



# Systematic review of functional outcomes and quality of life after transanal endoscopic microsurgery and transanal minimally invasive surgery: a word of caution

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Accepted: 18 October 2019 / Published online: 25 November 2019  
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## Abstract

**Purpose** The introduction of transanal endoscopic or minimally invasive surgery has allowed organ preservation for rectal tumors with good oncological results. Data on functional and quality-of-life (QoL) outcomes are scarce and controversial. This systematic review sought to synthesize fecal continence, QoL, and manometric outcomes after transanal endoscopic microsurgery (TEM) or transanal minimally invasive surgery (TAMIS).

**Methods** A systematic review of the literature including Medline, Embase, and the Cochrane Library databases was conducted searching for articles reporting on functional outcomes after TEM or TAMIS between January 1995 and June 2018. The evaluated outcome parameters were pre- and postoperative fecal continence (primary endpoint), QoL, and manometric results. Data were extracted using the same scales and measurement units as from the original study.

**Results** A total of 29 studies comprising 1297 patients were included. Fecal continence outcomes were evaluated in 23 (79%) studies with a wide variety of assessment tools and divergent results. Ten studies (34%) analyzed QoL changes, and manometric variables were assessed in 15 studies (51%). Most studies reported some deterioration in manometric scores without major QoL impairment. Due to the heterogeneity of the data, it was not possible to perform any pooled analysis or meta-analysis.

**Conclusions** These techniques do not seem to affect continence by themselves except in minor cases. The possibility of worsened function after TEM and TAMIS should not be underestimated. There is a need to homogenize or standardize functional and manometric outcomes assessment after TEM or TAMIS.

**Keywords** TEM · TAMIS · Rectal lesions · Rectal cancer · Functional outcomes · Continence · QoL · Manometric results · Systematic review

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## Introduction

Management of rectal lesions has radically evolved over the last decades. For locally advanced rectal cancer, the implementation of neoadjuvant chemo- and radiotherapy combined with total mesorectal excision raised the number of sphincter-saving procedures, but concern exists about the subsequent functional results [1–5]. On the other hand, full- or partial-thickness excision of the rectal wall with organ preservation can be sufficient to achieve oncologic clearance. This avoids the potential morbidity of pelvic surgery which involves anterior rectal resection, thus obtaining presumably better functional results.

In order to provide better access to the difficult rectal anatomy, transanal endoscopic microsurgery (TEM) was first introduced back in 1984 [6]. Later, the transanal endoscopic operation (TEO) was developed as a

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modification of TEM to treat rectal tumors. These two techniques are based on the use of a beveled rigid proctoscope attached to specialized pieces for insufflation in order to access rectal lesions with optimal visibility. More recently, transanal minimally invasive surgery (TAMIS) was introduced as an alternative to TEM and TEO, using a flexible and disposable single-port laparoscopic entry platform. TAMIS offers good tumor visualization with better versatility than the other transanal techniques since patient position is not influenced by tumor localization [7]. Compared with standard transanal excision, TEM has been associated with more intact, nonfragmented specimens (63% vs 100%), resulting in higher rates of negative resection margins (78% vs 98%) and lower rates of local recurrences (24% vs 8%) [8]. Similar findings have been reported for TAMIS, with R+ resection, fragmentation, and recurrence rates not exceeding 6%, 4%, and 2%, respectively [9]. Therefore, even if indications to TEM or TAMIS are similar to those of local excision, the former techniques are preferable in terms of visualization, exposure, and oncologic outcomes. Due to the evolution of minimally invasive instrumentation and advances in technologies, indications to transanal minimally invasive surgery have been expanded to different conditions, e.g., patients with advanced rectal lesions (T3) not fit to undergo major surgery, after chemoradiation therapy, or cT0 lesions after neoadjuvant chemotherapy (to confirm ypT0) [10, 11]. Indeed, the adoption of minimally invasive approach has rapidly grown worldwide during the recent years [10, 12].

Even though there is preservation of the rectum when these techniques are recommended, rectal and anal stretching produced by the introduction of a wide proctoscope or platform during the surgery, as well as partial organ resection, might provoke potential postoperative functional disorders such as fecal incontinence with consequent impairment of quality of life (QoL) [13, 14].

The aim of this systematic review is to synthesize the current evidence regarding continence, manometric, and QoL outcomes after TEM or TAMIS approaches for rectal lesions.

## Methods

This systematic review of the literature was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [15]. Aim of the review was to identify the functional outcome and quality of life after minimally invasive transanal surgery with organ preservation.

## Search strategy

Medline, Embase, and the Cochrane Library databases were reviewed for articles published between January 1995 and June 2018. Search terms included “Transanal Endoscopic Surgery,” “Transanal Endoscopic Microsurgery,” “transanal minimally invasive surgery,” “transanal endoscopic operation,” “Rectal Neoplasms,” “rectal tumor\*,” “rectal tumor\*,” “rectal cancer\*,” “rectal polyp\*,” and “rectal lesion\*.” The items were used in all possible combinations with the Boolean AND/OR to retrieve maximal number of articles. Exploded MeSH terms were included in the search strategy. English language restriction was imposed. Search strings for each database are attached as supplementary material. Additional articles by manually searching the reference lists from recent reviews and the extracted papers were also included. Detailed search strategy is reported in [Appendix](#).

## Study selection and quality assessment

Only studies reporting on pre- and postoperative functional outcomes of TEM or TAMIS surgery for rectal polyps or early rectal cancer were considered for inclusion. Outcomes of interest included the following: *continence, quality of life, and manometric results*. Studies reporting on low anterior resection of the rectum, local excision without endoscopic or minimally invasive techniques, or those only reporting on oncological outcomes, were excluded. Letters, guidelines, and systematic reviews were examined for cross-referencing and descriptive reasons, but not for data extraction. Studies were restricted to have a cohort of at least five patients. When the same cohort of patients was reported in different articles, only the article with the largest data and longest follow-up was selected. Inclusion and exclusion criteria are summarized in [Table 1](#).

The initial assessment by title and abstract highlighted studies of potential interest for posterior full-text analysis. A full-text copy of each paper was reviewed by two authors independently (AC and FM), and data were retrieved according to these criteria. A discussion among all authors was established in case of any discrepancies. In case data were missing on included studies, authors were contacted in order to retrieve the respective information. In case there was no answer, those papers were excluded. Also, studies were discarded if TEM or TAMIS was associated to any kind of colectomies during the same operating act.

In order to assess methodological quality, both reviewers evaluated each article using the Newcastle-Ottawa Scale [16]. This scale is a validated and reliable tool for quality assessment of observational studies in systematic reviews. It comprises the evaluation of patient selection, comparability of cohorts, and outcomes. A score higher than five points was required for study inclusion.

**Table 1** Inclusion and exclusion criteria

Characteristic	Inclusion criteria	Exclusion criteria
Population	Patients with rectal polyps or tumors suitable for rectal preservation by TEM or TAMIS approach with or without neoadjuvant therapy	Patients with rectal polyps or tumor undergoing rectal resection. Patients with simultaneous abdominal surgery and TEM or TAMIS
Intervention	TEM or TAMIS	Transanal resection–rectal resection
Comparator	Pre- and postoperative continence assessment, and/or quality-of-life and/or anorectal manometric evaluations	Not evaluating preoperative data. Only reporting oncological outcomes
Measuring results	Any continence scores, de novo incontinence incidence, any quality-of-life scores, anorectal manometric parameters	Survival outcomes and/or local recurrence incidence not reporting on functional assessment
Study design	Cohort studies (retrospective or prospective), comparisons, descriptive, case studies, and randomized clinical trials	Case reports ( $n < 5$ patients) Review articles Study presentation Technical notes
Language	English	Other languages
Date of publication	Up to June 2018	After June 2018

## Data extraction and analysis

Data of selected papers were extracted using a structured form which included year of publication, authors, number of patients, baseline demographics, technique, and follow-up. Continence and quality-of-life outcomes were recorded with the scoring system used in the respective study. When available, manometric parameters were also extracted.

In order to summarize patient and outcome data, descriptive statistics such as percentages, means, and total counts were used. As a result of the heterogeneity of patients and functional outcomes description, interpretation was limited to a pooled and selective descriptive analysis.

In those studies in which TEM or TAMIS was compared with other more invasive techniques, only data on minimally invasive approach were used.

The primary endpoint was continence; secondary endpoint included manometric results and QoL.

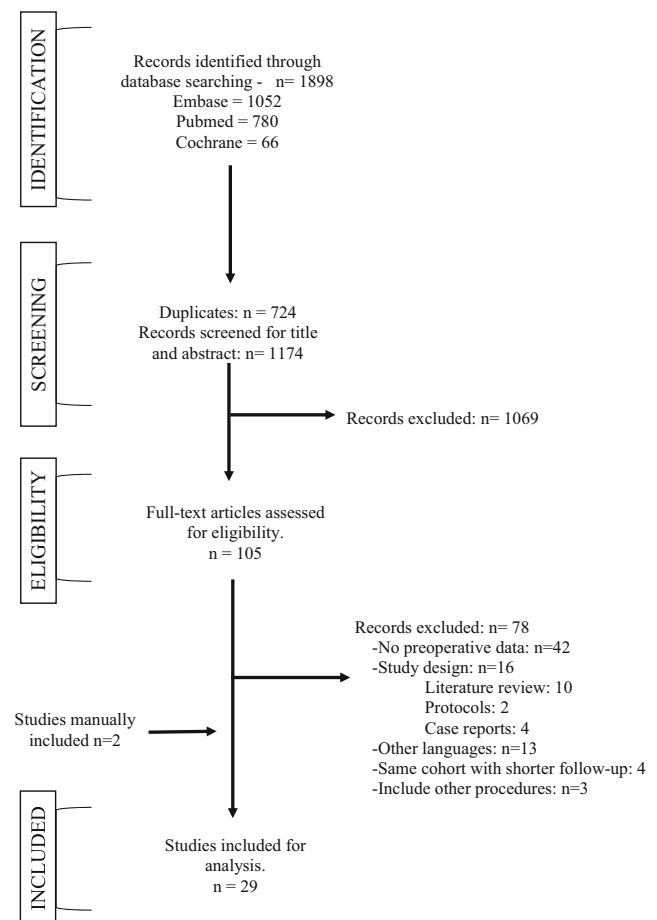
## Statistical analysis

Data were extracted using the same scales and measurement units as from the original study. Due to the heterogeneity of the data, it was not possible to perform any pooled analysis or meta-analysis.

## Results

The PRISMA flowchart is shown in Fig. 1. After duplicate removal, a total of 1174 studies were identified. After screening for title and abstract, 105 studies were reviewed by full-text assessment, and 78 studies were excluded after not meeting inclusion criteria. The reasons for exclusion were as follows: 42 of them did not include preoperative data; 13 of them were written in other languages than English; 10 of them were literature reviews; 4 articles were case reports not meeting inclusion criteria; in 4 cases, there existed other studies from the same cohort with longer follow-up or more participants; 2 studies included previous or simultaneous abdominal surgery when TEM/TAMIS was performed; in 1 study, the surgery performed was transanal resection; 1 article was a study presentation; and another one only described technical notes. Two studies which were not detected in the systematic search were manually included after cross-referencing. A total of 29 studies, comprising 1297 patients, were included for final analysis.

Eighteen studies reported on results after TEM, and 4 studies after TAMIS. One study compared results between TEM and total mesorectal excision (TME), one between TEM and

**Fig. 1** PRISMA flow diagram for the study

endoscopic mucosal resection (EMR), and one compared primary versus repeated TEM. Four studies included patients who underwent neoadjuvant therapy before transanal resection. Of them, one study described results of chemoradiotherapy (CRT) before TEM, and other before TAMIS. One study focused on patients who underwent short-course radiotherapy (SCRT) before TEM. Another study included two groups of patients comparing TEM alone versus CRT before TEM. No studies of TEO approach were retrieved.

## Continence

Of the included articles, 23 (79%) reported on pre- and postoperative continence outcomes which are expressed in Table 2. Of them, 18 studies evaluated changes after TEM and 5 after TAMIS, with a mean follow-up of 15.9 months. A variety of continence assessment tools were used. Ten studies reported results using the Wexner score, seven used the Fecal Incontinence Severity Index (FISI), one study the colorectal functional outcome (COREFO) questionnaire, one study used both Wexner and COREFO scores, one study an individualized interview, and the remaining studies used the Kirwan-Fazio scale, the Williams score, and the Pescatori scale respectively.

**TEM studies** Six studies reported on the outcomes using the Wexner score. Two studies found an increase in Wexner scores after surgery (worse continence) [17, 18], two studies found no changes in pre- and postoperative values [19, 20], and one found a decrease in the Wexner score (better continence) [21]. The sixth manuscript compared the results after a first versus repeated TEM, and found a worsening of continence after repeated TEM only, whereas no differences were noted between preoperative and postoperative functions after primary TEM [22].

Three studies described an improvement or worsening of continence after assessment with the Wexner score. One study reported a 21% incidence of de novo incontinence [23], and another one found an increase of 7% in incontinence after surgery in patients who underwent CRT + TEM [24]. The third study compared patients undergoing TEM alone and after CRT, and found that the latter had better continence in terms of soiling and urgency compared with TEM alone [25].

Five studies assessed patients using the FISI scale. Of them, three studies showed a decrease in FISI values (incontinence improvement) [26–28], whereas two studies did not show any changes [13, 29].

The study using an individualized interview found worsening in flatus and liquid stool incontinence, with no changes in gas incontinence after TEM [30]. After using the Kirwan-Fazio scale, Wang et al. [14] reported that 86.7% of patients showed no incontinence and 13.3% had flatus incontinence after TEM, while almost 45% of patients had any kind of

incontinence preoperatively. The two studies that used the Williams score and the Pescatori scale showed no changes in continence after TEM [31, 32].

**TAMIS studies** Among the five included studies, two used the Wexner scale and showed no changes in continence after surgery [33, 34]. Three studies used the FISI scale. Of them, two studies showed continence improvement by decreased FISI values [35, 36], while the other, which included patients who underwent CRT before TAMIS, found worse postoperative FISI values (continence impairment) [37].

## Quality of life

Ten studies (34%) analyzed QoL changes as reflected in Table 3. Of them, nine involved TEM technique and one TAMIS, with a mean follow-up of 19 months. Six studies used the Fecal Incontinence Quality of Life (FIQL) index, six studies used the European Organization for Research and Treatment of Cancer (EORTC) C-30, one study the EORTC C-29, four studies the EORTC C-38, and three the EuroQol-5D scale. Half of the retrieved articles reported improvement in QoL [20, 27, 28, 36, 38], four remained comparable with preoperative values [13, 24, 26, 39], and only one study had worsening in some QoL components [40].

The first study analyzing QoL was published by Cataldo et al. [13], who used the FIQL in patients undergoing TEM. They showed minimal deterioration of the four components of the index (lifestyle, coping, depression, and embarrassment) with no statistical differences. On the other hand, three of the studies using the FIQL index before and after TEM showed statistical improvement in some components of the scale. “Lifestyle” score was increased in two studies [20, 27], “coping” in one [28], “depression” in two studies [20, 28], and “embarrassment” in three studies [20, 27, 28]. Arezzo et al. [40] reported impairment in all components of the FIQL index in patients who underwent TEM after neoadjuvant therapy, but this was not statistically significant. Only Verseveld et al. [36] focused on QoL after TAMIS, and found an improvement in “coping” and “embarrassment.”

The EORTC C-30 was used in six studies on TEM. Three studies concluded that all domains of the scale were comparable with preoperative values [20, 26, 39]. Another study comparing TEM with TME showed that patients who underwent TEM experienced an improvement in “insomnia,” “global health status,” and “physical and emotional functioning roles” [38]. Planting et al. [28] found improvement in “diarrhea” after TEM. However, Arezzo et al. [40] assessed ten patients who underwent TEM after SCRT, and found that the total EORTC C-30 score decreased in 12 items after surgery compared with preoperative values, which translates to QoL worsening.

**Table 2** Continence assessment outcomes

Reference	Technique	n	Follow-up (months)	Continence scale	Continence assessment (longest follow-up)	
					Preoperative	Postoperative
Hermann RM (2001) [23]	TEM	33	6	Wexner	76% of patients had no preoperative incontinence	21% developed partial or moderate incontinence (5–15 points in the Wexner scale)
Kennedy ML (2002) [17]	TEM	18	1.5		Mean score 1.8 (range, 0–7; SD, 2.9)	Mean score 3.5 (range, 0–12; SD, 4.6) p:N/A
Jin Z (2010) [19]	TEM	37	6		Mean score 0	Mean score 0 p:N/A—intermediate worsening
Allaix ME (2011) [20]	TEM	93	60		Mean score 0.02 (± 0–14)	Mean score 0.05 (± 0.37), <i>p</i> = 0.421—intermediate worsening (p:NS)
Khoury W (2013) [22]	TEM (repeated)	14	N/A		Mean score 1.5 (± 2.3)	After first TEM: mean score was 1.5 (± 2.3) p:N/A After second TEM mean score was 3.3 (± 3.1) p:N/A
Karakayali F (2015) [33]	TAMIS	10	1.5		No incontinence	No incontinence
Mora López L (2015) [18]	TEM	201	4		Mean score 0.72 (± 2.17)	Mean score 1.41 (± 2.86) p:N/A
Ghiselli R (2017) [24]	CRT + TEM	84	48		Continence 76 patients Incontinence 8 patients	Continence 70 patients p:N/A Incontinence 14 patients p:N/A
Biviano I (2017) [25]	Group A: TEM alone Group B: CRT + TEM	Group A: 27 Group B: 10	12		Group A 15% flatus incontinence 7% soiling 7% urgency	Group A 41% flatus incontinence 26% soiling 18% urgency intermediate worsening (p:S)
Barendse RM (2013) [21]	ERM versus TEM	24 (13 TEM)	6	Wexner COREFO	Group B 12% flatus incontinence 25% soiling 12% urgency	Group B 38% flatus incontinence 12% soiling 12% urgency Intermediate worsening (p:NS)
Hompes (2015) [26]	TEM	102	13	COREFO	Wexner 2.2 (± 3.4) COREFO: 3 patients reported incontinence to solid stool 9 patients for liquid stool 17 patients for flatus 13 patients soiling	Wexner 0.3 (± 0.8) ( <i>p</i> = 0.006) COREFO: 1 patient solid stool incontinence (p:NS) 1 patient to liquid stool ( <i>p</i> = 0.013) 13 patients to flatus (p:NS) 7 patients soiling (p:NS)
Cataldo PA (2005) [13]	TEM	41	1.5	FISI	Mean score 12 (± 8)	Mean score 10 (± 9) (p:NS) Intermediate worsening (p:S)
Doornbosch PG (2008) [27]	TEM	47	6		Mean score 2.4 (range, 0–43) Mean score 10	Mean score 2.4 (range, 0–17) (p:NS) Mean score 7 ( <i>p</i> < 0.01)
Planting A (2013) [28]	TEM	30	12		Mean score 6.7	Mean score 6.3 ( <i>p</i> = 0.92)
Walega P (2014) [29]	TEM	10	42.6		Mean score 2.7	Mean score 2.7 (p:NS)
	TAMIS	37	11		Mean score 10 (0–40)	Mean score 5 (0–20) ( <i>p</i> = 0.01)



**Table 2** (continued)

Reference	Technique	n	Follow-up (months)	Continence scale	Continence assessment (longest follow-up)	
					Preoperative	Postoperative
Schiphorst AHW (2014) [35]						
Verseveld M (2016) [36]	TAMIS	24	6		Mean score 9.8 ( $\pm 2.3$ )	Mean score 7.3 ( $\pm 2.2$ ) ( $p = 0.26$ )
Clermonts SHEM (2017) [37]	CRT + TAMIS	42	36		Mean score 8.3	Mean score 10.1 ( $p = 0.01$ )
Kreis ME (1996) [30]	TEM	42	12	Individualized interview	14% flatus incontinence 24% liquid stool incontinence 5% solid stool incontinence	24% flatus incontinence (p:NS) 33% liquid stools incontinence (p:NS) 5% solid stools incontinence (p:NS)
Wang HS (2003) [14]	TEM	22	12	Kirwan-Fazio	55.6% no incontinence 22.2% flatus incontinence 16.7% flatus and liquid stools incontinence 5.6% major soiling incontinence	86.7% no incontinence (p:NS) 13.3% flatus incontinence (p:NS)
Meng WCS (2004) [31]	TEM	31	23	Williams score	No incontinence	No incontinence p:N/A
Gracia Solanas JA (2006) [32]	TEM	40	3 (6 in case of FI)	Pescatori scale	No incontinence	No incontinence p:N/A

FI fecal incontinence

Hompes et al. [26] also used the EORTC C-29 for QoL assessment reporting no differences in any domains to preoperative values.

Four studies included the EORTC C-38 test. Allaix et al. [20] showed that patients who underwent TEM had improved “body image,” “defecation problems,” and “future perspectives.” All other studies reported no changes in all domains, as compared with preoperative values [28, 38, 39]. The EuroQol-5D, an easier scale to assess QoL, was used in two TEM and one TAMIS studies. All of them showed improvement of the score [20, 27, 36].

## Manometric outcomes

A total of fifteen studies (51%) investigated manometric variables pre- and postoperatively. All but one studies focused on patients who underwent TEM. Results are reported in Table 4. The most commonly investigated variables included anal resting pressure (ARP) and squeeze pressure (SP), followed by the presence of rectoanal inhibitory reflex (RAIR), rectal compliance, and rectal sensitivity.

Eight studies on TEM found a significant ARP decrease after surgery [14, 17, 18, 21, 30, 32, 42, 43], while three other showed no difference in ARP [19, 23, 29]. Biviano et al. [25] found only significant decrease in ARP in patients who had undergone CRT before TEM. Only three studies showed a decrease in SP [18, 32, 43]. One study found decreased rectal compliance and rectal sensitivity [30] after TEM. RAIR tended to decrease after TEM [23, 30, 42], and one study showed no changes after surgery [29].

The only study analyzing manometric outcomes after TAMIS showed significant decrease of APR and SP [33].

## Discussion

There is great variability in the reporting of functional and QoL outcomes after TEM and TAMIS in available studies. The current systematic review with almost 1300 patients included found that most studies reported some deterioration in manometric scores after both TEM and TAMIS, and some suggested concerning worsening in function, at least in some items of the used scores, including de novo incontinence in some patients. However, QoL does not seem to be significantly affected after the procedures.

The implementation of TEM and TAMIS has radically changed the surgical approach to rectal polyps and early rectal cancer, since the rectal wall is partially excised and pelvic nerve injuries are potentially avoided. Many studies have analyzed the oncological outcomes associated with organ preservation techniques, but data on function and QoL results are scarce and controversial. Since different platforms are used for

**Table 3** Quality-of-life outcomes

Reference	n	Technique	Follow-up (months)	Quality-of-life assessment (longest follow-up)										EQ 5D		
				FIQL		EORTC C-30		EORTC C-29		EORTC C-38		EQ 5D				
				Lifestyle	Coping	Depression	Embarrassment	Preop	Postop	Preop	Postop		Preop		Postop	Preop
Cataldo PA (2005) [13]	41	TEM	1.5	3.6	3.5	3.7	3.5	3.9	3.8	3.6	3.4	-	-	-	-	-
Doornbosch PG (2008) [27]	47	TEM	6	3.7	3.9*	3.6	3.8	3.7	3.9	3.1	3.7*	-	-	-	-	Preop 84 (11) Postop 89 (9)*
Allaix ME (2011) [20]	93	TEM	60	3.97	3.99*	3.88	3.89	3.57	3.73*	3.87	3.96*	All domains comparable with preoperative values	-	-	-	Preop 97 (8) Postop 99 (4)*
Lezoche E (2013) [38]	36 (17 TE-M)	TEM versus ETM	12	-	-	-	-	-	-	-	-	Insomnia, global health status, physical and emotional functioning improved	-	-	-	-
Planting A (2013) [28]	30	TEM	12	3.64	3.89	2.95	3.6*	3.21	3.61*	3.48	3.74*	All domains comparable with preoperative values. Diarrhea improvement	-	-	-	-
Hompes (2015) [26]	102	TEM	13	-	-	-	-	-	-	-	-	All domains comparable with preoperative values	All domains comparable with preoperative values	-	-	-
Arezzo A (2015) [40]	14	SCRT + TEM	10	-	-	-	-	-	-	-	-	Total score decreased 12 point compared with preoperative values	-	-	-	-
D'Ambrosio G (2015) [39]	31	TEM	24	-	-	-	-	-	-	-	-	All domains comparable with preoperative values	-	-	-	-
Verseveld M (2016) [36]	24	TAMIS	6	3.8	3.9	3	3.6*	3.6	3.7	3.5	3.7*	-	-	-	-	Preop 82 (11) Postop 88 (10)

**Table 3** (continued)

Reference	n	Technique	Follow-up (months)	Quality-of-life assessment (longest follow-up)															
				FIQL		Lifestyle		Coping		Depression		Embarrassment		EORTC C-30	EORTC C-29	EORTC C-38	EQ 5D		
				Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop				
Ghiselli R (2017) [24]	84	CRT + TEM	48	3.56	3.25	2.91	2.85	3.47	3.4	2.56	2.55	-	-	-	-	-	-	-	-

\* $p < 0.05$  compared with baseline

TEM and TAMIS, results of the two techniques are herewith considered in details separately, when possible.

Continence assessment remains difficult in these patients, irrespective of the transanal approach used. Even before surgery, many aged patients already refer incontinence much before rectal tumor diagnosis. The presence of a rectal tumor, especially in the lower third of the rectum, also makes fecal incontinence plausible due to decreased rectal wall elasticity, sphincter reflexes impairment, and mucus or blood discharge [4, 21, 30]. In fact, after tumor resection, continence was recovered or improved in many studies with both TEM [21, 26–28] and TAMIS [35, 36]. However, de novo or worsening of fecal incontinence was also reported in several studies assessing TEM included in this review [17, 18, 23, 30]. This could be explained by sphincter damage caused by anal dilation during the surgery with the rigid TEM rectoscopes or platforms that are 4 cm wide [19]. Moreover, scar formation after partial rectal wall resection reduces rectal compliance, which might also result in later onset of fecal incontinence and urgency [20]. Of note, some authors reported that postoperative incontinence after TEM was transient in many patients and improved at initial follow-up [19, 20, 25, 26]. This improvement may be explained by rectal scar healing and anal tone recovery after surgery.

In order to detect those patients who might develop fecal incontinence after TEM, Mora Lopez et al. [18] found that only closer distance to the anal verge seemed to affect continence. Other reported risk factors for fecal incontinence included male gender, age at surgery, surgical time, extended resection, and full-thickness resection [17, 23, 24]. Khoury et al. [22] found that continence was only affected after repeated TEM, which might suggest that multiple traumas on the anal sphincter complex may be responsible for incontinence.

There were two studies which included patients who underwent chemoradiotherapy before TEM [24, 25], and one before TAMIS [37]. It has been postulated that radiotherapy compromises muscle and nerve fiber integrity and reduces wall elasticity often leading to fecal incontinence, tenesmus, and urgency [44, 45]. This was reported by Ghiselli et al. (TEM) [24] and Clermonts et al. (TAMIS) [37]. However, Biviano and colleagues [25] reported a decrease in soiling and the same rate in urgency after CRT + TEM, while patients without CRT showed worsening in flatus incontinence, soiling, and urgency. Therefore, the role of radiotherapy in continence impairment for patients undergoing TEM or TAMIS is difficult to interpret.

Only ten studies evaluated QoL changes after transanal endoscopic surgery (nine after TEM and one after TAMIS) (Table 3). Of them, five studies used the FIQL, which is a specific psychometric tool to assess the quality of life in incontinent patients in the domains of lifestyle, coping, depression, and embarrassment [46]. After TEM, all of these domains improved in the reported results, especially for



**Table 4** Manometric results

Reference	n	Technique	Follow-up (months)				Postoperative (longest follow-up)				Other outcomes		
			Preoperative	1	2	4	Anal resting pressure (mmHg)	Squeeze pressure (mmHg)	RAIR	Rectal compliance (mmHg)		Rectal Sensitivity (ml)	Rectal compliance ml/mmHg
Hemingway D (1996) [41]	6	TEM	-	4	-	-	-	-	-	-	-	-	Postoperative ARP fell 25% and SP 37% from baseline (data on figures)
Banerjee AK (1996) [42]	36	TEM	86.1 (±27.6)	12	164.8 (±58.2)	94%	-	173.5 (±71.8)	75%*	-	-	-	
Kreis ME (1996) [30]	42	TEM	84.2 (±32.1)	12	162.3 (±66.7)	93%	8 (±6)	167 (±82.4)	74%*	3.9 (±1.3)*	47.5 (±26.3)*	-	
Herman RM (2001) [23]	33	TEM	55.6 (±10.8)	6	140.6 (±36.2)	24.2 (±1.0, 0.2) <sup>+</sup>	9.8 (1.4)	146.8 (±28.6)	34.8 (±8.2) <sup>s*</sup>	8.6 (±2.2)	20.2 (±3)	-	
Kennedy ML (2002) [17]	18	TEM	73.5 (±23.5)	1.5	105.2 (±50.7)	-	-	59.7 (±22)*	-	-	(30±10)	-	ARP and SP converted from cmH <sub>2</sub> O to mmHg—correlation between length of procedure and ARP and ARP decrease
Wang HS (2003) [14]	22	TEM	81.5 (±6.4)	12	136.8 (±19.1)	93%	-	59.4 (4.49)*	67%	-	59.6 (±6.3)	-	
Gracia Solanas JA (2006) [32]	40	TEM	87.2 (±25.2)	3	152.5 (±45.2)	100%	-	70.1 (±31.4)*	80%	-	-	-	
Jin Z (2010) [19]	37	TEM	45 (±6)	6	181 (±20)	95%	-	45 (±5)	92%	-	-	-	Significant ARP decrease after 3 months—significant SP decrease at 2 weeks
Allaix ME (2011) [20]	93	TEM	-	60	-	-	-	-	-	-	-	-	No differences in ARP, SP, RAIR, and rectal sensitivity before and after TEM (data on figures)
	123	TEM	60 (±20)	3	137 (±79)	-	-	51 (±20)*	-	-	159 (±96)*	-	

Table 4 (continued)

Reference	n	Technique	Follow-up (months)					Postoperative (longest follow-up)					Other outcomes
			Preoperative	Anal resting pressure (mmHg)	Squeeze pressure (mmHg)	RAIR	Rectal compliance (ml/mmHg)	Rectal Sensitivity (ml)	Anal resting pressure (mmHg)	Squeeze pressure (mmHg)	RAIR	Rectal compliance ml/mmHg	
Léonard D (2012) [43]	24	ERM versus TEM	66 (±17)	135 (±89)	77%	-	80 (30–135)	51 (±12)*	165 (±85)	56%	-	45 (28–103)	SP increases after TEM Data for the TEM group
Barendse RM (2013) [21]	10	TEM	58.3	141.7	100%	-	-	58	144	100%	-	-	
Walega P (2014) [29]	10	TAMIS	57.7 (±4.6)	150.9 (±8.41)	-	-	37 (±8.2)	57 (±9.8)	148 (±8.3)	-	-	24 (±5.16)*	
Karakayali F (2015) [33]	201	TEM	64 (±26.2)	200.5 (±88.8)	-	-	-	48.86 (±21.1)*	173.6 (±79)*	-	-	-	
Mora López L (2015) [18]	27	Group A: TEM	68 (±23)	134 (±53)	23 (±9) ml/air <sup>^</sup>	4.5 (±2)	49 (±21)	60 (±30)	130 (±67)	24 (±8.6) ml/air	4 (±1.3)	41.2 (±17)	ARP, rectal compliance and sensitivity decrease after 4 months
Biviano I (2017) [25]	10	Group B: CRT + TEM	65 (±22)	121 (±53)	22 (±1.0) ml/air <sup>^</sup>	4.6 (±2.8)	34 (±13)	44 (±11)*	103 (±31)	20 (±6) ml/air	3.5 (±1.8)	32 (±12)	ARP decrease after 12 months was significantly higher in group B than in group A

ARP anal resting pressure, RAIR rectoanal inhibitory reflex, SP squeezing pressure; <sup>+</sup> total reflex duration in seconds, <sup>^</sup> volume to elicit RAIR, \* $p < 0.05$  compared with baseline

embarrassment [20, 27, 28]; the same finding was observed after TAMIS [36]. This is of vital importance since rectal tumors induce awareness of continence issues and its subsequent changes in daily activities. Tumor excision not only may improve symptoms but also decreases psychological disorders induced by the fact of having a tumor, and even in those studies with a long follow-up, this improvement is maintained over time [20]. The fact that these techniques preserve the rectum without the implantation of a stoma justifies the high rates of quality-of-life scores in these patients.

Other studies used the EORTC questionnaires, which evaluate areas common to different tumor sites and treatments. After systematic analysis, almost all studies except for one showed that—with TEM—all domains were comparable with preoperative values, or improvement in certain domains such as defecation problems [20], or physical and emotional functioning [38]. Since these questionnaires do not focus on specific issues related to rectal tumors, it is most likely that patients do not report changes or that these changes are reported within the first postoperative months [38]. One study, however, did show QoL worsening using these general questionnaires [40]. This study included patients who underwent SCRT and TEM, which induced serious wound healing complications that might have impaired QoL (e.g., enterocutaneous fistula). The authors hypothesized that SCRT-TEM could provide similar oncological results to radical surgery with better QoL outcomes, but due to the incidence of serious postoperative complications after this approach, they concluded that QoL in these irradiated patients is probably equivalent or worse compared with radical surgery [40].

Patients who underwent manometry before surgery showed lower threshold volume, maximal tolerable volume, and rectal compliance due to the presence of the rectal tumor [23]. After surgery, the majority of studies reported a decrease in ARP and SP and in the presence of RAIR. This could be explained by the resection and scar formation in the rectum, especially in cases of extended and full-thickness resection, which induces a decrease in the rectal wall elasticity and cessation of local reflexes such as RAIR. These changes in anal reflexes might be responsible for sphincter function inhibition, disturbed defecatory coordination, and fecal incontinence or urgency onset both with TEM [23] and with TAMIS [33, 37]. As previously discussed, induced trauma in anal sphincters after platform insertion might also induce striated and smooth muscle sphincter lesions and fibrosis, which can provoke worsening in manometric parameters.

However, all these changes are mainly detected within the first postoperative months, and seem to recover at 1 year after surgery; hence, they might not be outline clinically relevant to the patients [18, 21]. As a matter of fact, it is hard to correlate manometric changes with continence assessment. The current systematic review included studies with continence deterioration and decreased pressures [17, 18, 30], continence improvement and decreased pressures [14, 21], and others in which

there were neither changes in continence nor manometric pressures [19, 20, 29, 33] after TEM and TAMIS.

Only one study analyzed manometric outcomes in patients who underwent preoperative radiotherapy before TEM compared with those who underwent surgery alone [25]. Even though there were worse intermediate results in both groups, only patients who underwent surgery alone recovered the reported reduction in anal canal pressure, rectal compliance, and sensitivity at 1 year of follow-up. The authors suggest that TEM with CRT could cause more damage due to changes in the nerve fibers of the inner walls of the anal canal and/or the muscular structure of the sphincter which might impair tissue remodeling.

### Study limitations

The main limitation of this review is that retrieved data from the studies were heterogeneous. Not only outcome data were expressed in different formats (mean scores, percentage of patients affected, figures), but also continence and QoL assessment were evaluated in different scores and follow-up sequences. This made it impossible to perform a complete standardized comparison or meta-analysis. Another bias in assessing continence changes in this study was the lack of information of previous medical history which could have been responsible for incontinence, such as obstetric trauma.

Another limitation to account for is that anorectal manometry normal values are influenced by technique, age, and gender. Therefore, the reported outcomes are difficult to interpret and extrapolate, especially in the presence of a rectal tumor. Also, there were no strict definitions of incontinence in any of the studies.

This review focused on functional and quality-of-life outcomes after TEM and TAMIS. The aim of these techniques is similar, but the materials used in them differ. TAMIS may have a less harmful influence on fecal continence since a flexible port is used instead of a rigid rectoscope as in TEM, but data is scarce and inconclusive.

For all the above-reported limitations, potential biases could not be removed; therefore, caution is warranted when drawing conclusions on function and QoL after TEM and TAMIS.

However, the current study has strength. The review methodology was rigorous and followed the PRISMA recommendations; studies were thoroughly assessed by two independent screeners, and despite the different scores and scales used in the studies, the clinical relevance of the findings was taken into account. Several interesting results were observed. The possibility of worsened function after TEM and TAMIS should not be underestimated, even if the reasons underlying this are yet to be completely understood and are likely to be multifactorial. These techniques do not seem to affect continence by themselves, except in minor cases. Also, manometric findings did not always correlate with function. Of note, QoL does seem to be stable or improved after TEM or TAMIS. However, the perception of having being cured (avoiding a stoma) could be responsible for the improved QoL scores, and

longer follow-ups or more specific QoL tools might capture more issues. All these aspects need to be addressed in future studies and should be discussed with patients at the time of counseling. There is the need to homogenize or standardize functional and manometric outcomes assessment after TEM or TAMIS.

**Acknowledgments** The authors would like to thank Dr. Dimelza Osorio Sánchez for her assistance during the search process.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflicts of interest.

## Appendix

### MEDLINE

1. "transanal endoscopic surgery"[Mesh]	277
2. "transanal endoscopic microsurgery" [tiab]	771
3. "transanal minimally invasive surgery"[tiab]	131
4. "transanal endoscopic operation"[tiab]	36
5. 1 OR 2 OR 3 OR 4	1056
6. "rectal neoplasms"[Mesh]	43632
7. "rectal neoplasm*"[tiab]	114
8. "rectal tumor*"[tiab]	571
9. "rectal tumour*"[tiab]	184
10. "rectal cancer*"[tiab]	19521
11. "rectal polyp*"[tiab]	181
12. "rectal lesion*"[tiab]	142
13. 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12	49479
14. 5 AND 13	780

**EMBASE**

1. 'transanal endoscopic microsurgery'/exp	540
2. 'transanal endoscopic microsurgery':ti,ab	1,266
3. 'transanal minimally invasive surgery':ti,ab	212
4. 'transanal endoscopic operation':ti,ab	51
5. 1 OR 2 OR 3 OR 4	1,590
6. 'rectum cancer'/exp	183,450
7. 'rectal tumor*':ti,ab	2,205
8. 'rectal tumour*':ti,ab	980
9. 'rectal cancer*':ti,ab	31,011
10. 'rectal neoplasm*':ti,ab	421
11. 'rectal polyp*':ti,ab	826
12. 'rectal lesion*':ti,ab	993
13. 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12	191,313
14. 5 AND 13	1,187
15. 5 AND 13 AND [embase]/lim	1,052

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**CENTRAL**

1. MeSH descriptor: [Transanal Endoscopic Surgery] explode all trees	6
2. (Transanal Endoscopic Microsurgery):ti,ab,kw	60
3. (transanal minimally invasive surgery):ti,ab,kw	23
4. (transanal endoscopic operation):ti,ab,kw	19
5. 1 OR 2 OR 3 OR 4	87
6. MeSH descriptor: [Rectal Neoplasms] explode all trees	1466
7. (rectal tumor*):ti,ab,kw	1119
8. (rectal tumour*):ti,ab,kw	316
9. (rectal neoplasm*):ti,ab,kw	2366
10. (rectal cancer*):ti,ab,kw	3363
11. (rectal polyp*):ti,ab,kw	221
12. (rectal lesion*):ti,ab,kw	229
13. 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12	4132
14. 5 AND 13	66

**Table 5** Study characteristics by Newcastle-Ottawa quality assessment scale score

Year	Reference	Selection				Comparability		Outcome			Total score
		Representativeness	Selection	Ascertainment	Demonstration			Assessment	Length follow-up	Adequacy follow-up	
1996	Hemingway D	*	-	*	*	-	-	*	*	*	6
1996	Banerjee AK	*	-	*	*	-	-	*	*	*	6
1996	Kreis ME	*	-	*	*	-	-	*	*	*	6
2001	Hermann RM	*	*	*	*	*	-	*	*	*	8
2002	Kennedy ML	*	-	*	*	-	-	*	*	*	6
2003	Wang HS	*	-	*	*	-	-	*	*	*	6
2004	Meng WCS	*	-	*	*	-	-	*	*	*	6
2005	Cataldo PA	*	-	*	*	-	-	*	*	*	6
2006	Gracia Solanas JA	*	-	*	*	-	-	*	*	*	6
2008	Doornebosch PG	*	-	*	*	-	-	*	*	*	6
2010	Jin Z	*	-	*	*	-	-	*	*	*	6
2011	Allaix ME	*	-	*	*	-	-	*	*	*	6
2012	Léonard D	*	-	*	*	-	-	*	*	*	6
2013	Lezoche E	*	-	*	*	*	-	*	*	*	7
2013	Barendse RM	*	-	*	*	*	-	*	*	*	7
2013	Planting A	*	-	*	*	-	-	*	*	*	6
2013	Khoury W	*	-	*	*	*	-	*	*	*	7
2014	Walega P	*	-	*	*	-	-	*	*	*	6
2014	Schiphorst AHW	*	-	*	*	-	-	*	*	*	6
2015	Hompes	*	-	*	*	-	-	*	*	*	6
2015	Karakayali F	*	-	*	*	-	-	*	*	*	6
2015	Mora López L	*	-	*	*	-	-	*	*	*	6
2015	Arezzo A	*	-	*	*	-	-	*	*	*	6
2015	D'Ambrosio G	*	-	*	*	-	-	*	*	*	6
2016	Verseveld M	*	-	*	*	-	-	*	*	*	6
2017	Ghiselli R	*	-	*	*	*	-	*	*	*	7
2017	Clermonts SHEMA	*	-	*	*	*	-	*	*	*	7
2017	Biviano I	*	-	*	*	*	-	*	*	*	7
2017	García-Flórez LJ	*	-	*	*	-	-	*	*	*	6

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