n*	Recurrence
Said *et al*[67]	1995	3.2	260	6.5%
Platell *et al*[65]	2004	1.5	62	2.4%
Endreseth *et al*[60]	2005	2	64	13%
Whitehouse *et al*[71]	2006	3.3	143	4.8%
McCloud *et al*[63]	2006	2.6	75	16%
Guerrieri *et al*[86]	2008	3.7	588	4.3%
Speake *et al*[68]	2008	1	80	12.5%
Moore *et al*[64]	2008	1.7	40	3%
de Graaf *et al*[59]	2009	2.3	309	6.6%
Ramirez *et al*[66]	2009	3.6	149	5.4%
van den Broek *et al*[70]	2009	1.1	248	9.3%
Guerrieri *et al*[61]	2010	7	402	4%
Tsai *et al*[69]	2010	2	156	5%
de Graaf *et al*[58]	2011	2.7	208	6.1%

excision by TEMS have been reported by numerous largely single institution studies (2.4%-16%)[58-71]. The results are summarized in Table 3. Even though the majority of studies did not strictly compare the two approaches, there appeared overall to be a lower recurrence rate of rectal adenomas excised *via* TEMS compared to TAE (3%-40%) as mentioned earlier. In addition, 2 other studies designed to pitch TEMS against conventional transanal surgery have also demonstrated lower recurrence rates with TEMS[58,64]. De Graaf *et al*[58] resected 216 adenomas *via* TEMS and 43 *via* TAE and found more frequent negative margins (88% *vs* 50%, P < 0.001) and lower recurrence rates (6.1% *vs* 28.7%, P < 0.001) in the TEMS group. Similarly, Moore *et al*[64] demonstrated a lesser degree of specimen fragmentation (94% *vs* 65%, P < 0.001) in addition to increased negative margins (90% *vs* 71%, P = 0.001) and lower recurrence rates (5% *vs* 27%, P = 0.004) with TEMS. Numerous factors come together and contribute to the better quality and outcomes parameters achieved with TEMS, such as improved operative visualization and magnification, increased stability and decreased need for specimen traction, optimized hemostasis, as well as improved instrumentation, all of which lead to increased completeness of the excision and decreased fragmentation of the specimen. Technical challenges are encountered with either higher lesions or very low lesions. In the upper rectum, the risk of perforation into the peritoneum is higher and particularly true for anterior lesions in female patients. On the other hand, very distal rectal polyps may represent a challenge insofar as the pneumorectum may be difficult to entertain. Furthermore, there is a risk of creating a rectovaginal fistula. Nonetheless, reported complication rates for TEMS are comparably low and range between 3%-15% and includes among others bleeding, infection, urinary retention; retroperitoneal tracking of air can frequently be seen but typically does not require any intervention. Even the majority of perforations into the peritoneum can be managed directly through the transanal approach, hence without a need for an abdominal intervention[62,71-74]. The available evidence suggests that TEMS for rectal adenomas not only avoids major abdominal procedures, but also is safe and achieves acceptable recurrence rates that are favorable compared to TAE.

Given the improved success with management of adenomas with TEMS compared to TAE, the next natural progression would be to ascertain if these results extended to malignant disease. Comparing TEMS to TAE in early rectal cancers (T1, T2), Christoforidis *et al*[75] noted significantly higher rates of negative margins with TEMS (98% *vs* 75%, P = 0.017). Although not reaching statistical significance, they also estimated 5 year recurrence rates to be lower (15.4% *vs* 29.1%, P = 0.108) and 5 year overall survival rates to be higher (79.9% *vs* 66%, P = 0.119) with TEMS. Similarly, Langer *et al*[76] also found lower recurrence rates with TEMS compared to TAE (10% *vs* 15%). The authors surmised that this was likely due to the overall lower rates of R1 resections that resulted from TEMS excision (19% *vs* 37%, P = 0.001).

Head to head comparisons of TEMS against standard resection for T1 rectal cancers have also been reported by various single institutions (Table 4)[77-81]. In general, the risk of recurrence after TEMS, although lower than after TAE, remains substantially higher compared to standard oncological resection. Results of data regarding salvage therapy for recurrent disease after TEMS are similar to that reported for TAE[82,83]. Sphincter preservation was improved (50%-70%) compared to TAE (33%)[44]; however, this difference might simply be accounted for by the more proximal location of the lesions excised in the TEMS group thus allowing for more salvage low anterior resections to be performed. Comparable to salvage therapy after TAE, perioperative morbidity was high at 50% and overall 3 year survival after salvage surgery was decreased[82].

For more advanced rectal cancer (T2 and above), significant local recurrence rates have been reported after either TAE or TEMS likewise[84-92]. Lee *et al*[79] reported a 5 year recurrence rate of 20% with TEMS compared to only 9% recurrence with standard resection of T2 rectal cancer. Similarly, the Minnesota experience on utilizing TEMS for T2 and T3 rectal cancers found recurrence rates of 23.5% and 100%, respectively[69]. As a result, some groups have incorporated the use of neoadjuvant chemo and radiation therapy (CRT) prior to TEMS excision in hopes of reducing the unacceptably high local recurrence rates in T2 rectal cancers. Lezoche *et al*[93] reported a substantially decreased local recurrence rate of 5.7% after neoadjuvant CRT and TEMS for T2 cancers. However, the recurrence rate was still double that of standard resection (2.8%). More recently, Marks *et al*[94] demonstrated a recurrence rate of 6.8% with TEMS compared to 0% in the standard resection arm after neoadjuvant CRT. The ACOSOG Z6041 trial, a prospective, multi-center phase-2 trial of neoadjuvant CRT and local excision for T2 rectal

Table 4 Single center comparison of transanal endoscopic microsurgery and standard resection for T1 rectal cancer

Ref.	Year	Follow-up (yr)	*n*		5 yr local recurrence		5 yr overall survival	
			TEMS	SR	TEMS (%)	SR (%)	TEMS (%)	SR (%)
Winde *et al*[81]	1996	3.8[TEMS]/3.4[SR]	24	26	4.2	0	96	96
Heintz *et al*[78]	1998	4.3	46	34	4.3	2.9	79	81
Lee *et al*[79]	2003	2.6[TEMS]/2.9[SR]	52	22	4.1	0	100	92.9
Palma *et al*[80]	2009	7.2[TEMS]/7.8[SR]	34	17	5.9	0	88.23	82.35
De Graaf *et al*[77]	2009	3.5[TEMS]/7[SR]	80	75	24[1]	0[1]	75	77

[1]Statistically significant. SR: Standard resection; TEMS: Transanal endoscopic microsurgery.

cancers recently reported its preliminary results[95]. The neoadjuvant protocol included treatment with capecitabine and oxaliplatin in addition to 50.4 Gy of external beam radiotherapy. Local excision *via* TAE or TEMS was performed 4 wk after completion of neoadjuvant CRT. At the price of substantial toxicity, 34 out of 77 patients completing the protocol (44%) showed a complete pathological response with overall 49 (64%) patient's tumors being downstaged (ypT0-1). Four patients (5%) did progress to ypT3 tumors. Long term follow up on recurrence and overall survival rates are still pending. Furthermore, neoadjuvant CRT protocols will likely further undergo optimization to improve the adverse event profile. The current evidence suggests that local excision for more advanced rectal cancers (T2 and above) risks treatment understaging and leads to significant local recurrence. It should therefore be restricted to palliation of patients that are otherwise not able to undergo standard resection.

A different target for which TEMS has been increasingly used are rectal carcinoids. With growing numbers of colonoscopies being performed, a 10 fold increase in the incidence of rectal carcinoids has been noted in the Surveillance, Epidemiology and end results registry[96]. As a result, there has also been a substantial increase in the number of transanal surgical excisions of the incidental rectal carcinoids. General consensus guidelines for rectal carcinoids consider them amenable to transanal excision include if they are well differentiated, no more than 2 cm in size, are confined to the submucosa and show no lymphovascular invasion[97]. The majority of published data on rectal carcinoids have utilized the TEMS platform as the approach to carry out the transanal excision[98-103]. Kumar *et al*[102] in a review of 24 patients who underwent TEMS excision of rectal carcinoids demonstrated no recurrence. Kinoshita *et al*[100] reported no recurrence or carcinoid-specific mortality after TEMS excision in 27 patients over a follow-up period of 70.6 mo. Likewise, Ishikawa *et al*[99] found no recurrence when rectal carcinoids were excised by either TEMS or conventional transanal surgery after a mean follow-up of 2 years. However, the analysis of 202 patients with rectal carcinoids surprisingly found that up to 30% of carcinoid tumors > 1 cm harbored nodal disease (OR = 32.7, P = 0.006), with lymphovascular invasion being an additional independent risk factor for nodal disease (OR = 19.6, P < 0.001)[104]. Despite the limitations of the data and generally rather small cohorts, it appears that transanal excision either by conventional approach or TEMS is appropriate to tumor sizes up to 1 cm.

TAMIS

TAMIS was "accidentally" reported in 2009 and quickly gained attention as a cheap and easily available alternative to the TEMS[105]. A SILS port (Covidien, Mansfield, MA, United States) was used in the beginning. Subsequently, specifically designed single-use transanal port systems (GelPOINT Path, Applied Medical, Rancho Santa Margarita, CA, United States) were developed and made commercially available. The GELPOINT path platform is about 44 mm long with a diameter of 34 mm and was specifically designed for TAMIS. The TAMIS port should sit on the levator ani muscles just above the puborectalis. The port is then optionally secured in place with sutures. Usually, 3 working ports are placed into the GelPOINT path: 2 working instruments and a laparoscopic 5 mm camera. As in TEMS, a seal is created between the anus and the TAMIS port allowing for distention of the rectum with CO_2 insufflation. Unlike TEMS, the camera position is not fixed and the TAMIS port is shorter and not angled at the end: this enables an increased working angle allowing for potentially near/circumferential excision without having to re-position the patient. No specialty laparoscopic instruments are required. However, there some potential drawbacks: The stability of the transanal platform is overall reduced given that there is no stabilizing arm to dock onto. In addition, the laparoscopic camera generally has to be removed quite often and cleaned. To combat this, the use of an endoscope has been employed[106].

Like for TAE and TEMS, morbidity associated with TAMIS has been minimal[105,107-109]. Schiphorst *et al*[109], over a median short term follow-up of 11 mo, recently reported comparable anorectal function based on FISI scores to TEMS after TAMIS.

Given the relatively short interval since TAMIS inception, the majority of data on TAMIS - related the excision of rectal neoplasms is limited to small cohort single institution studies and case reports. A comprehensive review of the TAMIS experience from 2010-2013 was recently published by Martin-Perez *et al*[5]. The authors reported an overall margin positivity rate of 4.36% (12/275). Local recurrence was 2.7% (7/259) on short term follow-up (mean 7.1 mo). Conversion was only 2.3% (9/390) with a 1.025% (4/390) rate of unintended entry to the peritoneal cavity. In the largest published single institution series, Albert *et al*[107] resected 25 rectal adenomas, 23 malignancies (1 TIS, 16 T1, 3 T2, 3 T3) and 2 neuroendocrine tumors. The authors reported a 94% negative margin rate (47/50) with 4% (2/50) specimen fragmentation. Over a median of 20 mo follow-up, a local recurrence rate of 4% (2/50) was reported. Overall, the preliminary data showed that TAMIS achieved results comparable to TEMS in terms of recurrence rates and morbidity. Head to head comparisons in prospective studies with more long term follow up data are needed before any final recommendation can be made on the preferred transanal platform for local excision.

EMR

In recent years, application of EMR has led to more aggressive endoscopic resection of rectal adenomas and even early rectal cancers in specialized centers. The technique involves circumferentially marking the resection margin as done in transanal surgery. A submucosal injection of mixture of dye, saline and diluted epinephrine is performed to accomplish lifting of the lesion away from the underlying tissue. In some instances, magnification or chromoendoscopy can help further elucidate the true edges of a rectal lesion. Snare excision with cautery is performed whereby lesions < 2 cm are usually resected en bloc, while larger lesions may require several separate excisions. Reported complications include bleeding, post polypectomy syndrome and perforation, the vast majority of which resolve conservatively or require application of endoscopic clips for resolution[110-112].

In an earlier prospective study on use of EMR in resection of rectal adenomas, Hurlstone *et al*[113] resected 62 rectal adenomas (4 T1 cancers, 58 adenomas). The 3 mo local recurrence rate was 8% (5/62): 4 patients underwent repeat EMR and 1 patient had a low anterior resection. After a median follow-up of 14 mo, they noted that 98% (61/62) of the cohort remained free of recurrence. Main complication was bleeding (8%) that was managed with an endoclip placement. Based on this, the authors suggested that EMR for rectal adenomas and early rectal cancers is safe and effective.

More recently, Arezzo *et al*[114] completed a meta-analysis comparing EMR to TEMS in the resection of large rectal lesions. Eleven EMR and 10 TEMS studies involving 2077 patients were included for review. *En bloc* resection rates were 87.8% (CI: 84.3-90.6) for EMR compared to 98.7% (CI: 97.4-99.3) for TEMS. This corresponded to a substantially reduced R0 resection percentage for EMR *vs* TEMS (74.6% *vs* 88.5%, P < 0.001). Interestingly, recurrence rates were lower in the EMR group (2.6% *vs* 5.2%, P < 0.001). However, this difference could be explained by the significantly longer length of follow-up in the TEMS arm (mean 58.9 mo *vs* 6-12 mo). Even though there was a lower recurrence rate in the EMR group, a larger percentage of EMR patients eventually required standard resection (8.4% *vs* 1.8%, P < 0.001). Morbidity was similar at 8% in both groups.

In summary, the available data demonstrate that while feasible, EMR for rectal lesions appears to have poorer results compared to TEMS. No data comparing TAMIS to EMR is available at present, but it seems reasonable to expect similar results given the overall comparability of results obtained between TEMS and TAMIS thus far.

FUTURE APPLICATION OF TRANSANAL SURGERY

Expanding on the principles of NOTES, preliminary case series reported utilizing the transanal route to accomplish TME. An updated assessment of the transanal NOTES experience by Emhoff *et al*[18] included a total of 72 cases where a complete TME excision with largely negative circumferential margins could be obtained. The overall intraoperative and postoperative complication rate was 8.3% and 27.8%, respectively. There was a 2.8% incidence of conversion to open surgery with no 30 d mortality. No recurrence was reported but follow-up periods were generally limited to a few months only. Furthermore, there was an inherent patient selection bias with the majority of patients having early rectal cancer (T1, T2), low body mass indexs (BMIs), non-recurrent tumors and no previous history of pelvic surgery. Of the 10 case series reviewed, only 1 study by Rouanet *et al*[115] included higher risk patients (BMI > 30, narrow pelvis, T3/T4, recurrent and large tumors) with longer follow-up (median 21 mo). Not surprisingly, the results were less favorable: negative margin rates were lower (87% *vs* 95%) compared to lower risk patients in the other studies. Distant disease was noted in 8 patients (26.7%) and local recurrence occurred in 4 patients (13.3%). Overall survival was only 80.5% at 2 years. A 20 patient experience utilizing the TAMIS platform to achieve a TME were comparable to those by Emhoff *et al*[18]: 90% negative margin, 85% complete/near complete TME, and a 5% recurrence rate over median follow-up of 6 mo[17].

Transanal/TAMIS TME are techniques still in their infancy. The current data are limited to single institution cases series and lack a control arm. In addition, functional data are extremely limited with regard to the colo-anal anastomoses that generally ensues from the transanal/TAMIS TME. Data from randomized controlled studies with long term follow-up will ultimately be needed to determine if this new approach to TME

Table 5 Appropriate indications for the use of transanal excision/transanal endoscopic microsurgery/transanal minimally invasive surgery or endoscopic mucosal resection

Category	Primary approach	Secondary or individualized approach
Benign pathology	Low rectum: TAE or TEMS Middle to high rectum: TEMS/TAMIS/EMR or LAR Proximal to rectum: EMR or L/O CR	Very large lesion: LAR
Borderline pathology	Carcinoid < 1 cm with favorable features: TEMS/TAMIS Scar after colonoscopic removal of cancerous polyp: TEMS/TAMIS Uncertain dignity: TEMS/TAMIS mucosal resection as excisional biopsy	Excisional biopsy with TEMS/TAMIS/TAE → LAR if malignant?
Malignant (Rectum)	u/pT1: LAR u/pT2: LAR u/pT3: CRT + LAR Recurrence: CRT + LAR Carcinoid > 1 cm: LAR	u/pT1 + morbidity: TAE/TEMS/TAMIS u/pT2: TAE/TEMS/TAMIS + CRT
Malignant (Colon)	pTis: EMR/polypectomy pT1: L/O CR (unless free stalk > 2 mm) > T1: L/O CR	pTis (large): L/O CR pT1 + morbidity: EMR + observation

LAR: Low anterior resection (laparoscopic, robotic, open); L/O CR: Laparoscopic *vs* open colon resection; TAE: Transanal excision; TAMIS: Transanal minimally invasive surgery; TEMS: Transanal endoscopic microsurgery; TME: Total mesorectal excision; EMR: Endoscopic mucosal resection.

is truly needed and should be adopted on a more universal level.

SYNOPSIS

Transanal surgery has undergone significant technical advances in the last 25 years. The onset of improved video and computer technology and the onset of laparoscopic surgery in general have undoubtedly contributed to the evolution of this field. Conventional TAE remains a widely accepted approach in the management of low rectal adenomas. However, the transanal platforms of TEMS and TAMIS offer improved visualization, reach and allow for a finer and better controlled dissection in the limited rectal space. This likely explains the overall lower recurrence rates observed in the TEMS-/TAMIS-assisted local resection of benign rectal tumors. EMR for rectal lesions, while feasible, requires considerable technical expertise and more importantly offers inferior results compared to transanal or laparoscopic resective surgery. Based on the available evidence, local excision of rectal adenomas (which by definition are limited to the mucosa) is safe technique affording low morbidity without compromising patient outcome.

Data surrounding transanal excision of rectal malignancies remain more of a mixed baggage because the local excision does not achieve a lymphadenectomy and risk implanting malignant cells into the surgical wound. Small size (1 cm or less) rectal carcinoids appear to be amenable to local resection without any long term increase risks of recurrence. However, local recurrence rates of even early rectal adenocarcinoma unquestionably are higher than with a standard oncological resection and cannot reliably be improved with (neo-)adjuvant chemoradiation without substantial morbidity. Salvage therapy after local failure is not always possible but is usually associated with high perioperative morbidity and lower overall long term survival.

The true philosophical question a surgeon should not only ask the patient but also him-/herself is whether vanity and fear from an abdominal surgery, its scars, or a potential stoma are sufficient reason to jeopardize the chances to cure an early cancer (stage Ⅰ) which by all means should have a > 90% of disease-free survival. A wealth of data in the literature has supported the use of laparoscopic surgery in particular for mid and high rectal tumors, not to speak of any colon tumors. Intermediate and long term outcomes from various randomized controlled trials from Europe and Asia (CLASICC, COLOR Ⅱ, COREAN) have demonstrated non-inferiority of laparoscopic surgery compared to traditional open surgery for rectal cancer in regards to completeness of the resection, lymph node harvest, local recurrence rates, and overall survival. In addition, the laparoscopic approach has consistently been associated with shorter length of stay and reduced time to bowel function recovery[116-118]. Even for low tumors, the laparoscopic or robotic approach allows for a sphincter-preserving complete mesorectal excision and colo-anal anastomosis in the overwhelming majority of cases with excellent oncological and acceptable functional outcomes, and with no local recurrence noted for early rectal cancers[119-121]. It therefore seems not justifiable to risk an incomplete excision or seeding the operative field with cancer cells, which in the case of a TAMIS/TME would come to be located right on the freed presacral fascia, pelvic side wall, or the free peritoneal cavity. An unbiased discussion highlighting the risks and benefits of transanal surgery with the patient should assure to make the best informed decision in the setting of rectal adenocarcinoma. Appropriate use of an excellent technology should include self-restriction to define the best selection of pathologies and patients (Table 5). In cases where the diagnosis and/or stage are uncertain, the transanal local excision can be used as excisional biopsies (potentially limited to the mucosa only to avoid distortion of the mesorectum), but final judgment on the appropriateness of the transanal approach as opposed to the ultimate best treatment should be reserved until the definitive pathology report has been obtained. If more treatment should be needed, it might-for concerns of postsurgical tissue changes-be desirable to postpone it for 4-6 wk.

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