Transanal versus conventional total mesorectal excision for rectal cancer using the IDEAL framework for implementation

R. L. Robertson, A. Karimuddin, T. Phang, M. Raval and C. Brown*

Department of Surgery, St Paul’s Hospital, University of British Columbia, Vancouver, British Columbia, Canada

*Correspondence to: Department of Surgery, St Paul’s Hospital, Room C313, 3rd floor Burrrard Building, 1081 Burrard Street, Vancouver, British Columbia, V6Z 1Y6, Canada (e-mail: cbrown@providencehealth.bc.ca)

Abstract

Background: Transanal total mesorectal excision (TaTME) is an innovative technique for distal rectal cancer dissection. It has been shown to have similar short-term outcomes to conventional open and laparoscopic total mesorectal excision (cTME), but recent studies have raised concern about increased morbidity and local recurrence rates. The aim of this study was to assess outcomes after TaTME versus cTME for rectal cancer.

Methods: TaTME was implemented in 2014 using IDEAL principles in a single institution. The institution maintains databases for all patients undergoing rectal cancer surgery. This retrospective review compared data collected from all patients who had TaTME with those from a propensity-matched cohort of patients who underwent cTME. The primary outcome was a composite pathological measure combining margin status and quality of total mesorectal excision (TME). Short-term clinical and survival outcomes were also measured.

Results: Propensity matching created 109 matched pairs for analysis. Nine patients (8.3 per cent) undergoing TaTME had positive margins and/or incomplete TME, compared with 11 (10.5 per cent) undergoing cTME (P = 0.65). There were no significant differences in morbidity between the TaTME and cTME groups, including number of anastomotic leaks (13.8 versus 18.3 per cent; P = 0.37). The estimated 3-year local recurrence-free survival rate was 96.3 per cent in both groups (P = 0.39). Estimated 3-year overall (93.6 per cent for TaTME versus 94.5 per cent for cTME; P = 0.09) and disease-free (88.1 versus 76.1 per cent; P = 0.90) survival rates were similar.

Conclusion: TaTME provided similar outcomes to cTME for rectal cancer with the application of IDEAL principles.

Introduction

Transanal total mesorectal excision (TaTME) is an innovative approach to distal rectal dissection that is particularly useful for low rectal cancer in selected patients. The approach has several potential benefits that may overcome well recognized challenges associated with conventional laparoscopic and open total mesorectal excision (cTME). Delineation of the distal resection margin (DRM), enhanced visualization of circumferential resection planes, and improved sphincter-sparing are all proposed advantages. Initial reports from expert centres and the international TaTME registry suggest the procedure has acceptable short-term perioperative and pathological features that are surrogates for long-term oncological outcomes. However, TaTME is a technically challenging procedure with a long learning curve. Recent publications have raised concern about the safety of TaTME with regard to local recurrence (LR), suggesting that surrogate features may not be adequate for assessment of safety. Similarly, new data from the TaTME registry suggest that more widespread adoption may be associated with higher morbidity rates and less favourable outcomes than initially reported.
available from randomized trials, ongoing assessment of non-randomized prospectively collected data can add to the understanding of TaTME outcomes. TaTME was first performed in 2014 at St Paul’s Hospital (SPH) in Vancouver. The procedure was adopted carefully with a systematic approach using IDEAL framework principles. SPH presented a unique environment for the study of the programmatic adoption of TaTME into clinical practice, and the impact of this on patient outcomes. In this study, the early experience of patients undergoing TaTME at SPH using rigorous adherence to IDEAL principles was compared with results from a propensity-score matched cohort of patients with rectal cancer who had cTME.

Methods

TaTME was adopted into practice at SPH in October 2014. IDEAL principles were considered during each step of adoption and reporting. The procedure was performed by four colorectal surgeons, all of whom were proficient in advanced laparoscopic surgery for low rectal cancer and transanal endoscopic surgery before starting TaTME. All four surgeons participated in a proctored TaTME course before offering the procedure. Patient selection criteria and procedural methods were developed and agreed on between surgeons before instituting the procedure.

Patient selection and counselling

A systematic approach was used to select patients for TaTME. All patients referred with rectal cancer have been reviewed at existing multidisciplinary oncology rounds since 2014. Patient consideration and selection for TaTME was included and documented as a discussion point during rounds. Surgeon consensus on patient suitability for TaTME was required for the patient to be offered this procedure over conventional approaches. This decision was guided by the potential for patient benefit based on clinical factors (obesity, mid–low tumours, narrow pelvis, previous transanal excision), thereby selecting patients whose surgery was considered technically difficult from an abdominal approach. Decisions regarding neoadjuvant treatment were also determined at multidisciplinary rounds. Patients with cT1–T3 Nx low to mid rectal cancer were considered for TaTME, those with T4 disease or a threatened circumferential resection margin (CRM) were not eligible. Clinical T category and CRM status were assessed by MRI, and reviewed at multidisciplinary rounds for all patients. Patients offered TaTME were counselled before operation as part of the informed consent process regarding the novel nature of TaTME, and lack of data on long-term outcomes compared with cTME.

Intraoperative factors

TaTME procedures required two operating surgeons. The transanal portion of the operation was performed first, with both primary and secondary surgeons attending to the transanal dissection. A Transanal Endoscopic Microsurgery (TEM) Platform (Karl Storz, Tuttingen, Germany) and ENDOmotion arm (Richard Wolf, Knittlingen, Germany) were used. This platform was used exclusively at SPH and all surgeons were experienced in its use for transanal endoscopic surgery before implementing TaTME. Purse-string closure of the rectum was followed by full-thickness proctotomy via the TEM port. Initial proctotomy followed by purse-string closure was performed if a low distal margin or intersphincteric dissection was required (generally for Rullier type II or III distal tumours). TaTME dissection was undertaken proximally until the anterior peritoneal reflection had been reached, or to a level at the discretion of the surgeons when it was felt best to proceed to the abdominal portion of the procedure owing to technical factors. The abdominal portion of the operation was then performed laparoscopically or via an open approach, followed by anastomosis and diverting ileostomy. Specimens were extracted transabdominally. Both surgeons were present for the anastomosis, which was done by a 28-mm end-to-end or side-to-side stapled technique where feasible. Hand-sewn anastomoses were fashioned when the distal margin was too low for stapled anastomosis. All patients who underwent TaTME received a diverting ileostomy. To ensure surgical quality, all TME specimens were photographed and the entire procedure video-recorded.

Data collection

Institutional ethics approval for this study was obtained from the University of British Columbia Research Ethics Board. SPH has maintained a database of all patients with rectal cancer undergoing surgery since 2006. Patients who had TaTME have been recorded in a separate database since 2014. A retrospective review of these databases was completed in May 2019, to compare data collected on patients who had TaTME with a propensity-matched cohort of patients who underwent cTME. In addition to routine surgical follow-up and surveillance, patients with rectal cancer at SPH have bi-yearly follow-up overseen by a nurse navigator. Standardized synoptic operative and pathology reports used for rectal cancer also assisted with data collection. All TaTME procedures were submitted to the international TaTME registry.

Outcomes

The primary outcome was a composite measure of surgical quality consisting of CRM, distal DRM, and completeness of TME. The outcome variable was selected during study design to assess whether there were differences in surgical quality provided to patients undergoing TaTME at SPH compared with those having cTME. This outcome variable has been used by other studies as a marker of adequate surgical resection. Margins were considered involved if tumour cells were measured within 1 mm from the margin. TME quality was measured as incomplete, near-complete or complete, in accordance with the Quirke grading system. Completeness of TME was reviewed independently by a pathologist, and was included in the synoptic pathology report. A score of 1 was assigned if the patient had any one of: involved DRM, involved CRM, and/or incomplete TME. The score was 0 if the margins were clear and the TME was near-complete or complete. Secondary outcomes included: intraoperative events such as conversion to open surgery and urethral injuries, postoperative complications, overall in-hospital morbidity, duration of hospital stay, and 30-day mortality. Perioperative complications were graded according to the Clavien–Dindo classification, and included anastomotic leak, venous thromboembolism, myocardial infarction, surgical-site infection, ileus, and urinary retention. AL was diagnosed by clinical and/or radiographic criteria. Long-term oncological outcomes, including LR, overall survival (OS), and disease-free survival (DFS) were captured and analysed.

Statistical analysis

Propensity scores were estimated for each patient using a multivariable logistic regression model. In the model, the treatment group was the dependent variable, and patient’s age, BMI, sex, ASA fitness grade, tumour height, preoperative radiation, pT category, and operating surgeon were the independent variables.
All patients in the cTME and TaTME databases with sufficient available regression variable data were included for matching. Patients who had TaTME were matched to those having cTME using a 1 : 1 optimal matching algorithm, with a caliper of 0.25 standard deviations of the propensity score.

After matching, outcomes between groups were compared using McNemar’s test for categorical variables and Wilcoxon signed-rank test for continuous variables. Kaplan–Meier curves for the two groups were constructed to estimated 3-year OS, DFS, and recurrence-free survival, and were compared using the log rank test.

Results

More than 30 TaTME procedures have been performed annually at SPH since 2016 (Fig. 1). At the time of propensity matching in June 2019, there were 484 patients from 2006 to 2019 in the cTME database, and 133 patients from 2014 to 2019 in the TaTME database. Of these, 300 patients in the cTME group and 114 patients in the TaTME group had sufficient data to be included for matching (Table 1). For both groups, there were no significant differences in the characteristics of patients with sufficient data for matching compared with all patients in the databases. Patient characteristics between the unmatched TaTME and cTME groups were similar in terms of age, sex, BMI, and ASA grade (Table 1).

Before matching, tumours were on average lower and of less advanced pT category for TaTME than cTME. Patients in the TaTME group had higher rates of neoadjuvant treatment.

Propensity matching generated 109 matched pairs for analysis. Characteristics of the matched cohorts are shown in Table 1. Matching adequately adjusted for the differences between the two groups (Table S1). For example, there was an apparent

![Fig. 1 Proportion of low anterior resections for rectal cancer performed by laparoscopic, converted, open and transanal total mesorectal excision approach at St Paul’s Hospital by year](https://example.com/fig1)

TaTME, transanal total mesorectal excision.

| Table 1 Characteristics of patients in total cohorts and propensity-matched pairs |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Patients with complete data     | Propensity-matched pairs        |                                |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| cTME (n = 300)                  | TaTME (n = 114)                 | cTME (n = 109)                  | TaTME (n = 109)                 |
| Age (years)*                    | 62.0 (54.0–69.0)                | 62.5 (53.0–70.0)                | 62.0 (54.0–68.0)                | 63.0 (54.0–70.0)                |
| Sex ratio (F : M)               | 109 : 191                       | 38 : 76                         | 34 : 75                         | 36 : 73                         |
| BMI (kg/m²)*                    | 25.8 (22.7–28.6)                | 26.10 (23.7–29.9)               | 26.6 (23.2–30.9)                | 26.2 (23.8–29.9)                |
| ASA fitness grade               |                                |                                |                                |                                |
| I                               | 11 (3.7)                        | 3 (2.6)                         | 1 (0.9)                         | 3 (1.8)                         |
| II                              | 154 (51.3)                      | 62 (54.4)                       | 55 (50.5)                       | 60 (55.0)                       |
| III                             | 126 (42.0)                      | 47 (41.2)                       | 51 (46.8)                       | 45 (109)                        |
| IV                              | 9 (3.0)                         | 2 (1.8)                         | 2 (1.8)                         | 2 (1.8)                         |
| Pathological tumour category    |                                |                                |                                |                                |
| pT0                             | 24 (8.0)                        | 27 (23.7)                       | 20 (18.3)                       | 25 (22.9)                       |
| pT1                             | 26 (8.7)                        | 11 (9.6)                        | 9 (8.3)                         | 11 (10.1)                       |
| pT2                             | 82 (27.3)                       | 27 (23.7)                       | 32 (29.4)                       | 27 (24.8)                       |
| pT3                             | 142 (47.5)                      | 36 (31.6)                       | 43 (39.4)                       | 34 (31.2)                       |
| pT4                             | 22 (7.3)                        | 2 (1.8)                         | 1 (0.9)                         | 2 (1.8)                         |
| pTx                             | 4 (1.3)                         | 11 (9.6)                        | 4 (3.7)                         | 10 (9.2)                        |
| Tumour height (cm)*             | 5.0 (3.0–7.0)                   | 3.0 (2.5–4.0)                   | 3.0 (2.0–4.0)                   | 3.0 (2.5–4.0)                   |
| Radiotherapy                    |                                |                                |                                |                                |
| No                              | 143 (47.7)                      | 39 (34.2)                       | 30 (27.5)                       | 38 (34.9)                       |
| Yes                             | 157 (52.3)                      | 75 (65.8)                       | 79 (72.5)                       | 71 (65.1)                       |

Values in parentheses are percentages unless indicated otherwise; continuous variables are presented as the mean value (%)*values are presented as median (IQR). cTME, conventional total mesorectal excision; TaTME, transanal total mesorectal excision.
decrease in the proportion of patients with T4 disease in the propensity-matched cTME cohort compared with the overall cTME cohort (0.9 per cent versus 7.3 per cent). Two patients in the TaTME group had tumours understaged by MRI and had pT4 tumours on final pathology.

There was no significant difference in the composite pathological outcome between TaTME and cTME (Table 2). In the TaTME group, nine patients (8.3 per cent) had a positive composite score compared with 11 (10.5 per cent) who had cTME (P = 0.65). The CRM was positive in three and six patients respectively (2.8 versus 5.5 per cent; P = 0.32). The DRM was positive in one patient in the TaTME group owing to a positive anastomotic doughnut, compared with four who had cTME (0.9 versus 3.7 per cent; P = 0.18). TME quality was incomplete in 10 TaTMEs and 16 cTMEs (9.2 versus 15.2 per cent; P = 0.22).

There were no significant differences in perioperative morbidity between groups (Table 2), and no 30-day mortality in either group. The overall morbidity rate was 45.8 per cent (50 of 109) for TaTME and 44.0 per cent (48 of 109) for cTME. There were no urethral injuries. The AL rate was 13.8 per cent (15 of 109) for TaTME and 18.3 per cent (20 of 109) for cTME. AL graded as Clavien–Dindo grade III or higher occurred after 8.3 per cent of TaTMEs and 10.1 per cent of cTMEs. Four of the 15 ALs after TaTME occurred within the first year after introduction the procedure. Clavien–Dindo grade III or higher AL requiring further intervention occurred in 11/20 TaTME AL and in 9/15 cTME AL. Seven patients who had TaTME returned to the operating room for further management, and two underwent percutaneous drain placement. Two patients were treated with antibiotics, and the remaining four were diagnosed with radiographic Clavien–Dindo I leaks.

Forty-one of 109 patients (37.6 per cent) had laparoscopic surgery in the cTME group compared with 99 of 109 (90.8 per cent) in the TaTME cohort. The procedure was converted to open surgery in seven of 106 patients (6.6 per cent) in the TaTME group and three of 44 (7 per cent) in the cTME group. The hospital stay was shorter for TaTME (Table 3). In analysis of laparoscopic matched pairs, duration of hospital stay remained significantly reduced by 1 day in the TaTME group.

There were no differences in survival outcomes between the two groups. Median follow-up was 1.3 (IQR 0.7–2.1) years for TaTME and 4.0 (IQR 2.2–6.1) years for cTME. Estimated 3-year OS rates from Kaplan–Meier curves were 93.6 per cent for TaTME and 94.5 per cent for cTME (P = 0.09), and DFS rates were 88.1 and 76.1 per cent respectively (P = 0.90) respectively (Fig. 2). The estimated 3-year LR-free survival rate was 96.3 per cent in both groups (P = 0.39). Characteristics of LRs after TaTME are summarized in Table 4. Three of the patients had synchronous local and distant recurrences. Two patients with LR experienced AL, and a third patient had a pelvic haematoma requiring percutaneous drainage. One patient had a positive CRM with near-complete TME, and another underwent incomplete TME.

**Discussion**

TaTME has several potential benefits over cTME, but remains technically challenging with a significant learning curve. Similar to other surgical innovations, there is a risk of increased morbidity during adoption. Recent publications have raised concern regarding high LR and complication rates with TaTME. In Norway, TaTME was associated with a six-fold increase in LR compared with cTME (LR 7.9 per cent for TaTME), with half of these patients presenting with multifocal pelvic recurrences not seen with cTME. Van Oostendorp and colleagues’ reported LR in 10 per cent of patients undergoing TaTME in the early phase of implementation. Similarly, most LRs were multifocal pelvic recurrences, despite a structured training programme and good pathological outcomes. However, many other series and data from the TaTME registry have shown TaTME to be safe, with clinical and pathological outcomes similar to those of cTME. The largest TaTME series to date assessing LR in 767 patients at six high-volume centres had a LR rate of 3.1 per cent. These findings have created much debate surrounding the safety of TaTME, how and when it should be performed, and what methods are available for safe adoption of the technique.

At SPH, TaTME provided equivalent outcomes to those of a propensity-matched group of patients who underwent cTME.

**Table 2 Outcomes for propensity-matched pairs**

|                      | cTME (n = 109) | TaTME (n = 109) | P† |
|----------------------|---------------|----------------|----|
| **Composite score**  |               |                |    |
| 0                    | 94 of 105 (89.5) | 100 (91.7) | 0.65 |
| 1                    | 11 of 105 (10.5) | 9 (8.3) |    |
| Missing              | 4             | 0             |    |
| **Circumferential resection margin** |           |                | 0.32 |
| Negative             | 103 (94.5) | 106 (97.2) |    |
| Positive             | 6 (5.5) | 3 (2.8) |    |
| **Distal resection margin** |           |                | 0.18 |
| Negative             | 105 (96.3) | 108 (99.1) |    |
| Positive             | 4 (3.7) | 1 (0.9) |    |
| **TME quality**      |               |                | 0.22 |
| Complete             | 89 of 105 (84.8) | 99 (90.8) |    |
| Incomplete           | 16 of 105 (15.2) | 10 (9.2) |    |
| missing              | 4             | 0             |    |
| **Secondary outcomes** |             |                |    |
| Anastomotic leak     |               |                | 0.37 |
| Yes                  | 20 (18.3) | 15 (13.8) |    |
| No                   | 89 (81.7) | 94 (86.2) |    |
| Clavien–Dindo grade  |               |                |    |
| I–II                 | 9 (8.3) | 6 (5.5) |    |
| III/a/b              | 11 (10.1) | 9 (8.3) |    |
| Surgical-site infection |         |                | 0.13 |
| Yes                  | 15 (13.8) | 8 (7.3) |    |
| No                   | 94 (86.2) | 101 (92.7) |    |
| Ileus                |               |                | 0.86 |
| Yes                  | 21 (19.3) | 22 (20.2) |    |
| No                   | 88 (80.7) | 87 (79.8) |    |
| Urinary retention    |               |                | 0.13 |
| Yes                  | 6 (5.5) | 12 (11.0) |    |
| No                   | 103 (94.5) | 97 (89.0) |    |

Values in parentheses are percentages. *Includes total mesorectal excision (TME) specimens graded as complete or nearly-complete. cTME, conventional TME, TaTME, transanal TME. †McNemar’s test.

**Table 3 Duration of hospital stay for all matched patients and those who had a laparoscopic procedure**

|                      | cTME (n = 108) | TaTME (n = 109) | P† |
|----------------------|---------------|----------------|----|
| **Duration of hospital stay (days)** |           |                |    |
| All matched pairs    | 9.0 (6.0–14.5) | 6.0 (4.0–9.0) | < 0.001 |
| All laparoscopic procedures | 6.0 (5.0–9.0) | 6.0 (4.0–10.0) | 0.08 |
| Laparoscopic matched pairs | 6.0 (5.0–9.0) | 5.0 (4.0–7.0) | 0.050 |

Values are median (i.q.r.). cTME, conventional total mesorectal excision; TaTME, transanal total mesorectal excision. *Wilcoxon signed-rank test.
Fig. 2 Estimated 3-year survival outcomes for transanal and conventional total mesorectal excision surgery for rectal cancer at St Paul’s Hospital

| Year of surgery | Distance from anal verge(cm) | pT | CRM | TME quality | nCRT | Anastomotic leak | Type of recurrence | Time to local recurrence (months) | Treatment | Status at end of study |
|-----------------|-----------------------------|----|-----|-------------|------|------------------|-------------------|-------------------------------|-----------|----------------------|
| 2015            | 3                           | T3 | +   | Near-complete | Yes  | Yes              | Synchronous-lung    | 19                            | Chemotherapy | Lost to follow-up     |
| 2015            | 3                           | T3 | –   | Complete     | No   | No               | Local              | 15                            | Chemotherapy | Dead                 |
| 2016            | 5                           | T3 | –   | Complete     | Yes  | No               | Synchronous-bone,liver | 1                            | Chemotherapy | Dead                 |
| 2017            | 3                           | T3 | –   | Incomplete   | Yes  | Yes              | Synchronous-lung    | 9                             | Chemotherapy | Dead                 |

CRM, circumferential resection margin; TME, total mesorectal excision; nCRT, neoadjuvant chemoradiation.
| Reference           | n  | Study duration (months) | cT category | Distance from anal verge (cm) | Neoadjuvant treatment | Incomplete TME | Positive CRM | Positive distal margin Length (mm) | No. with local recurrence Follow-up (months) | Anastomotic leak |
|---------------------|----|------------------------|-------------|-------------------------------|-----------------------|---------------|-------------|-----------------------------------|-----------------------------------------------|-----------------|
| Atallah et al.      | 20 | 32                     | cT2: 3 (15)  | 5 (1–9)†                     | 17 (85)               | 3 (15)       | 1 (5)§       | 0 (6) 1–24)†                     | 1 (7)                                         |
|                     |    |                        | cT3: 12 (60)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | cT4: 5 (25) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | ≥ cT3: 23 58|                               |                       |               |             |                                   |                                               |
| Buchs et al.        | 40 | 24                     |             |                               |                       |               |             |                                   |                                               |
|                     |    |                        |             |                               |                       |               |             |                                   |                                               |
| Burke et al.        | 50 | 41                     | T1: 1 (2)   | 4.4 (3–6)‡                   | 43 (86)               | 1 (2)        | 2 (4)       | 1 (2) 4.0 15.1 (7–23)†            | 3 (7)                                         |
|                     |    |                        | T2: 6 (12)  |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 35 (70) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 8 (16)  |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T2: 8 (22)  |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 26 (72) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 2 (6)   |                               |                       |               |             |                                   |                                               |
| Fernandez–Hevia et al. | 37 | 17                     | Mid: 8.1 (2) | 27 (73)                      | 1 (3)                | 0 (0)        | 0 (0) 28 (18)‡ | n.r.                            | 2 (5)                                         |
|                     |    |                        | Low: 3.5 (1)‡|                               |                       |               |             |                                   |                                               |
|                     |    |                        |              |                               |                       |               |             |                                   |                                               |
| Hol et al.          | 159| 53                     | T1: 2 (1.3) | 5.7 (3.5)§                   | 112 (70.4)           | 4 (2.5)      | 1 (0.6)     | 0 (0) 54.8 36–88§               | 10 (6.3)                                      |
|                     |    |                        | T2: 39 (24.5)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 103 (64.8)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 11 (6.9) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T2: 27 (19.3)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 90 (64.3) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 11 (7.9) |                               |                       |               |             |                                   |                                               |
| Lacy et al.         | 140| 37                     | T1: 2 (1.4) | 7.6 (3.6)§                   | 94 (67.1)            | 1 (0.7)      | 9 (6.4)     | 0 (0) 28 (21)‡                  | 3 (2.1) 15 (7.1–20.7)†                        | 12 (8.6)        |
|                     |    |                        | T2: 27 (19.3)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 90 (64.3) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 11 (7.9) |                               |                       |               |             |                                   |                                               |
| Kang et al.         | 211| 72                     | T1: 11 (5.2)| 5.9 (2.0)§                   | 58 (27.5)            | 3 (1.4)      | 5 (2.3)     | 0 (0) 19 (0.9)‡                 | 13 (6.2) 35 (2–86)†                          | 17 (8.1)        |
|                     |    |                        | T2: 56 (26.5) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 106 (50.2)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 29 (13.7)|                               |                       |               |             |                                   |                                               |
| Perdawood et al.    | 100| 22                     | T2: 56 (56.0)|                               | 18 (18.0)           | 14 (14.0)    | 7 (7.0)     | 0 (0) 25 (14)‡                 | n.r.                                          | 6 (9.5)         |
|                     |    |                        | T3: 43 (43.0) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 11 (1.0) |                               |                       |               |             |                                   |                                               |
| Roodbeen et al.     | 767| 84                     | T1: 23 (3.0)| 3.0 (1–5)†                   | 527 (68.7)           | 62 (8.1)     | 56 (7.3)    | 14 (1.8) 25.5 15–39)†           | n.r.                                          |                                               |
|                     |    |                        | T2: 196 (25.6)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 421 (54.9)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 52 (6.8) |                               |                       |               |             |                                   |                                               |
| Rouanet et al.      | 30 | 29                     | T1: 1 (3)   | 1 (0–7)†                     | 29 (97)              | 0 (0)        | 4 (13)      | 0 (0) 9 (3–40)†                 | 4 (13) 21 (10–41)†                           | n.r.            |
|                     |    |                        | T2: 1 (3)   |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 21 (70) |                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 7 (23)  |                               |                       |               |             |                                   |                                               |
| Simó et al.         | 100| 59                     | T1: 20 (20.0)|                               | 4.9 (1.3)§           | 58 (58.0)    | 4 (4.0)     | 2 (2.0) 15 (5–24)†              | 2 (2.0) 24 (13–39)†                           | 12 (12.0)       |
|                     |    |                        | T2: 27 (27.0)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T3: 50 (50.0)|                               |                       |               |             |                                   |                                               |
|                     |    |                        | T4: 3 (3.0) |                               |                       |               |             |                                   |                                               |
| Wasmuth et al.      | 157| 48                     | n.r.        | 8.0 (2–13)†                  | 33 (21.0)           | n.r.         | 8 (5.1)     | 12 (7.6) 12 (7.9) 11 (8.4)      |                                               |
Pathological outcomes were favourable for TaTME, and the estimated 3-year LR-free survival rate was 96.3 per cent. However, other studies have highlighted that good pathological outcomes may not be reflective of actual LR rates. Thus, more follow-up is required to establish the true LR rate and long-term outcomes of TaTME. Of note, there were no multifocal pelvic recurrences, and nearly all LRs after TaTME were associated with high-risk features such as positive margins, incomplete TME, or AL. The AL rate for TaTME was 13.8 per cent, which is similar to the rate of anastomotic failure in the TaTME registry (15.7 per cent of 1594 patients). This was not significantly different from the AL rate of 18.3 per cent in the propensity-matched cTME cohort. AL in the cTME cohort was much higher than the overall rate of AL in the SPH database, which was 5.4 per cent. Patients selected for TaTME at SPH are a subset at increased risk of AL by design. Furthermore, the definition of AL included lower-grade leaks. The rate of AL requiring intervention after TaTME was 8.3 per cent, which is within the acceptable range for rectal cancer, particularly for high-risk patients in the TaTME group. Overall, four of the 15 ALs at SPH among patients who had TaTME occurred in the first year of implementation, consistent with evidence showing increased morbidity during the learning curve.

When instituting TaTME at SPH, criteria from the IDEAL framework were used to ensure systematic adoption, with stringent patient selection criteria, and methods to ensure surgical quality. Undertaking the perineal dissection first may have optimized the quality of dissection and ensured closure of the distal rectum before dissection of other planes. The presence of two operating surgeons for the perineal dissection likely contributed to favourable outcomes. The perineal dissection is the novel aspect of TaTME; collaboration and communication between two expert surgeons subjectively shortened the learning curve and mitigated the risk of surgery in the wrong plane. Similar to other technically challenging operations, TaTME may have better outcomes when performed at specialized high-volume centres. Surgical volumes for rectal cancer are associated with improved outcomes. It seems logical that a challenging innovative approach like TaTME be restricted to high-volume, expert pelvic surgeons until long-term oncological equivalence is proven in principle. In series reporting suboptimal TaTME outcomes, procedure numbers at individual institutions have been low. Wasmuth et al. reported on four high-volume centres where TaTME volumes averaged fewer than 10 procedures per year. No mention was given to assessment of surgical quality, and inclusion for TaTME had no specified selection criteria. Van Oostendorp and colleagues looked at only the first 10 TaTME procedures at any institution. At four high-volume centres that performed more than 45 procedures, the LR rate dropped to less than 5 per cent after 10. The learning curve for TaTME has been shown to be upwards of 40 procedures, so it is possible that outcomes were related to lack of completion of the learning curve. This highlights the need for structured training and proctoring when adopting TaTME. Similar to laparoscopic colonic surgery, where early concerns were raised about port-site metastases and safety, these findings do not undermine TaTME as an important surgical advance in rectal cancer treatment.

There are several limitations to the present study. The results are from a single-institution cohort study and can be generalized only to other high-volume centres that employ a similarly rigorous IDEAL-driven adoption strategy. Robust short- and long-term data are needed to ensure the safety of TaTME, and will hopefully be forthcoming in randomized trials such as COLOR III. In the interim, more prospective, appropriately case-matched cohort studies are needed to critically assess the safety and efficacy of TaTME. Studies should report on strategy for TaTME implementation, as it is clear that these factors contribute to outcomes and understanding of the safety of this new procedure. Although the inherent biases of observational cohort studies apply to this work, the reporting of the implementation process, along with use of propensity score matching to ensure these difficult procedures have an appropriate comparator group, is consistent with the recommendations of the IDEAL framework.

**Funding**

This study received no funding.

**Disclosure.** The authors declare no conflict of interest.

**Supplementary material**

Supplementary material is available at BJ Open online.

**References**

1. Penna M, Cunningham C, Hompes R. Transanal total mesorectal excision: why, when, and how. Clin Colon Rectal Surg 2017; 30:339–345.
2. Motson R, Whiteford M, Hompes R, Albert M, Miles W. Current status of trans-anal total mesorectal excision (TaTME) following the Second International Consensus Conference. Colorectal Dis 2019; 18:13–18.
3. Simillis C, Hompes R, Penna M, Rasheed S, Tekkis PP. A systematic review of transanal total mesorectal excision: is this the future of rectal cancer surgery? Colorectal Dis 2016; 18:19–36.
4. Penna M, Hompes R, Arnold S, Wynn G, Austin R, Warusavitarne J, et al. Transanal total mesorectal excision international registry results of the first 720 cases. Ann Surg 2017; 266:111–117.
5. Koedam TWA, Veltcamp Helbach M, van de Ven PM. Transanal total mesorectal excision for rectal cancer: evaluation of the learning curve. Tech Coloproctol 2018; 22:279–287.
6. Lee L, Kelly J, Nassif GJ, deBeche-Adams TC, Albert MR, Monson JRT. Defining the learning curve for transanal total mesorectal excision for rectal adenocarcinoma. Surg Endosc 2020; 34:1534–1542.
7. van Oostendorp SE, Beigers HJ, Bootma BT et al. Locoregional recurrences after transanal total mesorectal excision of rectal cancer during implementation. Br J Surg 2020; 107:1211–1220.
8. Wasmuth HH, Faerden AE, Myklebust T et al. Transanal total mesorectal excision for rectal cancer has been suspended in Norway. Br J Surg 2020; 107:121–130.
9. Penna M, Hompes R, Arnold S et al. Incidence and risk factors for anastomotic failure in 1594 patients treated by transanal total mesorectal excision results from the international TaTME registry. Ann Surg 2019; 269:700–711.
10. Barkun JS, Aronson JK, Feldman LS, Maddern, GJ, Strasberg SM. Evaluation and stages of surgical innovations. Lancet 2009; 374:1089–1096.
11. Ergina PL, Barkun JS, McCulloch P, Cook JA, Altman DG, IDEAL Group. IDEAL framework for surgical innovation 2: observational studies in the exploration and assessment stages. BMJ 2013; 346:f3011.
12. McCulloch P, Altman DG, Campbell WB et al. No surgical innovation without evaluation: the IDEAL recommendations. Lancet 2009; 374:1105–1112.
13. Hirst A, Agha RA, Rosin D, McCulloch P. How can we improve surgical research and innovation?: The IDEAL framework for action. *Int J Surg* 2013;11:1038–1042

14. Khachane A, Philippou Y, Hirst A, McCulloch P. Appraising the uptake and use of the IDEAL Framework and Recommendations: a review of the literature. *Int J Surg* 2018; 57: 84–90.

15. McCulloch P, Feinberg J, Philippou Y et al. *Recommendations: a review of the literature.* *Surg Endosc* 2018;32: 3210–3215

16. Deijen CL, Velthuis S, Tsai A et al. COLOR III: a multicentre randomised clinical trial comparing transanal TME versus laparoscopic TME for mid and low rectal cancer. *Surg Endosc* 2016;30: 3210–3215

17. Rullier E, Denost Q, Vendrely V et al. Transanal total mesorectal excision for rectal cancer: early outcomes in 50 consecutive patients. *Colorectal Dis* 2016;18: 570–577

18. Stevenson A, Solomon M, Lumley J et al. The prediction of local recurrence in rectal cancer the ALaCaRT randomized clinical trial. *Int J Surg* 2015;314: 1356–1363

19. Benson AB, Venook AP, Al-Hawary MM et al. Rectal cancer, version 2.2018 clinical practice guidelines in Oncology. *JNCCN J Natl Compr Cancer Netw* 2018; 16: 874–901.

20. Quirke P, Dixon MF. The prediction of local recurrence in rectal adenocarcinoma by histopathological examination. *Int J Colorectal Dis* 1988;3:127–131

21. Larsen SG, Pfeffer F, Kørner H. Norwegian moratorium on transanal total mesorectal excision. *Br J Surg* 2019; 106: 1120–1121

22. Atallah S, Albert M, Nassif G, Hunter L, Larach S. Transanal minimal 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

23. Lacy AM, Tasende MM, Delgado S, Jimenez M, Lacy B De, Castells A. Transanal total mesorectal excision for rectal cancer: outcomes after 140 patients. *J Am Coll Surg* 2015;221:415–423

24. Roodbeen SX, Spinelli A, Bemelman WA et al. Local recurrence after transanal total mesorectal excision for rectal cancer. *Ann Surg* 2020;Jan 14, online ahead of print.

25. Fernandez-hevia M, Delgado S, Castells A et al. Transanal total mesorectal excision in rectal cancer: short-term outcomes in comparison with laparoscopic surgery. *Ann Surg* 2015;261:221–227

26. Hol JC, van Oostendorp SE, Tuynman JB, Sietes C. Long-term oncological results after transanal total mesorectal excision for rectal carcinoma. *Tech Coloproctol* 2019; 23:903–911 doi: 10.1007/s10151-019-02094-8

27. Buchs NC, Wynn G, Austin R et al. A two-centre experience of transanal total mesorectal excision. *Colorectal Dis* 2016;18: 1154–1161

28. Burke JP, Khan A, Nassif G, Larach SW, Albert MR, Atallah S. Transanal total mesorectal excision for rectal cancer: early outcomes in 50 consecutive patients. *Colorectal Dis* 2016;18:570–577

29. Rouanet P, Mourregot A, Azar CC et al. Transanal endoscopic proctectomy: an innovative procedure for difficult resection of rectal tumors in men with narrow pelvis. *Dis Colon Rectum* 2013; 4: 7–9

30. Perdawood SK, Thinggaard BS, Bjoern MX. Effect of transanal total mesorectal excision for rectal cancer: comparison of short-term outcomes with laparoscopic and open surgeries. *Surg Endosc* 2017;32:2312–2321

31. Kang I, Chen YG, Zhang H et al. Transanal total mesorectal excision for rectal cancer: a multicentric cohort study. *Gastroenterol Rep* 2020; 8:36–41

32. Simó V, Arredondo J, Hernán C et al. Tratamiento del cáncer de recto mediante escisión completa del mesorrecto por vía transanal. Resultados en 100 pacientes consecutivos. *Cirugía Española* 2019;97:510–516

33. Atallah S, Sylla P, Wexner SD. Norway versus The Netherlands: will taTME stand the test of time? *Tech Coloproctol* 2019; 23: 803–806

34. Caycedo-Marulanda A, Brown CJ, Chadi SA et al. Canadian taTME expert collaboration (CaTaCO) position statement. *Surg Endosc* 2020;34:1–6

35. Borowski DW, Bradburn DM, Mills SJ et al. Volume–outcome analysis of colorectal cancer-related outcomes. *Br J Surg* 2010; 97:1416–1430

36. Billingsley KG, Morris AM, Green P et al. Does surgeon case volume influence nonfatal adverse outcomes after rectal cancer resection? *J Am Coll Surg* 2008;206:1167–1177

37. Xu Z, Becerra AZ, Justiniiano CF et al. Is the distance worth it? Patients with rectal cancer traveling to high-volume centers experience improved outcomes. *Dis Colon Rectum* 2017;60:1250–1259

38. Caycedo-Marulanda A, Verschoor CP. Experience beyond the learning curve of transanal total mesorectal excision (taTME) and its effect on the incidence of anastomotic leak. *Tech Coloproctol* 2020;24:309–316

39. Pihlman L. Problem of port-site metastases after laparoscopic cancer surgery. *Ann Med* 1997;29:477–481