Transanal total mesorectal excision – a systematic review

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ABSTRACT

INTRODUCTION: Total mesorectal excision (TME) is the standard surgical treatment for mid and low rectal cancer. The procedure is performed by open, laparoscopic or robotic approaches. Transanal TME (TaTME) is a new procedure that potentially solves some difficulties in the pelvic part of the dissection. We aimed to evaluate the literature on TaTME.

METHODS: We performed a systematic search of the literature in the PubMed and Embase databases. Both authors assessed the studies. All publications on TaTME were included with the exception of review articles.

RESULTS: A total of 29 studies (336 patients) were included. Only low-quality evidence is available, and the literature consists of case reports and case series. Studies represent the initial experience of surgeons/centres. No precise indication for TaTME is yet specified other than the presence of mid and low rectal tumours, although the potential advantages seem to be related to a bulky mesorectum in the male pelvis. The preliminary results are encouraging and the most serious complication is urethral injury. The oncological results are acceptable, although the follow-up is short.

CONCLUSION: TaTME is a feasible approach for mid and low rectal cancers. Long-term follow-up data are awaited regarding functional results, local recurrence and survival, and to facilitate comparison with standard laparoscopic or robotic rectal resections.

Rectal cancer surgery has undergone major advances in the past century. Miles described abdominoperineal excision [1]. Heald introduced total mesorectal excision (TME), which has improved the oncological results [2]. While open TME is associated with significant morbidity and impairment of urogenital function [3], laparoscopy has improved the short-term results and with equivalent oncological outcomes [4]. Laparoscopic TME is, however, challenging in the lowest part of the rectum [5, 6]. An abdominal incision may therefore be needed to facilitate transection, and in some cases conversion to open procedure is required. The rate of conversion from a laparoscopic to open TME remains significant, 12.9% [7]. Robotic surgery has been shown to decrease rates of conversion, but are more expensive [8]. Surgical site infections are still common after laparoscopy, mostly at the specimen extraction sites [9].

Transanal TME (TaTME) potentially overcomes these difficulties [10]. It involves a "bottom-up" dissection of the lowermost part of the mesorectum. The procedure may solve "some old problems" [11]. It is presently done mostly with abdominal assistance. Various nomenclatures are used in the literature such as transanal TME (TaTME), transanal minimally invasive TME (TAMIS-TME), perirectal natural orifice transluminal endoscopic surgery (NOTES) access, natural orifice TME, transanal endoscopic TME, endoscopic transanal proctectomy (ETAP), transanal transabdominal resection (TATAR), and transanal endoscopic proctectomy (TAEP) etc. [10, 12-14]. This systematic review analysed current literature on this topic.

METHODS

We performed a systematic search in the PubMed and Embase databases on 9 March 2015 using the following words separately and in combination: "transanal", "TAMIS", "TME", "NOTES", "natural orifice", "total mesorectal excision", "ETAP" and "rectal excision". The following MeSH terms were combined: "Natural Orifice Endoscopic Surgery" and "Rectum/surgery". The search and the review processes were undertaken by the two authors and followed the PRISMA guidelines [15]. The search was restricted to English articles published during the past six years. The search yielded 76 articles. After crosschecking the reference lists, another 54 articles were retrieved. When duplicates were removed, 91 articles remained. The abstracts were assessed and 36 full-text articles were retrieved and reviewed systematically for eligibility. The inclusion criteria were studies on rectal resection in which the mesorectal excision involved transanal dissection – solely or in addition to abdominal dissection. Due to the scarcity of the literature, single case reports were also included. Review articles, cadaver and porcine studies were excluded, as were studies on local resection of polyps or cancers along with studies in which the transanal part of the operation involved only specimen extraction. We included 29 studies counting a total of 336 patients (**Figure 1**).

RESULTS

The included studies comprise six single case reports [16-21], and 23 case series [12-14, 22-41]. One of the

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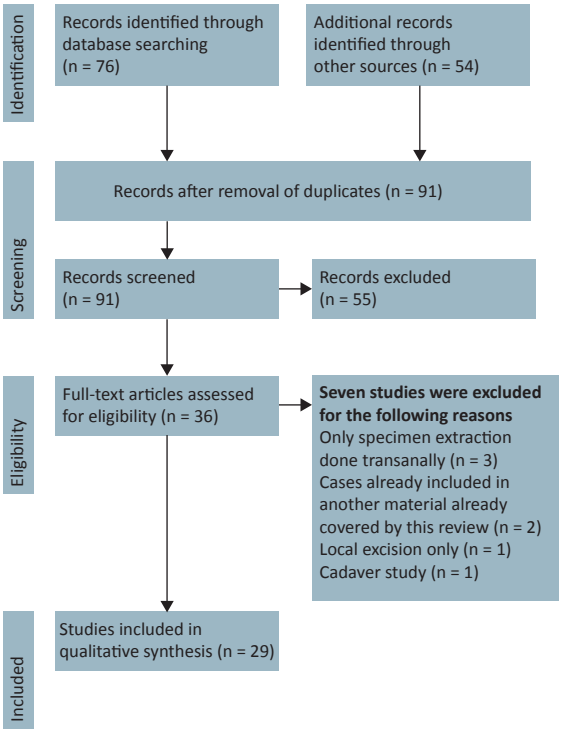
FIGURE 1

Flow diagram of article selection.



case series was a prospective study [14], and two [40, 41] included a comparative group. The search profile is presented in Figure 1. The extracted data are presented systematically in **Table 1**, **Table 2** and **Table 3**.

Indications

With few exceptions, body mass index (BMI) was normal and the patients were both men and women, aged 36-87 years. However, the largest patient series reviewed included obese patients [26, 28, 31, 34, 40, 41]. Tuech et al [14] included 11 patients (19.6%) with a BMI above 30 kg/m². The pathology was adenocarcinoma in most studies, although Wolthuis et al [18] reported a patient with a supralevator abscess, and Leroy et al [19] reported their pure transanal procedure on a patient with adenoma. Wolthuis et al [32] included nine patients with benign lesions. Tumours were mostly located in the lower two thirds of the rectum. The seven largest series in this review [13, 14, 26, 29, 31, 40, 41] included low and mid-rectal tumours. Some authors [13, 39] also included high-rectal tumours. Tuech et al [14] only included tumours located at or below 5 cm from the anal verge. Rouanet et al [26] specifically selected patients with advanced or recurrent rectal cancer in patients with a narrow pelvis, bulky mesorectum, high BMI, large prostate, fibrosis or advanced anterior tumours. They occasionally changed to TaTME intraoperatively. Verheijen et al [21] operated a non-obese, female patient with a wide pelvis and no co-morbidities. A clear selection bias related to the study cohort is reported in five studies [13, 26, 29, 34, 40].

Operative details

TaTME was performed either as a "pure" transanal procedure or more commonly as a "hybrid" procedure with laparoscopic or robotic assistance. Three "platforms" were used. The first platform involved device-facilitated exposure and maintained intraabdominal pressure without the need to insufflate from below or even without any device inserted. An example is the Lap disc mini (HAKKO Group, Tokyo, Japan) used by Funahashi et al [22], were dissection was performed from below under direct vision, and pressure was maintained during laparoscopy. Zorron et al [12] and [28] used a colonoscope for the transanal dissection (**Figure 2**) and did not use devices to maintain pressure. The second platform involved rigid instruments like the TEO proctoscope used in transanal endoscopic microsurgery (TEM) (Karl Storz, Tuttlingen, Germany) which was employed in five studies [16, 19, 26, 30, 33]. The third and most recent platform takes advantage of single-port laparoscopic surgery. Various manufacturers' products were used; GelPoint (Applied Medical, Inc., Rancho Santa Margarita, CA, USA) [13, 21, 24, 25, 31, 32, 34-37, 39, 40], SILS port (Covidien, Inc., Stafford, Texas, USA) [18, 20, 23, 27, 41], Trocar (Aspide, 42 350 La Talaudére, France) [14, 17], and even a "home-made" single-port device [29]. Flexible devices seem to have gained more popularity in the more recent publications, but surgeon preferences and previous experiences play an important role. Four studies used a robot for the transanal part [21, 35-37].

The carbon dioxide pressure needed for pneumo-perirectum ranged from 8 to 15 mmHg [13, 25, 30]. The sequence of procedures was not standardised, starting from above or below according to author's preference. Some authors preferred a simultaneous dissection (push me-pull you principle), which has the advantage of being efficient and quick [13, 25, 30, 33, 40]. Most authors performed the transanal part at the beginning, and then switched to the abdominal part [12, 14, 16-18, 22-24, 26-28, 32, 34], while others started with the abdominal part first [21, 29, 31, 35-37, 39]. This choice appears to be surgeon-dependent. Velthuis et al [41] changed from a transanal start to transabdominal start due to the development of pneumo-perirectum, which disturbed the subsequent transabdominal approach. Two single case reports in this review described a "pure" TaTME [19, 20]. Chouillard et al [34] performed ten "pure" TaTMEs without any abdominal assistance. Some authors used a single-port device at the future protecting ileostomy site

TABLE 1

Patient characteristics.

Reference	Patients, n	Age, yrs	Gender, F:M, n	BMI, kg/m²	Pathology: n	Tumour distance from anal verge, cm: n	Preoperative TNM classification: n	Neoadjuvant therapy, yes/no: n
Funahashi et al, 2009 [22]	6	62.8[a]	2:4	29.8[a]	Adenocarcinoma	2.4[a]	T3N1M0: 1 T3N0M0: 5	No
Sylla et al, 2010 [16]	1	76	1:0	20	Adenocarcinoma	6.0	T2N2M0	Yes
Gaujoux et al, 2011 [23]	2	59, 61	1:0	None-obese	–	0.2, 0.1[b]	–	Yes
Tuech et al, 2011 [17]	1	45	1:0	20	Adenocarcinoma	31[b]	T1	–
Zorron et al, 2012 [12]	2	54, 74	1:1	-	Adenocarcinoma	8.0, 6.0	–: 1 T3N0M0: 1	No
Wolthuis et al, 2012 [18]	1	51	1:0	-	Supralevator abscess with fistula	–	–	–
Dumont et al, 2012 [24]	4	65.51[a]	0:4	23.25[a]	Adenocarcinoma	5.0[a]	T3N0: 3 T3N1: 1	Yes
Lacy et al, 2013 [25]	3	73[a]	2:1	23.5[a]	Adenocarcinoma	10.0[a]	T2N0: 1 T3N0: 2	Yes: 2 No: 1
Zhang et al, 2013 [20]	1	48	1:0	20	Adenocarcinoma	8.0	T3N1	No
Rouanet et al, 2013 [26]	30	65[a]	0:30	26[a]	Adenocarcinoma	< 5: 20 5-10: 10	pT1sm3: 1[c] T2:1 T3:21 T4:7	Yes: 29 No: 1
Velthuis et al, 2013 [27]	5	69[a]	2:3	–	Adenocarcinoma	5.0[a]	T2N0:1 T3N0:3 T3N2:1	Yes
Zorron et al, 2014 [28]	9[d]	62.6[a]	4:5	42[e]	Adenocarcinoma	7.56	T3-T4	Yes: 4 No: 5
Choi et al, 2013 [29]	22	67.5[a]	12:10	21.9[a]	Adenocarcinoma	6.0[a]	T1: 1 T2: 2 T3: 19 N0: 10 N1: 12	Yes: 3 No: 19
de Lacy et al, 2013 [13]	20	65[a]	9:11	25.7[a]	Adenocarcinoma or high-grade dysplasia in polyps	6.5	–	Yes: 14 No: 6
Sylla et al, 2013 [30]	5	48.6[a]	2:3	25.7[a]	Adenocarcinoma: 3 Intra-mucosal carcinoma: 1 Adenocarcinoma + tubulovillous adenoma: 1	5.7[a]	T1N0M0: 2 T2N0M0: 1 T3N0M0: 2	Yes: 2 No: 3
Atallah et al, 2014 [31]	20	57[a]	6:14	24[a]	Adenocarcinoma	5.0[a]	–	Yes: 12 No: 8
Leroy et al, 2013 [19]	1	54	1:0	–	Tubulovillous adenoma	Middle 3rd of rectum	T2	No
Wolthuis et al, 2014 [32]	14	65[a]	9:5	25[a]	Adenocarcinoma: 5 Benign: 9	–	T1N0: 2 T1N1: 1 T3N0: 1 –: 1 Benign: 9	No
Meng & Lau, 2014 [33]	3	80[a]	1:2	–	Adenocarcinoma	4.3[b]	TisN0: 1 T3N0: 1 T3N2: 1	Yes: 1 No: 1 –: 1
Chouillard et al, 2014 [34]	16	57.7[a]	10:6	27.9	Adenocarcinoma	0-12[b]	TyN0: 1 T1N0: 3 T2N0: 3 T2N1: 1 T3N0: 3 T3N1: 3 T3N2: 1 T4N0: 1	–
Tuech et al, 2015 [14]	56	65[a]	15:41	27	Adenocarcinoma	4	T1: 3 T2: 7 T3: 44 T4: 2	Yes: 47
Velthuis et al, 2014 [41]	25	64[a]	7:18	25[a]	Adenocarcinoma	8	T1: 1 T2: 11 T3: 13	Yes: 13
Atallah et al, 2014 [35]	3	45[a]	1:2	32	Adenocarcinoma: 2 Adenoma: 1	4	T1NX: 1 T4N1: 1 T4N2: 1	Yes: 2 No: 1
Verheijen et al, 2014 [21]	1	48	1:0	23.6	Adenocarcinoma	8	T3NX	Yes
Ruiz et al, 2015 [36]	5	57[a]	1:4	25.8	Adenocarcinoma: 3 No tumour: 1 Dysplasia: 1	5	T2N0: 1 T2N1: 4	Yes: 4 No: 1
Huscher et al, 2015 [37]	7	63.2[a]	4:3	29.9	–	2	T2: 5	No
Muratore et al, 2015 [38]	26	65.8[a]	10:16	26.2	Adenocarcinoma	4.4	T1: 2 T2: 6 T3: 18	Yes: 19 No: 7
Knol et al, 2015 [39]	10	60.5[a]	2:8	26.5[a]	–	28.9[f]	T2N1: 2 T2N2: 1 T3N0: 1 T3N1: 3 T3N2: 3	Yes
Fernandez-Hevia et al, 2015 [40]	37	64.5[a]	13:24	37.7	Adenocarcinoma	3.5/8.1[g]	T2: 8 T3: 26 T4: 2	Yes: 27 No: 9 Only radiotherapy: 1

F = female; M = male; TNM = tumour-node-metastasis.

a) Median; b) From dentate line; c) After transanal endoscopic microsurgery; d) Natural orifice transluminal endoscopic surgery: 7; e) Only recorded for 1 patient; f) From ano-rectal junction; g) For tumours in low and middle rectum respectively.

TABLE 2

Operative details.

Reference	Transanal platform	Pneumoretroperi-toneum, mmHg	Sequence of procedures	Splenic flexur mobilisation, yes/no: n	Protecting stoma, yes/no
Funahashi et al, 2009 [22]	Lap disc mini (HAKKO Group, Tokyo, Japan)	–	Transanal/abdominal	No	Yes
Sylla et al, 2010 [16]	TEO proctoscope	9	Transanal/abdominal	No	Yes
Gaujoux et al, 2011 [23]	SPA-device/SILS port and GelPoint	–	Transanal/abdominal	Yes	Yes
Tuech et al, 2011 [17]	Endorec trocar	10	Transanal/abdominal	Yes	Yes
Zorron et al, 2012 [12]	Colonoscope, single port device	15 10	Transanal/abdominal	Yes	Yes (1 proximal colostomy)
Wolthuis et al, 2012 [18]	SSL port	15	Transanal/abdominal	No	Yes
Dumont et al, 2012 [24]	GelPoint	12	Transanal/abdominal	Yes	Yes
Lacy et al, 2013 [25]	GelPoint	9	Simultaneous	Yes: 2 No: 1	Yes: 2 No: 1
Zhang et al, 2013 [20]	PPH anoscope	10	Pure transanal	No	No
Rouanet et al, 2013 [26]	TEO proctoscope	10	Transanal/abdominal	Yes	Yes
Velthuis et al, 2013 [27]	SILS port	15	Transanal/abdominal	No	Yes
Zorron et al, 2014 [28]	Triport, colonoscope	8-10	Transanal/abdominal	Yes	Yes
Choi et al, 2013 [29]	”Home-made”	–	Abdominal/ Transanal/abdominal	Yes	Yes: 12 No: 10
de Lacy et al, 2013 [13]	GelPoint	9	Simultaneous	Yes: 6 No: 14	Yes: 16 No: 4
Sylla et al, 2013 [30]	TEO proctoscope	9-12	Simultaneous	Yes	Yes
Atallah et al, 2014 [31]	GelPoint, SILS port	–	Abdominal/transanal	Yes	Yes: 14
Leroy et al, 2013 [19]	TEO proctoscope	–	Pure transanal	No	No
Wolthuis et al, 2014 [32]	GelPoint	10	Transanal/abdominal in 11/14	Yes	Yes: 3 No: 9
Meng & Lau, 2014 [33]	TEO proctoscope	–	Simultaneous	Yes	No
Chouillard et al, 2014 [34]	GelPoint, SILS port	–	Pure transanal: 10 transanal/ Abdominal: 6	Yes	Yes: 4
Tuech et al, 2015 [14]	GelPoint, trocar, SILS port	10	Transanalabdominal	–	Yes
Velthuis et al, 2014 [41]	SILS port (Covidien)	14	Transanal/transabdominal: 5 Transabdominal/transanal: 25	Yes	Yes
Atallah et al, 2014 [35]	GelPoint	15	Abdominal/transanal[b]	Yes	Yes
Verheijen et al, 2014 [21]	GelPoint	–	Abdominal/transanal[b]	Yes	Yes
Ruiz et al, 2015 [36]	GelPoint + transanal access proctoscope	–	Abdominal/transanal[b]	Yes	Yes
Huscher et al, 2015 [37]	GelPoint	–	Abdominal/transanal[b]	Yes	Yes
Muratore et al, 2015 [38]	SILS	10-12	Transanal/abdominal	Yes	Yes
Knol et al, 2015 [39]	GelPoint	8-12	Abdominal/transanal	Yes: 8 No: 2	Yes
Fernandez-Hevia et al, 2015 [40]	GelPoint	10-12	Simultaneous	Yes: 14 No: 13	Yes: 32 No: 5

a) Median; b) Robotic transanal part performed with DaVinci.

[14, 17, 27, 29, 34], while others used multiple (2-5) laparoscopic trocars [12, 13, 16, 18, 22-25, 28, 30, 32, 33]. Specimen extraction was done either transanally [12-14, 16, 17, 19-21, 23, 25-28, 30, 36-39, 41, 42] or through an abdominal incision [24, 26, 33, 35, 38-40], either through the stoma site or using a Pfannenstiel incision. The extraction site was generally dependent on the size of mesorectum and the tumour. Most used sealing devices, like Harmonic scalpel (Ethicon Endo-surgery) [14, 16, 22, 26, 30] or Ligasure (Covidien) [27]. However, some used bipolar or monopolar Hook [20, 25, 31].

The mean total operating time ranged from 143 min. [25] to 400 min. [33]. Few authors have reported the specific time spent for the transanal part; the short-

TABLE 2, CONTINUED

Operative details.

Anastomosis, yes/no	Instrument for transanal dissection	Drain, yes/no: n	Operation time: transanal/total, min.	Intraoperative complications: n
Yes	Harmonic scalpel	No	64/–	None
Yes	Harmonic scalpel	Yes	–/270	Small tear of the anterior rectal wall
Yes	–	Yes	–/195 –/210	None
Yes	–	Yes	-/300	None
Yes	Endoscopic monopolar scissors, laparoscopic hook	Yes	–/350 –/360	None
Yes	Laparoscopic instruments, not specified	No	50/122	None
Yes	Bipolar-scissor grasper	Yes	–/360	None
Yes	Monopolar hook and bipolar dissecting instrument	Yes	–/143	None
Yes	Electrocautery, Harmonic scalpel	Yes	–/300	None
Yes	Harmonic scalpel	No	–/304	Conversion to open surgery: 2 Urethral injury: 2 Air embolism: 1
Yes	Ligasure device	Yes: 1	–/175[a]	Pneumatosis of the retroperitoneum and mesentry : 1
Yes	Ultrasonic shears, monopolar hook	Yes	–/311	Conversion to open surgery: 1 Conversion to laparoscopy: 1
Yes	–	Yes	–/260	None
Yes	–	Yes	–/234.7	None
Yes	Monopolar cautery, harmonic scalpel	Yes	–/274.6	None
Yes: 15	Electrocautery	No	–/243	None
Yes	–	No	–/190	None
Yes: 7 n: 7	Conventional laparoscopic instruments	–	55/138.5[a]	Conversion: 2 Perforation: 1
Yes	Ultrasonic dissector	Yes: 1 –: 2	–/400, –/– –/330	Surgical emphysema: 1
Yes: 14	–	No	–/265	Conversion to laparoscopy: 1
Yes	Harmonic scalpel	Yes	100/270	None
Yes	Ligasure (Covidien)	–	–	–
Yes	Monopolar hook cautery	–	–/376	–
Yes	Monopolar hook cautery	–	65/205	None
Yes	Monopolar curved scissor	Yes	123/398	None
Yes	Monopolar hook cautery	Yes	55.5/165.7	–
Yes	–	–	–/241	–
Yes	Electrocautery	Yes	–/–	None
Yes	Electrocautery	Yes	–/215	None

a) Median; b) Robotic transanal part performed with DaVinci.

est was 50 min. [18] and the longest 123 min. [36]. Laparoscopic assistance reduced the operating time [13], whereas "pure" transanal [14] and robotic approaches [36] augmented it.

Intraoperative complications were reported in seven studies and included: conversion to laparoscopic or open surgery (seven patients) [12, 26, 32, 34], pneumatosis of the small bowel mesentry (one patient) [27], intraoperative bowel perforation [32]. Rouanet et al [26] had two episodes of urethral injury during transanal dissection, and one patient developed air embolism. Most authors agreed that lateral dissection is the most challenging part due to the risk of damaging the neurovascular bundle and the ureters. Conversion to either lapar-

TABLE 3

Post-operative outcomes.

Reference	Hospital stay, days	Post-operative complications	Sphincter function assessment, yes/no	pTNM: n	Retrieved lymph nodes, n	Specimen quality	Circum-ferential resection margin
Funahashi et al, 2009 [22]	–	None	No	T2N0M0: 1 T3N1M0: 2 T3N0M0: 3	–	–	Clear
Sylla et al, 2010 [16]	4	None	No	T1N0	23	Complete	Clear
Gaujoux et al, 2011 [23]	5, 6	None	No	–	12, 16	Complete	Clear
Tuech et al, 2011 [17]	–	–	No	T1sm3N0	15	Complete	–
Zorron et al, 2012 [12]	6[a]	Transitory paraesthesia of both feet: 1	No	T3N1M0: 2	12, 11	Complete	Clear
Wolthuis et al, 2012 [18]	7	None	No	–	–	–	–
Dumont et al, 2012 [24]	13[a]	Anastomotic fistula: 1[b]	Yes	T3N0: 3 T3N1: 1	16[a]	Complete	Clear
Lacy et al, 2013 [25]	5[a]	Severe dehydration + re-admission: 1	No	T1N0: 1 T3N0: 2	–	Complete	Clear
Zhang et al, 2013 [20]	–	Anal incontinence until day 4	No	T3N1M0	12	Complete	Clear
Rouanet et al, 2013 [26]	14[a]	Sepsis: 2 Septic shock: 2 Peritonitis: 1 Bowel obstruction: 1 Fistula: 1	Yes	T1sm3: 1 T2: 1 T3: 21 T4: 7	13[a]	Complete	Clear: 26
Velthuis et al, 2013 [27]	–	Pneumatosis, pneumonia and ileus: 1 Presacral abscess: 1[c]	No	T0N0: 1 T2N0: 2 T3N0: 1 T3N1: 1	12[a]	Complete	Clear
Zorron et al, 2014 [28]	7.6[a]	Anastomotic leakage: 1 Anastomotic leakage: 1[d]	No	T2N0: 3 T3N0: 2 T3N1: 3 T4N1: 1	13	Complete: 7 Incomplete: 2	Clear: 8
Choi et al, 2013 [29]	6[a]	Pancreatitis: 1 Urinary retention: 2 Small bowel obstruction: 1 Anastomotic leakage: 1[d]	No	T1: 1 T2: 2 T3: 19 N0: 10 N1: 12	22[a]	Complete	Clear
de Lacy et al, 2013 [13]	6.5[a]	Urinary retention: 2 Ileus: 1 Severe dehydration:1	No	–	15,9	Complete	Clear
Sylla et al, 2013 [30]	5.2[a]	Ileus: 1 Transient urinary dysfunction: 2	No	T0N0: 1 T1N0: 1 T2N0: 2 T2N1: 1	33[a]	–	Clear
Atallah et al, 2014 [31]	4.5[a]	Wound infection: 2 Pelvic abscess: 4 Prolonged ileus: 4 Anastomotic leakage: 1 Pneumonia: 1 Renal failure: 1 Peri-anastomotic fluid collection: 2	Yes	–	22.5[a]	Complete or near-complete: 17 Incomplete: 2 – : 1	Clear: 18
Leroy et al, 2013 [19]	–	Pelvic haematoma with *E. coli*: 1	No	T2 (benign)	16	Complete	–
Wolthuis et al, 2014 [32]	8.5[a]	Fever: 2 Urinary tract infection: 3 Pelvic haematoma: 1	No	T1N0: 2 T1N1: 1 T3N0: 1 –: 1 Benign: 9	–	–	–

oscopy or laparotomy occurred in seven patients in the included studies [18, 26, 28, 42].

Immediate post-operative outcomes

Rouanet et al [26] reported a median hospital stay of 14 days (range: 9-25 days) and a post-operative morbidity of 30%, which included peritonitis due to bowel perforation (one patient), sepsis (one patient), urinary disorders (two patients) and anaemia requiring blood transfusion (six patients). Tuech et al [14] reported a

TABLE 3, CONTINUED

Post-operative outcomes.

Reference	Hospital stay, days	Post-operative complications	Sphincter function assessment, yes/no	pTNM: n	Retrieved lymph nodes, n	Specimen quality	Circum-ferential resection margin
Meng & Lau, 2014 [33]	8 –: 5	None	No	TisN0M0 T3N0M0 T3N2M0	–	–	Clear
Chouillard et al, 2014 [34]	10[a]	Small bowel obstruction: 2 Pelvic abscess: 1	No	TyN0: 1 T1N0: 3 T2N0: 3 T2N1: 1 T3N0: 3 T3N1: 3 T3N2: 1 T4N0: 1	17[a]	–	Clear
Tuech et al, 2015 [14]	10[a]	Anastomotic leakage: 3[e] Pelvic sepsis: 3 Urinary disorders: 5 Anaemia: 2 Cerebral infarction: 1	Yes	Complete remission: 11 T1: 7 T2: 16 T3: 21 T4: 1	12[a]	Complete: 47 Nearly complete: 9	Clear: 53 Not clear: 3[f]
Velthuis et al, 2014 [41]	–	–	No	–	14	Complete: 24 Near-complete: 1	Clear: 2 Involved: 1
Atallah et al, 2014 [35]	3[a]	Pulmonary embolism: 1 Stoma dermatitis: 1 Dehydration: 1	No	T1N0: 1 T2N0: 1 T2N1: 1	30	Complete: 1 Near-complete: 2	Clear
Verheijen et al, 2014 [21]	3	None	No	T0N0	–	Complete	Clear
Ruiz et al, 2015 [36]	6[a]	Anastomotic leakage: 1[g]	Yes: 1	No tumour: 1 Dysplasia: 1 TisN0: 1 T2N0: 1 T3N1: 1	14	Complete	Clear
Huscher et al, 2015 [37]	4.8[a]	Tranfusion requiring rectal haemorrhage: 1	No	T1N0: 2 T2N0: 2 T3N0: 2 T3N1: 1	14	Complete: 6 Near-complete: 1	Clear
Muratore et al, 2015 [38]	7[a]	Myocardial infarction: 1 Anastomotic leakage: 2[h] Intestinal occlusion: 2 Inguinal lymphorrhoea: 1 Acute urinary retention: 1	No	T0: 5 T1: 7 T2: 6 T3: 8	10	Complete: 23 Near-complete: 3	Clear
Knol et al, 2015 [39]	6.4[a]	Gastroparesis with high-output ileostomy: 1	No	T1N0: 2 T2N0: 3 T2N1: 1 T3N0: 3 T3N2: 1	10.4[a]	Complete: 9 Near-complete: 1	Clear
Fernandez-Hevia et al, 2015 [40]	6.8[a]	Anastomotic leakage: 2[g] Collection: 1 Haemorrhage: 1 Acute urinary retention: 1 Ileus: 4 Others: 3 Second look surgery: 3	No	T1: 3 T2: 7 T3: 22 T4: 1	14.3	Complete: 34 Near-complete: 2 Incomplete: 1[i]	Clear

pTNM = pathological tumour-node-metastasis (staging system).
a) Median; b) Treated with antibiotics and transanal abscess drainage; c) Without anastomotic leakage; d) Underwent re-operation; e) Not re-operated; f) Of which 1 local recurrence at 24-month follow-up; g) Treated with antibiotics; h) No clinical symptoms, no comments on treatment; i) Patient previously underwent total colectomy.

median hospital stay of ten days (range: 6-21 days); and post-operative complications in this study included: anastomotic leakage (three patients, treated conservatively), pelvic sepsis (three patients), urinary disorders (five patients), anaemia requiring blood transfusion (two patients) and cerebral infarction (one patient). Some authors reported bowel obstruction [13, 27, 29, 30, 34, 40].

Bowel transection during TaTME can contribute to septic complications [43]. The majority of authors re-

FIGURE 2

Transanal dissection.

ported closure of the rectum (and irrigation with aseptic solution) prior to dissection. However, Rouanet et al [26] did not close the rectal lumen in 11 out of the 30 patients in their study. They had two septic complications. Atallah et al [31] closed the rectal lumen in all patients and had four septic complications among 20 patients. One patient in this study developed anastomotic leakage, which was treated operatively. Chouillard et al [34] had one patient with pelvic sepsis among 16 operated patients. Zorron et al [28] reported one case of anastomotic leakage that required an operative procedure with anastomosis take down and colostomy creation. Choi et al [29] treated one anastomotic leakage operatively by peritoneal lavage and transanal closure.

There is concern as to whether TaTME worsens low anterior resection syndrome (LARS). Most studies (n = 25) did not report on the assessment of post-operative functional results. A Wexner Score questionnaire was used in four studies: Dumont et al [24] reported no cases of severe incontinence after ileostomy closure. In the study by Rouanet et al [26], one year post-operatively, 40% of patients were fully continent, 15% reported incontinence to liquids, 35% to gas and 25% had stool fragmentation; the median Wexner score was 11. Atallah et al [31] reported that most patients suffered from mild faecal incontinence defined as less than one daily accident at their eight-week follow-up. One patient reported lifestyle-altering incontinence; the Wexner score was 16, and this had not improved at post-operative follow-up after 12 months. Tuech et al [14] reported a median Wexner score of 5 at the one-year follow-up. Of 56 patients, three required a colostomy due to severe faecal incontinence (Wexner scores: 15, 17, and 18). For the remaining 49 patients without stoma, the median Wexner score was 4; and 14 patients had a score above 7. A total of 13 patients reported stool fragmentation and difficulty in evacuation.

Oncological results

An incomplete specimen comprises a significant risk of local recurrence [44]. Assessment of specimen quality - performed by pathologists and/or by the surgeon - according to Quirke's method [45] ("complete", "near-complete" or "incomplete") was reported in all but five studies. Zorron et al [28] reported incomplete specimen in two patients, and attributed that to intraoperative partial tumour rupture before extraction. Atallah et al [31] demonstrated 17 ''completely intact'' or ''near-completely intact" mesorectal envelopes, whereas two were graded as "incomplete" due to defects ≥ 5 mm in the mesorectal envelope. They did not report specimen quality assessment for one patient. Tuech et al [14], reported an intact specimen in 47 cases and a "nearly complete" mesorectum in nine patients; none were incomplete. Fernandez-Hevia et al [40] reported one incomplete specimen from a patient who had undergone total colectomy prior to TaTME. Seven studies reported "nearly-complete" specimens [31, 35, 37-39]. The two studies that compared TaTME with laparoscopic TME [40, 41] reported high rates of complete specimen. Velthuis et al [41] showed a significantly higher rate of complete specimen in TaTME compared with laparoscopic TME.

The circumferential resection margin (CRM) involvement was defined as the presence of tumour cells located < 1 mm from the radial margin in all studies except two [31, 41], where any margin < 2 mm was considered a positive margin.

Rouanet et al [26] reported four patients with involved CRMs. CRM was microscopically involved in two patients with locally advanced disease. One patient presented with a fixed tumour to the surrounding structures, including the sacral plane, seminal vesicles and prostate. One patient had regional recurrence; the residual tumour was located across the S2 vertebral plane.

Zorron et al [28] reported one patient with a T4 tumour with inadequate CRM. In the two cases with incomplete specimens reported by Atallah et al [31], both the distal and the circumferential margins were clear. In the same study, two other patients had a CRM of 1 mm, thus defined as "not clear". Of these patients, one had a rectal tumour that invaded the anal canal. Tuech et al [14] reported three patients with a CRM of < 1 mm, who all underwent neoadjuvant chemoradiation for a large anterior tumour with a margin of < 1 mm on the preoperative MRI. Velthuis et al [41] reported one positive

CRM among 25 patients who underwent TaTME (4%), compared with 8% in the laparoscopic group. Altogether, 11 out of 336 (3%) patients in this review have had involved CRMs.

The number of retrieved lymph nodes varied and the majority of studies have reported numbers larger than 12, except two [12, 39].

Local recurrence

The majority of studies reported no local recurrence. However, the follow-up time varied greatly, ranging 1-52 months. Rouanet et al [26] reported four patients with loco-regional recurrence. Tuech et al [14] reported one local recurrence among 56 patients. The case of local recurrence occurred in one of three patients with positive CRM.

DISCUSSION

TME has improved rectal cancer surgery [2, 46, 47], and laparoscopy has reduced morbidity [48]. However, conversion to open procedure remains a common procedure [49]. Robotics have lowered the conversion rate, but the cost is high [50, 51]. TaTME seems to be feasible and safe for selected patients, e.g., male, high BMI and tumours less than 10 cm from the anal verge. The procedure is probably less advantageous for high-rectal tumours, female patients, advanced tumours, and when a colostomy rather than a low anastomosis is planned.

This review included 336 patients, most with a normal BMI. There is a tendency towards the use of flexible platforms for the transanal part of the procedure. The optimal pressure for the pneumo-perirectum is generally around 10 mmHg. The optimal dissecting instrument for the transanal part has yet to be defined, although modern sealing devices seem to be popular. Anterior dissection in the transanal part should be performed with caution due to risk of urethral injury, and in the lateral part due to the risk of injury to the neurovascular bundle.

TME has improved the outcomes [2, 35]; hence, an abdominal approach combined with modern technology has allowed for low anastomosis in the pelvis [36]. Some issues remained unresolved like dissection in a narrow pelvis and bowel transection during TME [11]. In this review, studies reported splenic flexure mobilisation selectively. Transection of the rectal lumen is an advantage of TaTME, but raises concern about the risk of local recurrence. Lumen irrigation is, however, a potential advantage of TaTME over laparoscopic TME in which the bowel lumen is usually not irrigated.

Sphincter function after TaTME is another reason for concern, but most authors have not assessed anal sphincter function following TaTME, and no solid conclusions can be made in this regard. All but one study [14] are subject to selection bias. Expert bias must be considered when assessing the reported high specimen qualities and lymph node yields. Also, there is a risk of publication bias, as most studies have reported very favourable results.

Few reports exist on "pure" TaTME, which apart from its obvious cosmetic benefits jeopardizes the diagnostic value of laparoscopy in combined laparoscopic - TaTME. Patient selection involves also tumour stage, and patients with T4 tumours are probably not candidates for TaTME as most cases with involved CRM in this review were in patients with T4 tumours [26], and conversion was also related to advanced tumour stage [26]. TaTME involves bowel transection, which could lead to local recurrence in a way similar to intraoperative perforation that is shown to increase the recurrence rate [52]. Long-term results could clarify this.

Immediate outcomes, septic complications and oncological surrogate markers seem promising based on the existing data. However, long-term data and functional results such as LARS need to be available before full implementation of the procedure.

Studies on robotic TaTME showed outcomes and operative times comparable to those reported for laparoscopic TaTME. The potential advantages of robotic TaTME are ergonomic issues for the surgeon, precise dissection and lower conversion rates. Limiting factors include the cost [21, 35-37].

The overall colorectal experience of the individual surgeon - rather than the number of TaTME procedures - will determine the learning curve. Longer follow-up data and large randomised studies are needed. Ran-

! KEY POINTS

Total mesorectal excision (TME) is the standard in surgical treatment of mid- and low-rectal cancer.

TME may be performed as open, laparoscopic or robotic operation.

Transanal TME is a new procedure that potentially solves difficulties in the pelvic dissection, particularly in obese, male patients with a bulky mesorectum and narrow pelvis. Precise indications have yet to be specified.

TaTME can be performed "purely" transanally or as a "hybrid" with transabdominal assistance.

The vast majority of studies reported in this systematic review are the initial experience of the surgeon/centre.

Surgical technique and instruments have still to be standardised.

Immediate results are encouraging and the most important complication is urethral injury.

Oncological results are comparable with standard laparoscopic TME, but the follow-up is too short.

Literature is still sparse and larger, prospective randomised studies are needed to identify the benefits.

domisation is, however, dependent upon optimal standardisation and the experience gained. Based on the existing data, the following are possible indications for TaTME: Male, obese, low- and mid-rectal tumours (due to the otherwise difficult pelvis dissection). Contraindications include T4 tumours due to the risk of involved CRM. Potential advantages are: 1) precise dissection (and thus better oncological outcomes), 2) higher rates of anastomosis in patients with very low tumours, 3) a reduced risk of local recurrence (through sufficient distal resections margin and rectal washout), 4) a lower risk of anastomotic leakage (as the specimen has always sufficient length when it should reach the anal verge, no need for stapling, and because the rectal stump is not dissected as in other approaches), 5) a reduced risk of surgical site infection and hernia (when an abdominal incision is not done for specimen extraction). Potential risks are: 1) a risk of sphincter damage and more severe LARS and, 2) pelvic sepsis due to bowel transection.

CONCLUSION

TaTME is feasible and safe. Indications and contraindications have yet to be defined. Long-term follow-up data and larger studies are needed to assess functional results, local recurrence and survival compared with laparoscopic or robotic resections. As a novel approach, TaTME needs to be introduced carefully and - preferably - under the supervision of an ethical committee.

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