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A Systematic Review of Outcomes After Transanal Mesorectal Resection for Rectal Cancer

Lakshmanan Arunachalam, M.D., F.R.C.S. • Helen O'Grady, M.D., F.R.C.S.I.
Iain A. Hunter, Ph.D., F.R.C.S. • Shane Killeen, M.D., F.R.C.S.

Department of Colorectal Surgery, Castlehill Hospital, Cotttingham, East Yorkshire, United Kingdom

BACKGROUND: Transanal mesorectal resection has been developed to facilitate minimally invasive proctectomy for rectal cancer.

OBJECTIVE: The purpose of this study was to evaluate the evidence regarding technical parameters, oncological outcomes, morbidity, and mortality after transanal mesorectal resection.

DATA SOURCES: The Cochrane Library, PubMed, and MEDLINE databases were reviewed.

STUDY SELECTION: Systematic review of the literature from January 2005 to September 2015 was used for study selection.

INTERVENTION: Intervention included transanal mesorectal resection for rectal cancer.

MAIN OUTCOME MEASURES: Technical parameters, histological outcomes, morbidity, and mortality were the outcomes measured.

RESULTS: Fifteen predominately retrospective studies involving 449 patients were included (mean age, 64.3 years; 64.1% men). Different platforms were used. The operative mortality rate was 0.4% and the cumulative morbidity rate 35.5%. Circumferential resection margins were clear in 98%, and the resected mesorectum was grade III in 87% of patients. Median follow-up was 14.7 months. There were 4 local recurrences (1.5%) and 12 patients (5.6%) with metastatic disease. No study followed patients long enough to report on 5-year overall and disease-free survival rates. Functional outcome was only reported in 3 studies.

LIMITATIONS: A low number of procedures were performed by expert early adopters. There are no comparative or randomized data included in this study and inconsistent reporting of outcome variables.

CONCLUSIONS: Transanal mesorectal resection for rectal cancer may enhance negative circumferential margin rates with a reasonable safety profile. Contemporary randomized, controlled studies are required before there can be universal recommendation.

KEY WORDS: Rectal cancer; Transanal mesorectal excision.

Adequate longitudinal and circumferential resection margins (CRMs) allied to high-quality total mesorectal excision (TME) are paramount for successful outcomes after low rectal cancer surgery.[1,2] Achieving these parameters can be challenging in patients with large tumors, a narrow pelvis, high BMI, and poor response to neoadjuvant chemoradiotherapy. Furthermore, minimally invasive resection can be technically demanding in this setting.[3,4]

Recent reports of a novel transanal caudal-to-cranial approach to TME using a variety of endoscopic techniques with or without laparoscopic assistance potentially addresses these difficulties.[5,6] This concept amalgamates features of TME, transanal transabdominal anterior resection, transanal endoscopic microsurgery, and transanal minimally invasive surgery (TAMIS) to achieve clear resection margins and a complete TME.[7–10] A number of terms have been applied to the series of similar techniques encompassing this promising approach, including transanal TME, TAMIS-TME, bottom-up proctectomy, and transanal proctectomy.[5,6,11]

Before universal implementation of this technique, rigorous systemic scrutiny of the available data is mandatory. Although some reviews have examined the early technical accounts, the overall included cases totaled less than 100, involved small, single-institution case series with restrictive inclusion criteria, and did not assess functional outcomes.[11,12] Since these initial descriptions, a plethora of studies have been published by early expert adopters,

Corresponding author: Shane Killeen, M.D., F.R.C.S., Department of Colorectal Surgery, Castlehill Hospital (CHH), Cottingham, East Yorkshire HU16 5JQ, United Kingdom. sdfkileen@eircom.net

Dis Colon Rectum 2016; 59: 340–350
DOI: 10.1097/DCR.0000000000000571

detailing surgical technique, specimen histopathological parameters, short-term morbidity, and mortality, with some functional data also reported. Furthermore, whereas a number of randomized controlled trials comparing this approach with standard top-down TME have been registered in the major trial databases, none have been reported to date.[13] The purpose of this systematic review was to synthesize the current evidence regarding technical aspects, perioperative morbidity and mortality, and short-term functional and oncological outcomes after transanal mesorectal resection (TaTME) for rectal cancer.

MATERIALS AND METHODS

Search Strategy

A systematic review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines.[14] The Cochrane Library, PubMed, and MEDLINE databases were reviewed from January 2005 to September 2015.

The Cochrane database was searched using a combination of the following terms with the Boolean AND/OR operators: "transanal," "proctectomy," "rectum," "resection," "mesorectum," "rectal cancer," "total mesorectal excision," "TME," "bottom up proctectomy," "transanal minimally invasive surgery," "TAMIS," "transanal minimally invasive surgery for total mesorectal excision (TAMIS–TME)," "transanal total mesorectal excision," "TaTME," "HYBRID-NOTES," "robotic transanal total mesorectal excision (RATS)," and "endoscopic total mesorectal." For the MEDLINE and PubMed database searches, these same key words (and variants) were used as text words and Medical Subject Headings, and were combined by using the following Boolean operators: "rectal cancer*" OR "rectal tumour" OR "rectal tumor" AND ("resection" OR "surg*") AND "transanal total mesorectal excision" OR "bottom up proctectomy" OR "transanal proctectomy" OR "transanal mesorectal excision" OR "bottom up transanal mesorectal excision" OR "transanal minimally invasive surgery" OR "TAMIS" OR "transanal minimally invasive surgery for total mesorectal excision (TAMIS–TME)" OR "HYBRID NOTES" OR "robotic proctectomy" OR "robotic transanal total mesorectal excision (RATS)" OR "endoscopic total mesorectal excision."

Selected reviews, expert consensus statements, and reference lists from included and excluded studies were hand searched to detect additional articles. Titles and abstracts were screened, studies that potentially fulfilled the inclusion criteria were identified, and full-text publications of these articles were assessed.

Inclusion and Exclusion Criteria

Studies were included if TaTME for pathologically verified rectal cancer was clearly described, if they had a minimum of 3 patients, and if they reported oncological outcomes, morbidity, or mortality as primary end points. There was no restriction on the date or language of publication. If separate publications included the same cohort of patients, the larger and more complete data set was used. Where there was uncertainty regarding duplicate patient groups (same group or institution reporting outcomes for a similar period, without clear indications that the smaller report was a substudy or described interim results), a consensus was reached among the authors regarding its inclusion or exclusion. Articles detailing transanal large bowel resections other than the rectum were excluded. TaTME was defined as caudal-to-cranial mobilization of at least the lower third of the rectum using any transanal resectional platform device or endoscopic system.[11,12]

Assessment of Methodological Quality of Included Studies

Drs Arunachalam and Killeen independently extracted data from included studies and assessed the methodological quality using the Newcastle–Ottawa Quality Assessment Scale.[15] Points were awarded for methodology of patient selection (4 variables assessed, scored 0 for absent or * for present), comparability of cohorts (2 variables assessed, scored 0 for absent or * for present), and outcome assessment (3 variables, scored 0 for absent or * for present). A total score was calculated of a maximum of 9 points. A score of 5 points or above was mandatory for study inclusion.

Data Extraction and Analysis

Data was extracted using a predefined proforma that included year of publication, country of origin, author's institute, number of included patients, baseline patient demographics, preoperative stage of disease, details of TaTME technique, neoadjuvant therapy, surgical pathology (CRM, distal resection margin, lymph node number, and mesorectal excision grade), adjuvant therapy, morbidity, and operative (30-day) mortality. Functional outcome was recorded, when reported, with the scoring system used or by using the number of bowel movements in 24 hours as a surrogate marker, because this is a feature common to many classification systems available for assessing functional outcome after low anterior resection.[16]

Basic descriptive statistics (simple counts, percentages, and means) were used to summarize patient and outcome data. Mean weighted values were calculated for oncological outcomes, morbidity, and mortality across all of the studies. Long-term outcomes, such as recurrence rates, metastasis, and disease-specific and overall survival rates were recorded where present, but given that this technique is relatively new, such data were generally lacking.

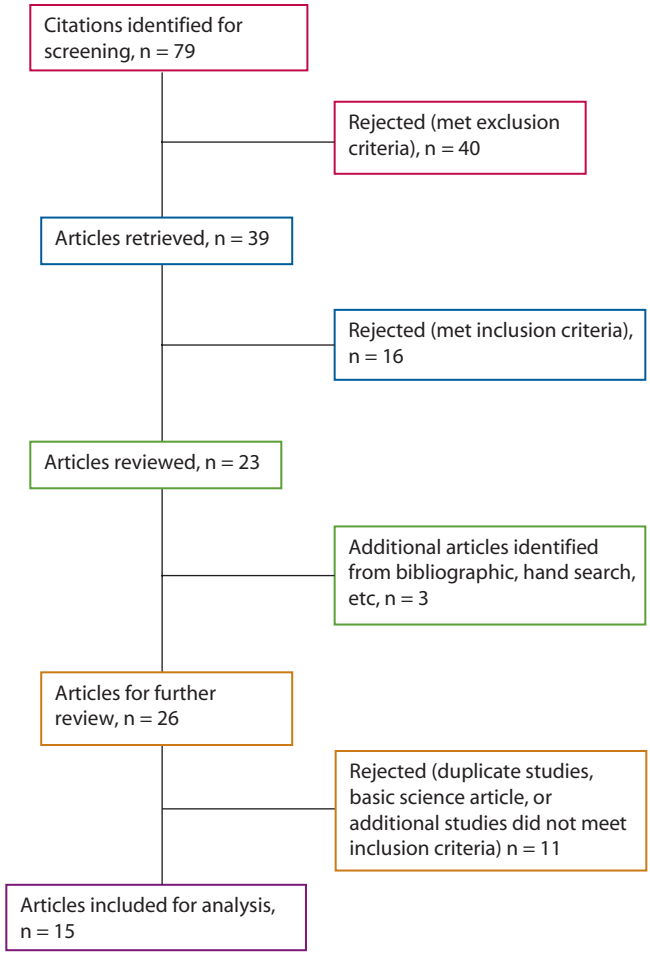

FIGURE 1. Exclusion criteria.

RESULTS

Search Yield and Data Retrieval

A total of 79 potential articles were identified. Forty were disregarded because they met exclusion criteria (Fig. 1). A total of 39 studies were retrieved for full review, but 16 were rejected because they did not fulfill inclusion criteria. An additional 3 articles were identified from bibliographies and related citations that were deemed suitable for inclusion. Eleven studies were excluded because they represented an earlier study involving a patient population from an included article or basic science articles. Fifteen articles satisfied all of the criteria and had sufficient detail to permit analysis.[17–31]

Study Characteristics

Most included studies originated from Europe (3 studies originated in Spain and France, 2 were from the Netherlands and Italy, and 1 study was from Belgium and the Czech Republic), whereas 2 studies were from America, and 1 was a multinational project. The median Newcastle–Ottawa Quality Assessment Scale score was 6, and all were published between 2012 and 2015. Individual study patient numbers were small, and the median number of included patients was 17 (Table 1).

Baseline Patient Demographics and Tumor Characteristics

The median age of included patients was 64 years, with a significant preponderance of men (65%). The median BMI was 23.4 but ranged from 18 to 41 kg/m^2 (Table 2). Assessment of patient comorbidities and fitness for surgery, including metrics such as ASA grade, were incompletely recorded. Where detailed, most patients were ASA I or II. Some studies excluded patients with ASA grade III or IV.[23,27] Preoperative staging was variably noted. Only 3 studies included patients with preoperatively staged T4 tumors, and such lesions were explicitly excluded from a number of series. The mean distance from the anal verge was 5.6 cm. A total of 72% of patients received preoperative radiotherapy or chemoradiotherapy (Table 2).

Technical Considerations

A number of commercially available platforms were used to perform transanal proctectomy. Some authors used a different device depending on the location of the neoplasm relative to the anal sphincter complex.[18,29] Median operative time was 254 minutes but ranged widely (91–495 minutes). Most authors acknowledge increased procedure duration when initially embarking on the technique. Procedure sequence also contrasted considerably, but a majority of studies performed the rectal phase first, with 3 studies reporting concurrent abdominal and rectal mobilization involving separate teams.[23,24,31] The median operative time for a sequential approach was 267 minutes (range, 204–376 minutes) compared with 236 minutes (range, 166—398 minutes) for a concurrent 2-team technique.[23,30,31]

The abdominal approach included open, laparoscopic (often single port), and robotic colonic mobilization.[17,22,29] Approximately 90% of cases required splenic flexure mobilization, and 98% involved stoma formation (Table 3). Six studies specifically mentioned using a defined fast-track protocol (Table 3).[21,22,25,27,29,30]

Histological Outcomes

The mesorectum was graded in 12 studies, with 87% grade I specimens and 13% classified as incomplete or undefined. One study had >50% grade I/II specimens.[25] The mean distal and CRMs were 2.5 and 1.1 cm. The CRM was negative in 98% of cases for the 9 studies that specifically recorded it, and the weighted mean number of lymph nodes harvested was 16. The final pathological stage was stage I, II, or III in almost all of the cases (Table 4).

TABLE 1. Study characteristics by Newcastle–Ottawa Quality Assessment Scale score

Reference, Location	*Selection*				*Comparability*		*Outcome assessment*			*Score*
Dumont et al,[17] France	*	0	*	*	0	0	*	*	*	6
Atallah et al,[18] US	*	0	*	*	0	0	*	*	*	6
Zorron et al,[19] multinational	*	0	*	*	0	0	*	*	*	6
Atallah et al,[20] US	*	0	*	*	0	0	*	*	*	6
Chouillard et al,[21] France	*	0	*	*	0	0	*	*	*	6
Velthuis et al,[22] Netherlands	*	*	*	*	*	0	*	*	*	8
Gómez Ruiz et al,[23] Spain	*	0	*	*	0	0	*	*	*	6
Tuech et al[24], France	*	0	*	*	0	0	*	*	*	6
Procházka et al,[25] Czech Republic	*	0	*	*	0	0	*	*	*	6
Serra-Aracil et al,[26] Spain	*	0	*	*	0	0	*	*	*	6
Muratore et al,[27] Italy	*	0	*	*	0	0	*	*	*	6
Knol et al,[28] Belgium	*	0	*	*	0	0	*	*	*	6
Veltcamp Helbach et al,[29] Netherlands	*	0	*	*	0	0	*	*	*	6
Elmore et al,[30] Italy	*	0	*	*	0	0	*	*	*	6
Lacy et al, [31] multinational	*	0	*	*	0	0	*	*	*	6

Perioperative Morbidity and Mortality

Perioperative mortality and morbidity were generally well reported, although data were lacking on a number of parameters from some series. The overall procedure-associated morbidity was 34.6%, with a 30-day mortality rate of 0.8%. The reoperation rate was 9.1%, with an anastomotic leak rate of 9.1%. Blood loss averaged ≈150 mL. Median length of stay was 7.3 days (Table 5).

Survival and Functional Outcomes

Median follow up was 4.5 months (range, 1.0–21.0 months). The need for adjuvant therapy was not recorded. Two studies reported 3 local recurrences after 30 months of follow up (2.5%), whereas 3 noted 10 patients (7.9%) with distal metastasis after ≥23 months of surveillance.[24,27,31] Data on postoperative functional outcomes were lacking. Time to first flatus and oral intake or patient satisfaction were not recorded. Only 3 studies reported a postoperative Wexner score, with a mean of 4.3 (Table 6).[17,23,30]

DISCUSSION

TaTME potentially promises safe, minimally invasive rectal resections for rectal cancer with preserved histological and oncological outcomes. This systematic review has demonstrated a low mortality rate and analogous overall morbidity compared with outcomes after contemporary standard open, laparoscopic, or robotic oncological proctectomy.[32–35] Understandably, given the relative newness of the procedure, long-term 5-year survival and functional data are lacking. The histological outcomes, specifically circumferential/distal resection margins, mesorectal grade, and lymph node yield, were also comparable and potentially superior (CRM = 98%) when equated.[32–35] This appears to be the predominant advantage over laparoscopic or robotic TME at present.

Anecdotally there appears to be considerable interest in TaTME throughout the colorectal research community, as reflected in the numerous introductory cadaveric courses on offer across the world. However, transanal proctectomy demands not only a specific surgeon but also a team skill set (including theater staff, anesthesiology, and pathology). Many of the included series were performed by authors who were already highly proficient in TAMIS or transanal endoscopic microsurgery, suggesting that this procedure should ideally be performed in centers with pre-existing experience in either of the above modalities, in addition to transanal transabdominal approaches to low rectal tumors.[19,29,30] Given recent data on unit volume and CRM grade, the unit should have a high volume throughput of lower third rectal cancers sufficient to establish and maintain the necessary surgeon and unit expertise.[36,37]

This approach needs to be adopted cautiously. Initial enthusiasm for extralevator abdominoperineal resection has been tempered recently by studies suggesting equivalent local recurrence rates, long-term oncological outcomes, and lower morbidity with standard abdominoperineal resection when performed by dedicated colorectal surgeons.[38,39] Akin to the current situation with abdominoperineal resection and the tailoring of resection extent to tumor stage (ie, standard abdominoperineal resection or extralevator abdominoperineal resection), TaTME should perhaps be selectively used for low rectal tumors without T4 extension, because many studies excluded patients with this tumor subset.[29,30]

A number of randomized controlled trials have been prospectively registered on trial databases and are actively enrolling.[13] In the interim, for the United Kingdom at least, recent National Institute for Health and Care Excellence guidelines mandate clear clinical governance pathways for TaTME and instruct prospective procedure registration in a centrally maintained database.[40,41] Careful recording of perioperative morbidity and surgical specimen quality are vital, particularly at the start of the learning curve, to demonstrate equivalence with the surgeon and unit standard

TABLE 2. Baseline patient demographics and tumor characteristics

Reference	No. of patients	Median age (range), y	Men/women, n/N (%)	BMI (range), kg/m^2	ASA, n (%)	Pretherapy T stage, n (%)	Tumor location (range), cm from verge	Neoadjuvant chemoradiotherapy/ radiotherapy, n (%)
Dumont et al[17]	4	65.0 (60–76)	4 (100)	23.5 (22.4–24.0)	NS	T3N0 x3, T3N1	5.0	4 (100)
Atallah et al[18]	20	57.0 (36–73)	14/6 (70.0)	24.0 (18.0–41.0)	I-II, 14 (70) III-IV, 6 (30)	I, 2 (10.0) II, 3 (15.0) III, 15 (75.0)	5.0	17 (85.0)
Zorron et al[19]	9	62.6 (52–81)	5/4 (55.0)	NS	NS	NS	7.5	NS
Atallah et al[20]	3	45.0 (26–59)	2/1 (67.0)	32.0 (21.0–38.5)	I, 1 II, 1 IIII, 1	T4N1 T4N2 T1Nx	4.0	2 (67.0)
Chouillard et al[21]	16	57.7 (34–81)	6/10 (37.5)	27.9 (21.0–38.0)	NS	NS	NS	NS
Velthuis et al[22]	25	64.0 (49–86)	18/7 (72.0)	25.0 (20.0–36.0)	NS	T1, 1 (4.0) T2, 11 (44.0) T3, 13 (52.0)	8.0	25 (100)
Gómez Ruiz et al[23]	5	57.0 (43–70)	4/1 (80.0)	25.8 (23.1–28.5)	NS	T2N1, 4 T2N0, 1	5.0	4 (80.0)
Tuech et al[24]	56	65.0 (39–83)	41/15 (73.2)	27.0 (20.0–42.0)	I, 5 (9) II, 40 (71.4) III, 11 (19.6)	T1, 3 (5.4) T2, 7 (12.5) T3, 44 (78.5) T4, 2 (3.6)	4.0 (0–5.0)	47 (84.0)
Procházka et al[25]	17	68.0 (49–81)	11/6 (65.0)	28.0 (22.0–32.0)	I–II, 7 III–IV, 10	I, 4 (24.0) II, 0 III, 11 (64.0) IV, 2 (12.0)	6.0	11 (64.7)
Serra-Aracil et al[26]	32	68.0 (39–88)	24/8 (75.0)	25.0 (20.0–35.0)	II, 22 (68.8) III, 10 (31.3)	NS	8.0	16 (50.0)
Muratore et al[27]	26	65.8 (38–84)	16/10 (61.5)	26.2 (16.9–38.2)	NS	T1, 2 (7.7) T2, 6 (23.1) T3, 18 (69.2)	4.4	19 (73.1)
Knol et al[28]	10	60.5 (36–70)	8/2 (80.0)	26.5 (22.0–34.0)	NS	T2, 3 (30.0) T3, 7 (70.0)	2.9	10 (100)
Veltcamp Helbach et al[29]	80	66.5 (42–86)	48/32 (60.0)	27.5 (19.5–40.0)	I, 15 (19.0) II, 53 (66.0) III, 12 (15.0)	T0, 6 (7.5) T1, 3 (5.0) T2, 29 (36.0) T3, 42 (52.5)	5.3	65 (81.3)
Elmore et al[30]	6	64.5 (53–72)	2/4 (33.3)	25.0 (18.0–32.0)	I, 1 (16.7) II, 3 (50.0) III, 2 (33.3)	T2, 2 (33.3) T3, 4 (66.7)	5.2	3 (50.0)
Lacy et al[31]	140	65.5 (NS)	89/51 (63.6)	25.2 (21.3–29.1)	I, 8 (5.7) II, 117 (83.6) III–IV, 15 (10.7)	NA, 10 (7.1) T1, 2 (1.4) T2, 27 (19.3) T3, 90 (64.3) T4, 11 (7.9)	7.6	94 (67.1)
Overall	449	64.0 (36–88)	292/157 (65.0)	26.1 (16.9–40.0)	I/II, 287 (63.9) III/IV, 162 (36.1)	T0, 6 (2.1) T1, 32 (2.2) T2, 89 (22.1) T3, 222 (39.3) T4, 15 (1.8) I, 6 (2.1) II, 3 (1.5) III, 26 (8.9) IV, 2 (0.7)	5.5	317 (72.3)

NS = not significant.

procedures. In the absence of long-term outcome data, surgical specimen histological parameters are important surrogate markers of quality and future sequelas.[42] In this review, mesorectal grade, CRM, and lymph node yield were universally equal to and even superior to contemporary results from contemporary randomized controlled trials looking at minimally invasive TME.[33–35] However, in 1 study, <50% of specimens had a grade I mesorectal resection, highlighting the potential difficulty in achieving satisfactory resections with this technique even in experienced hands.[25]

TABLE 3. Technical considerations

Reference	*Platform*	*Technique*	*Operating time, min (range)*	*Trocar numbers, n (%)*	*Splenic flexure mobilization, n (%)*	*Anastomosis*	*Pelvic drain*	*Pouch, n (%)*	*Stoma, n (%)*	*Fast track protocol*
Dumont et al[17]	GelPOINT (Applied)	TAMIS then SILS	360 (270–460)	SILS	4 (100)	Handsewn	NS	4 (100)	4 (100)	NS
Atallah et al[18]	SILS (Covidien) or GelPOINT (Applied)	Abdominal (laparoscopy/robotic/open) then TAMIS	243 (140–495)	NS	20 (100)	Handsewn or stapled	NS	3 (15)	19 (95)	NS
Zorron et al[19]	Triport (Olympus)	Transanal proctectomy then laparoscopy	311 (230–420)	3	9 (100)	NS	NS	3 (33)	9 (100)	NS
Atallah et al[20]	GelPOINT (Applied)	Laparoscopy then robotic TAMIS	376 (339–409)	NS	NS	Handsewn	NS	0	3 (100)	NS
Chouillard et al[21]	SILS (Covidien) or GelPOINT (Applied)	TAMIS then laparoscopy	265 (155–440)	SILS	16 (100)	NS	0	0	16 (100)	Yes
Velthuis et al[22]	SILS (Covidien) or GelPOINT (Applied)	TAMIS then SILS or reverse	NS	SILS	25 (100)	Handsewn or stapled	NS	NS	25 (100)	Yes
Gómez Ruiz et al[23]	Lonestar (Lone Star) and GelPOINT (Applied)	Concurrent robotic TAMIS and laparoscopy	398 (310–486)	4	5 (100)	Handsewn	5 (100)	0	5 (100)	Yes
Tuech et al[24]	Lonestar (Lone Star) and GelPOINT (Applied)/ SILS (Covidien)/ Endorec (Aspide)	TAMIS then laparoscopy	270 (150–495)	4 or SILS	NS	Handsewn	56 (100)	4 (7.1)	56 (100)	NS
Procházka et al[25]	Endorec (Aspide) or GelPOINT (Applied) or SILS (COVIDIEN)	TAMIS then laparoscopy	280 212–375)	4–5	17 (100)	Handsewn	NS	0	17 (100)	NS
Serra-Aracil et al[26]	TEO (Karl-Storz)	Laparoscopy then transanal proctectomy	240 (165–360)	4	32 (100)	Stapled	32 (100)	0	32 (100)	NS
Muratore et al[27]	SILS (Covidien)	TAMIS then SILS	NS	3	NS	Handsewn	NS	NS	26 (100)	Yes
Knol et al[28]	GelPOINT (Applied)	Laparoscopy then TAMIS	235 (150–290)	4–5	8 (80)	Handsewn or stapled	10 (100)	0	10 (100)	NS
Veltcamp Helbach et al[29]	GelPOINT (Applied) and SILS (Covidien)	TAMIS then laparoscopy/SILS or SILS then TAMIS	204 (91–447)	SILS/multiple	80 (100)	Stapled	NS	0	80 (100)	Yes
Elmore et al[30]	Triport (Olympus)	Concurrent TAMIS and laparoscopy	236 (200–270)	4	6 (100)	Stapled	NS	0	6 (100)	Yes
Lacy et al[31]	Lonestar (Lone Star) and GelPOINT (Applied)	Concurrent TAMIS and laparoscopy	166 (60–360)	4	NS	Stapled or handsewn, NS	140 (100)	2 (1.4)	(100)	117 (83.6)
Overall	SILS (Covidien) = 4 GelPOINT (Applied medical) = 11 Triport (Olympus) = 1 Endorec (Aspide) = 1 TEO (Karl-Storz) = 1	Concurrent = 4 abdominal phase first (open, laparoscopy, robotic) = 5 Rectal phase first (TAMIS/TEO) = 9	254 (91–495)	SILS = 29 (11.1) 3 = 83 (31.8) 4 = 140 (48.6) Multiple = 22 (8.4)	236 (89.9)	Handsewn = 5 Stapled = 4 Handsewn or stapled = 5	Drain = 2407 (95.6) No drain = 16 (4.4)	Pouch = 16 (2.8) No pouch = 390 (97.2)	284 (97.9)	6 = yes 8 = NS

NS = not significant; TAMIS = transanal minimally invasive surgery.

TABLE 4. Histological outcomes

Reference	TME grade, n (%)	Distal margin, mean (cm)	CRM, mean (mm)	R0 resection (CRM >1 mm), n (%)	No. of lymph nodes (n)	Pathological stage (pTNM), n (%)
Dumont et al[17]	3, 4 (100)	2.3	7.4	4 (100)	16.0	NS
Atallah et al[18]	3, 11 (55.0) 2, 6 (30.0) 1, 2 (10.0) NS, 1 (5.0)	4.5	NS	18 (90.0)	22.5	0, 5 (25.0) I, 3 (15.0) II, 6 (30.0) III, 5 (25.0) IV, 1 (5.0)
Zorron et al[19]	NS	NS	NS	NS	NS	I, 2 (20.0) II, 3 (30.0) III, 4 (40.0) IV, 1 (10.0)
Atallah et al[20]	2, 2 (67.0) 1, 1 (33.0)	NS	NS	3 (100)	30.0	I, 2 (66.7) II, 0 III, 1 (33.3)
Chouillard et al[21]	NS	3.6	NS	NS	NS	0, 1 (6.3) I, 6 (37.5) II, 4 (25) III, 5 (31.3)
Velthuis et al[22]	3, 24 (96.0) 2, 1 (4.0)	2.3	13.0	24 (96.0)	14.0	NS
Gómez Ruiz et al[23]	3, 5 (100)	NS	NS	5 (100)	14.0	NS
Tuech et al[24]	3, 47 (84.0) 2, 9 (16.0)	1.0	8.0 (0–20)	53 (94.6)	12.0 (7–29)	pCR, 11 (19.6) pT1, 7 (12.5) pT2, 16 (28.6) pT3, 21 (37.5) pT4, 1 (1.8)
Procházka et al[25]	3, 8 (47.0) 2, 0 1, 9 (53.0)	2.0	8.0	NS	10.0	0, 1 (5.9) I, 8 (47.0) II, 2 (11.9) III, 4 (24.0) IV, 2 (11.9)
Serra-Aracil et al[26]	3, 30 (93.7) 2, 2 (6.3)	2.0	13.0	NS	15.0	0, 2 (6.25) I, 7 (21.9) II, 10 (31.3) III, 12 (37.5) IV, 1 (3.12)
Muratore et al[27]	3, 23 (89.0) 2. 3 (11.0)	1.9	11.1	NS	10.0	NS
Knol et al[28]	3, 9 (90.0) 2, 1 (10.0)	1.9	13.8	NS	10.4	0, 0 I, 5 (50.0) II, 3 (30.0) III, 2 (20.0)
Veltcamp Helbach et al[29]	3, 71 (88.0) 2, 7 (9.0) 1, 2 (3.0)	NS	NS	78 (97.5)	14.0	NS
Elmore et al[30]	3, 6 (100)	2.4	ns	6 (100)	32.0	0, 1 (16.7) I, 2 (33.3) II, 1 (16.7) III, 2 (33.3)
Lacy et al[31]	3, 136 (97.1) 2, 3 (2.1) 1, 1 (0.7)	2.8	22.0 (18–26)	131 (93.6)	15 (8–22)	0, 15 (10.7) I, 34 (24.3) II, 43 (30.7) III, 39 (27.9) IV, 9 (6.4)
Overall	3, 363 (80.8) 2, 34 (16.5) 1, 16 (3.5)	2.4	1.1	332 (98.0)	15.3	0, 20 (5.0) I, 71 (35.0) II, 69 (25.0) III, 72 (32.0) IV, 12 (3.0)

NS = not significant; CRM = circumferential resection margin.

TABLE 5. Perioperative morbidity and mortality

Reference	Conversion, n (%)	Anastomotic leak/stricture, n (%)	Wound complications, n (%)	Reoperation, n (%)	Perioperative blood loss volume, mL	Other surgical complication, n (%)	Nonsurgical complications, n (%)	Length of stay, median (IQR), d	Overall morbidity, n (%)	30-day operative mortality, n (%)
Dumont et al[17]	0	1 (25.0)	0	0	175	None	None	13.0 (10–21)	1 (25.0)	0
Atallah et al[18]	2 planned open	Leak, 1 (6.7) Stricture, 4 (26.7)	2 (10.0)	1 (5.0)	153	Abscess, 4 (20.0) Ileus, 4 (20.0) Perianastomotic fluid collections, 2 (10.0)	Pneumonia, 1 (5) Acute renal failure, 1 (5)	4.5 (3–24)	17 (85.0)	0
Zorron et al[19]	2 (22)	1 (11.0)	NS	1 (11.0)	96	NS	NS	7.6 (4–27)	4 (44.0)	0
Atallah et al[20]	0	0	0	0	200	High output stoma, 1 (33.0)	Pulmonary embolism, 1 (33.0)	4.3 (4–5)	2 (67.0)	0
Chouillard et al[21]	0	NS	NS	3 (18.8)	NS	Bowel obstruction, 2 (12.5) Pelvic collection, 1 (6.3)	0	10.4 (4–29)	3 (18.8)	0
Velthuis et al[22]	0	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gómez Ruiz et al[23]	0	1 (20.0)	0	0	90	0	0	6.0 (5–7)	1 (20.0)	0
Tuech et al[24]	3 (7.3)	3 (5.4)	NS	0	NS	Collection, 3 (5.4)	Urinary disorder, 5 (8.9) CVA, 1 (1.8)	10.0 (6–21)	14 (26.0)	0
Procházka et al[25]	0	2 (11.9)	1 (5.9)	1 (5.9)	200	Ileus, 2 (11.9)	Urinary retention, 1 (5.9)	9.0 (6–30)	8 (47.0)	0
Serra-Aracil et al[26]	0	3 (9.4)	3 (9.4)	2 (2.5)	158	0	Nosocomial infections, 3 (9.4)	8.0 (4–20)	10 (31.3)	0
Muratore et al[27]	0	2 (7.7)	0	0	NS	Bowel obstruction, 2 (7.7)	Myocardial infarction, 1 (3.8) Urinary retention, 1 (3.8) Inguinal lymphorrhea, 1 (3.8)	7.0 (3–25)	7 (26.9)	1 (3.8)
Knol et al[28]	0	0	NS	0	220	Gastroparesis and high-output ileostomy, 1 (10.0)	0	6.0 (5–9)	1 (10.0)	0
Veltcamp Helbach et al[29]	0	2 (2.5)	NS	9 (11.0)	NS	NS	NS	8.0 (3–41)	31 (38.8)	1 (1.3)
Elmore et al[30]	0	1 (16.7)	0	2 (33.3)	80	Bowel obstruction, 1 (16.7)	0	10.3 (7–19)	2 (33.3)	0
Lacy et al[31]	0	12 (8.6)	0	13 (9.3)	NS	Ileus, 11 (7.9) Obstruction, 1 (0.7) Collections, 4 (2.9) Bleeding, 5 (3.6) High-ileostomy output, 2 (1.4)	Urinary retention, 3 (2.1)	6.0 (5–9)	48 (34.3)	0
Overall	7 (1.6)	18 (7.3)	6 (8.2)	34 (7.5)	149	Abcess, 19.4 (6.8) Obstruction, 3 (1.9) Ileus, 21 (5.6) High-ileostomy output, 2 (1.1) Hemorrhage, 6 (1.3)	PE, 1 (0.6) ARF, 1 (0.6) MI, 1 (0.6) Nosocomial infection, 4 (2.4) Lymporrea,1 (0.6) Urinary retention, 12 (2.6)	7.3 (3–41)	161 (358.0)	2 (0.8)

NS = not significant; CVA = cerebrovascular accident; PE = pulmonary embolism; ARF = acute renal failure; MI = myocardial infarction; IQR, interquartile.

TABLE 6. Survival and functional outcomes

Reference	Median follow-up, mo	Adjuvant therapy, n (%)	Local recurrence, n (%)	Distant metastasis, n (%)	Functional outcomes
Dumont et al[17]	3	NS	NS	NS	3-mo follow-up Wexner score, 5
Atallah et al[18]	6	NS	NS	NS	NS
Zorron et al[19]	NS	NS	NS	NS	NS
Atallah et al[20]	3	NS	NS	NS	NS
Chouillard et al[21]	7	NS	NS	NS	NS
Velthuis et al[22]	NS	NS	NS	NS	NS
Gómez Ruiz et al[23]	3	NS	NS	NS	3-mo follow-up Wexner score, 5
Tuech et al[24]	29	NS	1 (1.7)	2 (3.5)	12-mo follow-up Wexner score, 5 (3–18)
Procházka et al[25]	NS	NS	NS	NS	NS
Serra-Aracil et al[26]	NS	NS	NS	NS	NS
Muratore et al[27]	23	NS	NS	2 (7.9)	NS
Knol et al[28]	NS	NS	NS	NS	NS
Veltcamp Helbach et al[29]	30	NS	2 (2.5)	NS	NS
Elmore et al[30]	6	NS	NS	NS	6-mo follow-up Wexner score, 3 (0–8)
Lacy et al[31]	15	NS	1	8 (5.5)	NS
Overall	14.7 (1–30), median (range)	NS	4 (2.5)	12 (7.9)	4.3 (mean)

NS = not significant.

The cost implications, both direct and indirect, also need to be factored in. Individual one-off devices are expensive, as is the initial outlay on apparatus for transanal endoscopic microsurgery. The additional time, particularly when a team is adopting this technique or using a simultaneous abdominal and anal approach with 2 teams, has latent resource implications for the unit and service provider. Furthermore, the mean overall length of stay is comparable to contemporary series for patients undergoing open/laparoscopic anterior resections within an enhanced recovery program, seemingly offsetting any hospital stay savings.[43]

This article has a number of limitations. The overall number of cases is small and represents series from experienced colorectal units skilled in laparoscopic colorectal resections, transanal transabdominal TAMIS, transanal endoscopic microsurgery, or robotics that are early adopters of the approach, constraining the generalizability of the data to the wider colorectal surgical community. It probably also includes learning curve cases. The heterogeneity of the included studies allied to the lack of long-term oncological and functional outcomes precluded formal meta-analysis.

There was no randomization or comparative group in any included study. Thus, selection and publication biases may be significant factors. Data for parameters of interest and complications are missing from a number of studies, further restraining analysis and hindering any formal meta-analysis. No formal cost analysis has been conducted in any series. Finally, long-term functional and survival outcomes are conspicuously absent.

CONCLUSION

TaTME potentially offers safe, minimally invasive rectal resections for rectal cancer with preserved and possibly superior histological outcomes from the limited data available when tailored to tumor characteristics and performed in specialized units. Contemporary randomized controlled studies are required before there can be a universal recommendation.

ACKNOWLEDGMENT

The authors acknowledge Trevor Grumbridge for his assistance with article translation.

REFERENCES

1. Glimelius B, Tiret E, Cervantes A, Arnold D. ESMO Guidelines Working Group. Rectal cancer: ESMO clinical practice guidelines for diagnosis, treatment and follow-up. *Ann Oncol*. 2013;24(suppl 6):vi81–vi88.
2. Monson JR, Weiser MR, Buie WD, et al.; Standards Practice Task Force of the American Society of Colon and Rectal Surgeons. Practice parameters for the management of rectal cancer (revised). *Dis Colon Rectum*. 2013;56:535–550.
3. Young M, Pigazzi A. Total mesorectal excision: open, laparoscopic or robotic. *Recent Results Cancer Res*. 2014;203:47–55.
4. Miskovic D, Foster J, Agha A, et al. Standardization of laparoscopic total mesorectal excision for rectal cancer: a structured international expert consensus. *Ann Surg*. 2015;261:716–722.

5. Sylla P, Rattner DW, Delgado S, Lacy AM. NOTES transanal rectal cancer resection using transanal endoscopic microsurgery and laparoscopic assistance. *Surg Endosc*. 2010;24:1205–1210.
6. Atallah S. Transanal total mesorectal excision: full steam ahead. *Tech Coloproctol*. 2015;19:57–61.
7. Martin-Perez B, Andrade-Ribeiro GD, Hunter L, Atallah S. A systematic review of transanal minimally invasive surgery (TAMIS) from 2010 to 2013. *Tech Coloproctol*. 2014;18:775–788.
8. Marks JH, Frenkel JL, D'Andrea AP, Greenleaf CE. Maximizing rectal cancer results: TEM and TATA techniques to expand sphincter preservation. *Surg Oncol Clin N Am*. 2011;20:501–520, viii.
9. Althumairi AA, Gearhart SL. Local excision for early rectal cancer: transanal endoscopic microsurgery and beyond. *J Gastrointest Oncol*. 2015;6:296–306.
10. Heald RJ, Karanjia ND. Results of radical surgery for rectal cancer. *World J Surg*. 1992;16:848–857.
11. Emhoff IA, Lee GC, Sylla P. Transanal colorectal resection using natural orifice translumenal endoscopic surgery (NOTES). *Dig Endosc*. 2014;26(suppl 1):29–42.
12. Araujo SE, Crawshaw B, Mendes CR, Delaney CP. Transanal total mesorectal excision: a systematic review of the experimental and clinical evidence. *Tech Coloproctol*. 2015;19:69–82.
13. National Institutes of Health. ClinicalTrials.gov. https://clinicaltrials.gov. Accessed July 20, 2015.
14. Moher D, Shamseer L, Clarke M, et al.; PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. 2015;4:1.
15. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol*. 2010;25:603–605.
16. Martin ST, Heneghan HM, Winter DC. Systematic review of outcomes after intersphincteric resection for low rectal cancer. *Br J Surg*. 2012;99:603–612.
17. Dumont F, Goéré D, Honoré C, Elias D. Transanal endoscopic total mesorectal excision combined with single-port laparoscopy. *Dis Colon Rectum*. 2012;55:996–1001.
18. Atallah S, Martin-Perez B, Albert M, et al. Transanal minimally invasive surgery for total mesorectal excision (TAMIS-TME): results and experience with the first 20 patients undergoing curative-intent rectal cancer surgery at a single institution. *Tech Coloproctol*. 2014;18:473–480.
19. Zorron R, Phillips HN, Wynn G, Neto MP, Coelho D, Vassallo RC. "Down-to-Up" transanal NOTES total mesorectal excision for rectal cancer: preliminary series of 9 patients. *J Minim Access Surg*. 2014;10:144–150.
20. Atallah S, Martin-Perez B, Pinan J, et al. Robotic transanal total mesorectal excision: a pilot study. *Tech Coloproctol*. 2014;18:1047–1053.
21. Chouillard E, Chahine E, Khoury G, et al. NOTES total mesorectal excision (TME) for patients with rectal neoplasia: a preliminary experience. *Surg Endosc*. 2014;28:3150–3157.
22. Velthuis S, Nieuwenhuis DH, Ruijter TE, Cuesta MA, Bonjer HJ, Sietses C. Transanal versus traditional laparoscopic total mesorectal excision for rectal carcinoma. *Surg Endosc*. 2014;28:3494–3499.
23. Gómez Ruiz M, Parra IM, Palazuelos CM, et al. Robotic-assisted laparoscopic transanal total mesorectal excision for rectal cancer: a prospective pilot study. *Dis Colon Rectum*. 2015;58:145–153.
24. Tuech JJ, Karoui M, Lelong B, et al. A step toward NOTES total mesorectal excision for rectal cancer: endoscopic transanal proctectomy. *Ann Surg*. 2015;261:228–233.
25. Procházka V, Kala Z, Škrovina M, Grolich T, Klos K. Transanal total mesorectal excision for low rectal cancer: first results [in Czech]. *Rozhl Chir*. 2015;94:64–68.
26. Serra-Aracil X, Mora-López L, Casalots A, Pericay C, Guerrero R, Navarro-Soto S. Hybrid NOTES: TEO for transanal total mesorectal excision: intracorporeal resection and anastomosis. *Surg Endosc*. In press.
27. Muratore A, Mellano A, Marsanic P, De Simone M. Transanal total mesorectal excision (taTME) for cancer located in the lower rectum: short- and mid-term results. *Eur J Surg Oncol*. 2015;41:478–483.
28. Knol JJ, D'Hondt M, Souverijns G, Heald B, Vangertruyden G. Transanal endoscopic total mesorectal excision: technical aspects of approaching the mesorectal plane from below–a preliminary report. *Tech Coloproctol*. 2015;19:221–229.
29. Veltcamp Helbach M, Deijen CL, Velthuis S, Bonjer HJ, Tuynman JB, Sietses C. Transanal total mesorectal excision for rectal carcinoma: short-term outcomes and experience after 80 cases. *Surg Endosc*. In press.
30. Elmore U, Fumagalli Romario U, Vignali A, Sosa MF, Angiolini MR, Rosati R. Laparoscopic anterior resection with transanal total mesorectal excision for rectal cancer: preliminary experience and impact on postoperative bowel function. *J Laparoendosc Adv Surg Tech A*. 2015;25:364–369.
31. Lacy AM, Tasende MM, Delgado S, et al. Transanal total mesorectal excision for rectal cancer: outcomes after 140 patients. *J Am Coll Surg*. 2015;221:415–423.
32. Quirke P, Steele R, Monson J, et al.; MRC CR07/NCIC-CTG CO16 Trial Investigators; NCRI Colorectal Cancer Study Group. Effect of the plane of surgery achieved on local recurrence in patients with operable rectal cancer: a prospective study using data from the MRC CR07 and NCIC-CTG CO16 randomised clinical trial. *Lancet*. 2009;373:821–828.
33. Jeong SY, Park JW, Nam BH, et al. Open versus laparoscopic surgery for mid-rectal or low-rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): survival outcomes of an open-label, non-inferiority, randomised controlled trial. *Lancet Oncol*. 2014;15:767–774.
34. Stevenson AR, Solomon MJ, Lumley JW, et al.; ALaCaRT Investigators. Effect of laparoscopic-assisted resection vs open resection on pathological outcomes in rectal cancer: the ALaCaRT randomized clinical trial. *JAMA*. 2015;314:1356–1363.
35. Fleshman J, Branda M, Sargent DJ, et al. Effect of laparoscopic-assisted resection vs open resection of stage II or III rectal cancer on pathologic outcomes: the ACOSOG Z6051 randomized clinical trial. *JAMA*. 2015;314:1346–1355.
36. Nussbaum DP, Speicher PJ, Ganapathi AM, et al. Laparoscopic versus open low anterior resection for rectal cancer: results from the national cancer data base. *J Gastrointest Surg*. 2015;19:124–131.
37. Gietelink L, Henneman D, van Leersum NJ, et al. Dutch Surgical Colorectal Cancer Audit Group. The influence of hospital volume on circumferential resection margin involvement: results of the Dutch Surgical Colorectal Audit. *Ann Surg*. In press.
38. Zhou X, Sun T, Xie H, Zhang Y, Zeng H, Fu W. Extralevator abdominoperineal excision for low rectal cancer: a systematic review and meta-analysis of the short-term outcome. *Colorectal Dis*. 2015;17:474–481.

39. Prytz M, Angenete E, Bock D, Haglind E. Extralevator abdominoperineal excision for low rectal cancer-extensive surgery to be used with discretion based on 3-year local recurrence results: a registry-based, observational national cohort study. *Ann Surg*. In press.
40. National Institute for Health and Care Excellence. Transanal total mesorectal excision of the rectum. https://www.nice.org.uk/guidance/ipg514. Accessed July 20, 2015.
41. http://www.lorec.nhs.uk/system/content.asp. Accessed July 20, 2015.
42. Maslekar S, Sharma A, Macdonald A, Gunn J, Monson JR, Hartley JE. Mesorectal grades predict recurrences after curative resection for rectal cancer. *Dis Colon Rectum*. 2007;50:168–175.
43. Khreiss W, Huebner M, Cima RR, et al. Improving conventional recovery with enhanced recovery in minimally invasive surgery for rectal cancer. *Dis Colon Rectum*. 2014;57:557–563.