Transanal versus laparoscopic total mesorectal excision for mid and low rectal cancer: a meta-analysis of short-term outcomes

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Abstract

Introduction: The benefit of transanal total mesorectal excision (TaTME) for mid and low rectal cancer is conflicting.
Aim: To assess and compare the short-term outcomes of TaTME with conventional laparoscopic total mesorectal excision (LaTME) for middle and low rectal cancer.
Material and methods: We searched PubMed, Embase and Cochrane Library databases for studies addressing TaTME versus conventional LaTME for rectal cancer between 2008 and December 2018. Randomized controlled trials (RCTs) and retrospective studies which compared TaTME with LaTME were included.
Results: Twelve retrospective case-control studies were identified, including a total of 899 patients. We did not find significant differences in overall intraoperative complications, blood loss, conversion rate, operative time, overall postoperative complication, anastomotic leakage, ileus, or urinary morbidity. Also no significant differences in oncological outcomes including circumferential resection margin (CRM), positive CRM, distal margin distance (DRM), positive DRM, quality of mesorectum, number of harvested lymph nodes, temporary stoma or local recurrence were found. Although the TaTME group had better postoperative outcomes (readmission, reoperation, length of hospital stay) on average, the difference did not reach statistical significance.
Conclusions: Transanal total mesorectal excision offers a safe and feasible alternative to LaTME although the clinicopathological features were not superior to LaTME in this study. Currently, with the lack of evidence on benefits of TaTME, further evaluation of TaTME requires large randomized control trials to be conducted.

Key words: rectal cancer, transanal total mesorectal excision, laparoscopic total mesorectal excision, meta-analysis.

Introduction

Colorectal cancer is one of the most common cancers worldwide [1]. Since laparoscopic surgery was first applied in colorectal cancer in 1991, the technique has spread worldwide [2]. Compared to open surgery, laparoscopic surgery for rectal cancer is safe and feasible with comparable short-term outcomes and long-term outcomes [3–6].

Since the principles of total mesorectal excision (TME) were first described by Heald et al. in 1982 [7], it has become a standard procedure for rectal cancer, and reduced the local recurrence to less than 5% [8–10]. However, there remained some difficulties in...
middle or low rectal cancer, especially in a low location, obese patients, or males with a deep, narrow pelvis. In 2010, the down-to-up approach, transanal total mesorectal excision (TaTME), was introduced to solve these problems [11–13]. And then, there were several randomized controlled trials focusing on middle and low rectal cancer compared TaTME with laparoscopic TME (LaTME) [14, 15].

Previous meta-analyses had demonstrated a relative merit of TaTME over LaTME [16–20]. However, these studies had a relatively small sample size. What is more, some previous meta-analyses included data from abdominoperineal resections, which may generate bias, affecting outcomes [18]. Hence, we conducted this meta-analysis to assess and compare the short-term outcomes of TaTME with LaTME for middle and low rectal cancer. Intraoperative outcomes, postoperative outcomes, oncological outcomes and local recurrence were measured with meta-analytical methods.

Aim

The aim of the study was to assess and compare the short-term outcomes of TaTME with conventional LaTME for middle and low rectal cancer.

Material and methods

This meta-analysis adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analysis and Meta-analysis guidelines [21, 22].

Literature-search strategy

Literature searches of PubMed, Embase and Cochrane Library databases for studies addressing TaTME versus conventional LaTME for rectal cancer between 2008 and December 2018 were performed. Only English-language publications were involved. The search terms were “Transanal or transanal total mesorectal excision or TaTME or transanal minimally invasive surgery or TAMIS or transanal endoscopic microsurgery or TEM or natural orifice transluminal endoscopic surgery or NOTES or natural orifice specimen extraction or NOSE or transanal specimen extraction” and “rectal cancer or proctectomy”.

Inclusion and exclusion criteria

Randomized controlled trials (RCTs) and retrospective studies that comparing TaTME with LaTME were included. All the included studies had to have at least one of the relevant outcomes mentioned below. The exclusion criteria were as follows: (a) lack of the sufficient data or outcomes of interest; (b) duplicate publication; (c) non-comparative studies, editorials, letters, conference abstracts, review articles, case reports and animal experimental studies; (d) studies included high rectal cancer (tumor distance from anal verge more than 10 cm) and abdomino-perineal resection (APR).

Data extraction and outcomes of interest

Two independent authors extracted and summarized the data from the included studies independently.

The intraoperative outcomes were estimated blood loss, operative time, conversion rate, and intraoperative complications. The postoperative outcomes were overall postoperative complications, anastomotic leakage, ileus, urinary morbidity, reoperation, readmission rate, and length of hospital stay. The oncological outcomes were quality of mesorectum, circumferential resection margin (CRM), positive CRM, distal margin distance (DRM), positive DRM, harvested lymph nodes and local recurrence.

Quality assessment

For continuous variables weighted mean differences (WMDs) were calculated. For dichotomous variables odds ratios (ORs) were calculated. For continuous data as median and range values, the means and standard deviations were calculated by the formula described by Liberati et al. [22].

Statistical analysis

Statistical heterogeneity between studies was assessed using the χ² test with significance set at \( p < 0.10 \) [23]. A random effects model was used and funnel plots were used to evaluate publication bias. The Newcastle-Ottawa scale was used to evaluate the methodological quality of all the retrospective studies.

Statistical analyses were done using RevMan 5.3 software (Cochrane Collaboration, Oxford, UK).

Results

One thousand two hundred and forty-seven citations were retrieved from the search strategy. Finally,
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Twelve studies (24–35) were included in the analysis, with a total of 999 patients (411 patients in TaTME group, 488 patients in LaTME group) (Figure 1). The characteristics of eligible studies are shown in Table I. Meta-analysis revealed no statistically significant difference in intraoperative outcomes: There were no statistically significant differences in blood loss ($p = 0.85$), operative time ($p = 0.79$), conversion rate ($p = 0.69$), or intraoperative complications ($p = 0.70$) between the two groups (Figure 2). There was no heterogeneity among studies ($I^2 = 0\%$).

Ten studies (24–26, 28, 30–35) that assessed 821 patients reported on overall postoperative complications. Meta-analysis showed no statistically significant differences in overall postoperative complications ($p = 0.39$), anastomotic leakage ($p = 0.60$), ileus ($p = 0.38$), or urinary morbidity ($p = 0.79$) between the two groups. There were no statistically significant differences in blood loss ($p = 0.85$), operative time ($p = 0.79$), conversion rate ($p = 0.69$), or intraoperative complications ($p = 0.70$) between the two groups (Figure 3). The TaTME group had non-significantly better postoperative outcomes in readmission ($p = 0.08$), fever ($p = 0.34$), and length of hospital stay ($p = 0.09$) (Figure 4).

### Table I. Characteristics of studies included in this meta-analysis

| Study                | Design               | Country          | TaTME/LaTME | Patients | BMI | T stage | Tumor location | Neoadjuvant therapy TaTME/LaTME | Quality score |
|----------------------|----------------------|------------------|-------------|----------|-----|---------|----------------|-----------------------------|---------------|
| Fernandez-Hevia 2014 | MCC                  | Spain            | 37/37       | 23.7 ±3.6 | 25.1 ±4.0 | T2–T4 | L + M          | TaTME 7 LaTME 8            | 28/23         | 7               |
| De'Angelis 2015      | MCC                  | France           | 32/32       | 25.2 ±3.5 | 24.5 ±3.2 | T2–T4 | L              | TaTME 8 LaTME 7            | 27/23         | 8               |
| Chen 2016            | MCC                  | Taiwan, China    | 30/100      | 24.2 ±3.7 | 24.0 ±3.1 | T2–T4 | L + M          | TaTME 7 LaTME 8            | 50/100        | 7               |
| Chouillard 2016      | Prospective cohort   | France           | 18/15       | 27.1 ±4.5 | 29.0 ±4.2 | T1–T3 | L + M          | TaTME 7 LaTME 8            | 14/12         | 7               |
| Lelong 2016          | MCC                  | France           | 34/38       | 24 (18.6–45.0) | 24.2 (17.7–32.7) | T1–T4 | L              | TaTME 8 LaTME 7            | 30/35         | 8               |
| Rasulov 2016         | Prospective cohort   | Russia           | 22/23       | 26.0 (19.7–32.3) | 26.0 (18.3–37.2) | T1–T4 | L + M          | TaTME 8 LaTME 7            | 19/11         | 8               |
| Chang 2017           | MCC                  | Taiwan, China    | 23/23       | 25.8 ±4.3 | 25.0 ±3.0 | T1–T3 | L              | TaTME 7 LaTME 8            | 8/14          | 7               |
| Mege 2018            | MCC                  | France           | 34/34       | 25 ±4     | 25 ±3    | T1–T4 | L              | TaTME 7 LaTME 8            | 29/29         | 8               |
| Persiani 2018        | MCC                  | Italy            | 46/46       | 25 (19.1–32.8) | 25.6 (18.8–33.4) | T1–T3 | L + M          | TaTME 7 LaTME 8            | 26/32         | 7               |
| Chen 2018            | MCC                  | Taiwan, China    | 39/64       | 25.4 ±4.0 | 24.6 ±3.3 | T1–T3 | L + M          | TaTME 7 LaTME 8            | 115/31        | 8               |
| Roozbeneh 2018       | MCC                  | Netherlands      | 41/41       | 26.7 ±1.9 | 26.1 ±4.0 | T1–T4 | L              | TaTME 7 LaTME 8            | 18/18         | 7               |
| Rubinkiewicz 2018    | MCC                  | Poland           | 35/35       | 26.1 ±4.09 | 27.1 ±4.71 | T1–T3 | L              | TaTME 7 LaTME 8            | 31/31         | 7               |

TaTME = transanal total mesorectal excision, LaTME = laparoscopic total mesorectal excision, BMI = body mass index. Tumor location: L = low, M = middle, MCC = matched case control.
Conversion events

| Study or subgroup | TaTME | LaTME | Weight | Odds ratio | Year | Odds ratio M-H, random, 95% CI |
|------------------|-------|-------|--------|------------|------|-------------------------------|
| Fernandez-Hevia  | 0     | 37    | 0      | Not estimable | 2014 |                               |
| De’Angelis       | 1     | 32    | 1      | 1.00 (0.06, 16.71) | 2015 |                               |
| Cherr            | 1     | 50    | 5      | 0.39 (0.04, 3.41)  | 2016 |                               |
| Chouillard       | 8     | 18    | 4      | 2.20 (0.50, 9.61)  | 2016 |                               |
| Lelong           | 1     | 34    | 9      | 0.10 (0.01, 0.82)  | 2016 |                               |
| Rasulov          | 1     | 22    | 1      | 1.05 (0.06, 17.85) | 2016 |                               |
| Chang            | 0     | 23    | 0      | Not estimable | 2017 |                               |
| Chen YT          | 1     | 39    | 1      | 1.66 (0.10, 27.29) | 2018 |                               |
| Roodbeen         | 0     | 41    | 9      | 0.04 (0.00, 0.73)  | 2018 |                               |
| Persiani         | 9     | 46    | 0      | 23.56 (1.33, 418.10) | 2018 |                               |
| Total (95% CI)   | 342   | 419   | 100.0  | 0.77 (0.22, 2.75)  |      |                               |

Heterogeneity: $\chi^2 = 557.78; \chi^2 = 15.72, df = 4 (p = 0.07); I^2 = 53$

Test for overall effect: $Z = 0.19 (p = 0.85)$

There were six studies [24–27, 31, 34] that reported CRM, eleven studies [24–26, 28–35] that reported positive CRM, eight studies [24–27, 30, 32–34] that reported DRM and five studies [25, 28, 31, 34, 35] that reported positive DRM. No differences were found in these pathological outcomes (Figure 5). Meanwhile, we did not find statistically significant differences in quality of mesorectum ($p = 0.39$), harvested lymph nodes ($p = 0.62$) or temporary stoma ($p = 0.27$) (Figure 6).

Four studies [25, 28, 31, 33] reported local recurrence; no difference was found in this outcome (Figure 7).

Publication bias

The funnel plot based on overall complication rate indicated no obvious publication bias (Figure 8).

**Discussion**

This study was the largest meta-analysis including 889 patients (411 patients in TaTME group, 488 patients in LaTME group). Our results showed no significant difference between TaTME and LaTME in overall intraoperative complications, postoperative outcomes, oncological outcomes or local recurrence. We hope that our findings can illustrate the safety and feasibility of TaTME, and promote its application in middle and low rectal cancer.

The TaTME is a novel technique which is expected to have better oncological outcomes. Lots of previous studies had shown that TaTME is superior to LaTME and may benefit in some surgical and pathological outcomes, but no RCT results prove these findings. There have been many meta-analyses [16–20] about TaTME in the last 3 years, but...
most of them contained substantial bias, and the results of Rubinkiewicz et al. [18] showed no significant differences in clinical outcomes between TaTME and LaTME recently. But we found this negative result based on overall complications and some surgical outcomes without systematically analyzing intraoperative outcomes, postoperative outcomes, oncological outcomes. What is more, TaTME is more suitable for middle and low rectal cancer, and it is inappropriate to include high rectal cancer, which was included in Rubinkiewicz’s study [36].

In this study, we included several of the most recent papers which were not included in previous analyses, and systematically analyzed surgical outcomes aiming to find out new proof of differences of clinical outcomes between TaTME and LaTME. Previous meta-analyses [16, 17] had conflicting results in conversion rate and postoperative complications. In this meta-analysis which included 899 patients, we were able to show evidence of decrease of the overall postoperative complication rate, urinary morbidity and readmission rate in the TaTME group. However, we found no significant difference in conversion rate in our result. As previous reports, temporary stoma may affect recovery after surgery [37, 38], but there was no difference in the rate of temporary stoma between two groups.
In our study, the quality of mesorectum did not reach statistical significance between the two groups. A previous meta-analysis [16] including six studies found a significant difference in the complete rate of complete mesorectum. But after adding more studies in this study, no significant result was found in the complete rate of complete mesorectum. Interestingly, the TaTME group had better postoperative outcomes (readmission, reoperation, length of hospital stay) on average, although the difference did not reach statistical significance. The heterogeneities in these parameters were 10%, 15%, 76% respectively, which may be an important factor affecting these results.

Fewer studies have assessed long-term observation. Only Zhang’s meta-analysis [19] reported 2-year survival and 2-years disease-free survival between TaTME and LaTME, which included only two studies, and found no significant result. It is impossible to prove the superiority of any technique due to lack of new data. One of the most different procedures between TaTME and LaTME is separating the rectum during the small pelvis. Therefore, we think the rate of local recurrence is an important long-term outcome.

**Figure 3.** Forest plots describing postoperative outcomes: overall postoperative complication (A), anastomotic leakage (B), ileus (C), urinary morbidity (D) between TaTME and LaTME.
this study we first compared local recurrence between TaTME and LaTME; the result showed no difference between TaTME and LaTME. It means that changing this key operative approach may not affect the surgical outcome of TME. It still requires more time for long-term follow-up in RCT studies, or more any other long-term outcome data from non-RCT results.

This meta-analysis has several limitations that must be taken into account. Firstly, all the included studies were observational studies but without RCTs. Without adequate random sequence generation and blinding, the risk of bias might increase. Therefore, the quality of the evidence pooled from these retrospective trials must be judged as low. Secondly, there may be publication bias due to all the included studies being in English, and these data were not from a high-volume center, which may also affect the results. Finally, no long-term outcome, such as overall survival and disease-free survival, was measured in the analysis.

Conclusions

TaTME offers a safe and feasible alternative to LaTME although the clinicopathological features were not superior to LaTME in this study. Currently, in view of the lack of evidence on benefits of TaTME, further evaluation of TaTME necessitates large randomized control trials.

Acknowledgments

Dezheng Lin, Zhaoliang Yu and Wenpei Chen contributed equally to this study and should be considered as co-first authors.

Conflict of interest

The authors declare no conflict of interest.
### Readmission

| Study or subgroup  | TaTME Events | TaTME Total | TaTME Weight (%) | Odds ratio M-H, random, 95% CI | Year |
|-------------------|-------------|-------------|-----------------|-------------------------------|------|
| Fernandez-Hevia   | 2           | 37          | 8               | 0.21 (0.04, 1.05)             | 2014 |
| De’Angelis        | 2           | 32          | 3               | 0.64 (0.10, 4.14)             | 2015 |
| Chen              | 3           | 50          | 10              | 0.57 (0.15, 2.19)             | 2016 |
| Lelong            | 0           | 34          | 6               | 0.07 (0.00, 1.34)             |      |
| Roodebeen         | 6           | 41          | 8               | 0.71 (0.22, 2.26)             | 2018 |
| Mege              | 2           | 34          | 0               | 5.31 (0.25, 114.79)           | 2018 |
| **Total (95% CI)**| 228         | 282         | 100.0           | 0.52 (0.25, 1.07)             |      |
| **Total events**  | 15          | 35          |                 |                               |      |

Heterogeneity: $t^2 = 0.009; \chi^2 = 5.56, df = 5 (p = 0.35); I^2 = 10%$

Test for overall effect: $Z = 1.77 (p = 0.08)$

### Reoperation

| Study or subgroup  | TaTME Events | TaTME Total | TaTME Weight (%) | Odds ratio M-H, random, 95% CI | Year |
|-------------------|-------------|-------------|-----------------|-------------------------------|------|
| Fernandez-Hevia   | 1           | 37          | 3               | 0.31 (0.03, 3.18)             | 2014 |
| De’Angelis        | 0           | 32          | 0               | Not estimable                 | 2015 |
| Lelong            | 0           | 34          | 4               | 0.11 (0.01, 2.14)             | 2016 |
| Chen              | 2           | 50          | 3               | 1.35 (0.22, 8.33)             | 2016 |
| **Total (95% CI)**| 153         | 207         | 100.0           | 0.50 (0.12, 2.09)             |      |
| **Total events**  | 3           | 10          |                 |                               |      |

Heterogeneity: $t^2 = 0.25; \chi^2 = 2.36, df = 2 (p = 0.31); I^2 = 15%$

Test for overall effect: $Z = 0.95 (p = 0.34)$

### Length of hospital stay

| Study or subgroup  | TaTME Mean | TaTME SD | TaTME Total | TaTME Weight (%) | Mean difference IV, random, 95% CI | Year |
|-------------------|------------|----------|-------------|-----------------|-----------------------------------|------|
| Fernandez-Hevia   | 6.8        | 3        | 37          | 9               | 7.2                      | –2.20 (–4.83, 0.43) | 2014 |
| De’Angelis        | 7.78       | 2.12     | 32          | 9.75            | 3.97                   | 10.3              | –1.97 (–3.53, –0.41) | 2015 |
| Chouillard        | 10.4       | 6.25     | 18          | 9.4             | 3.25                   | 15                | 5.6                     | 2016 |
| Chen              | 7.4        | 2.5      | 50          | 7.1             | 3.8                    | 100               | 11.9                     | 2016 |
| Rasulev           | 10         | 3        | 22          | 9.25            | 3.25                   | 23                | 9.5                      | 2016 |
| Lelong            | 8          | 4.25     | 34          | 9               | 4.5                    | 38                | 8.9                      | 2016 |
| Chang             | 9.7        | 3.2      | 23          | 9.4             | 3.6                    | 23                | 9.0                      | 2017 |
| Chen YT           | 9.2        | 2.7      | 39          | 9.6             | 4.6                    | 64                | 10.8                     | 2018 |
| Roodebeen         | 8          | 1        | 41          | 11              | 2.25                   | 41                | 12.6                     | 2018 |
| Persiani          | 5          | 3.25     | 46          | 7               | 8.5                    | 46                | 7.2                      | 2018 |
| Mege              | 10         | 6        | 34          | 11              | 5                      | 34                | 7.2                      | 2018 |
| **Total (95% CI)**| 376        | 453      | 100.0       | –0.89           | –0.13                  |                   |                           |

Heterogeneity: $t^2 = 2.04; \chi^2 = 41.38, df = 10 (p < 0.00001); I^2 = 76%$

Test for overall effect: $Z = 1.71 (p = 0.09)$

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**Figure 4.** Forest plots describing postoperative outcomes: readmission (A), reoperation (B), length of hospital stay (C) between TaTME and LaTME.
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### A. CRM

| Study or subgroup | TaTME Mean | SD | Total | LaTME Mean | SD | Total | Weight | CRM Mean difference | Year | Mean difference IV, random, 95% CI |
|------------------|------------|----|-------|------------|----|-------|--------|---------------------|------|-----------------------|
| Fernandez-Hevia  | 12         | 0.9| 37    | 11         | 0.6| 37    | 21.9   | 1.00 (0.65, 1.35)    | 2014 |                        |
| De'Angelis       | 9.68       | 4.57| 32    | 9.19       | 5.56| 32    | 17.6   | 0.49 (-2.00, 2.98)   | 2015 |                        |
| Chen             | 11.8       | 7.5 | 50    | 11.1       | 7.7 | 100   | 17.4   | 0.70 (-1.87, 3.27)   | 2016 |                        |
| Chouillard       | 11.4       | 6   | 18    | 13.7       | 8.3 | 15    | 10.8   | -2.30 (-7.33, 2.73)  | 2016 |                        |
| Mege             | 10         | 1.95| 41    | 5          | 1.75| 41    | 21.5   | 5.00 (4.20, 5.80)    | 2016 |                        |
| Rasulov          | 2          | 0.95| 34    | 2          | 1.75| 34    | 10.8   | -1.00 (-6.04, 4.04)  | 2018 |                        |
| Total (95% CI)   | 393        | 473 | 100.0 | 0.70       | 0.34, 1.42 |

Heterogeneity: $I^2 = 78.22$, $df = 8$ ($p = 0.45$), $F = 0$
Test for overall effect: $Z = 0.99$ ($p = 0.32$)

### B. Positive CRM

| Study or subgroup | TaTME Events | Total | LaTME Events | Total | Weight | Odds ratio M-H, random, 95% CI | Year | Odds ratio M-H, random, 95% CI |
|------------------|--------------|-------|--------------|-------|--------|-------------------------------|------|-----------------------------|
| Fernandez-Hevia  | 0            | 37    | 0            | 37    | Not estimable                  | 2014 |                            |
| De'Angelis       | 1            | 32    | 3            | 32    | 9.5         | 0.31 (0.03, 3.17)             | 2015 |                            |
| Chen             | 2            | 50    | 10           | 100   | 21.1        | 0.38 (0.08, 1.78)             | 2016 |                            |
| Lelong           | 2            | 34    | 4            | 38    | 16.5        | 0.53 (0.09, 3.10)             | 2016 |                            |
| Rasulov          | 1            | 22    | 0            | 23    | 4.8         | 3.28 (0.13, 84.87)            | 2016 |                            |
| Chang            | 0            | 23    | 4            | 23    | 5.8         | 0.09 (0.00, 1.82)             | 2017 |                            |
| Chen YT          | 0            | 39    | 4            | 64    | 5.9         | 0.17 (0.01, 3.25)             | 2018 |                            |
| Mege             | 4            | 34    | 2            | 34    | 16.4        | 2.13 (0.36, 12.51)            | 2018 |                            |
| Persiani         | 0            | 46    | 0            | 46    | Not estimable                  | 2018 |                            |
| Rabinkiewicz     | 1            | 35    | 0            | 35    | 4.9         | 3.09 (0.12, 78.41)            | 2016 |                            |
| Roodbeen         | 3            | 41    | 2            | 41    | 15.1        | 1.54 (0.24, 9.73)             | 2018 |                            |
| Total (95% CI)   | 393          | 473   | 100.0        | 0.70   | 0.34, 1.42 |

Heterogeneity: $I^2 = 0.00$, $df = 78$ ($p = 0.45$), $F = 0$
Test for overall effect: $Z = 0.99$ ($p = 0.32$)

**Figure 5.** Forest plots describing oncological outcomes: CRM (A), positive CRM (B), DRM (C), positive DRM (D) between TaTME and LaTME
### C

| Study or subgroup | TaTME | LaTME | Weight Mean difference | Year | Mean difference |
|------------------|-------|-------|------------------------|------|-----------------|
| Fernandez-Hevia  | 28    | 37    | 17 4.11 37 13.6 11.00 (8.74, 13.26) | 2014 |                 |
| De’Angelis       | 21.32 | 32    | 32 2.92 8.44 22.7 19.8 5.33 (0.25, 111.50) | 2015 |                 |
| Chouillard       | 32.5  | 16    | 18 36.1 13.9 15 8.8 3.60 (13.80, 6.60) | 2016 |                 |
| Chen             | 24    | 4.79  | 50 15 2.85 100 13.9 9.00 (7.81, 10.19) | 2016 |                 |
| Chang            | 13.5  | 10.5  | 23 15.5 10.5 23 11.6 2.00 (–8.07, 4.07) | 2017 |                 |
| Roodbeen         | 20    | 7.5   | 41 20 7.875 41 13.2 0.00 (3.33, 3.33) | 2018 |                 |
| Persiani         | 25    | 13.75 | 46 15 8.75 46 12.4 10.00 (5.29, 14.71) | 2018 |                 |
| Chen YT          | 16    | 4.43  | 39 19 4.11 64 13.8 3.00 (–4.72, –1.28) | 2018 |                 |

Total (95% CI) 286 358 100.0 2.83 (–2.11, 7.77)
Heterogeneity: $\chi^2 = 45.26; \chi^2 = 183.90, df = 7 (p < 0.00001); I^2 = 96%$
Test for overall effect: $Z = 1.12 (p = 0.26)$

### D

| Study or subgroup | TaTME | LaTME | Weight Mean difference | Year | Mean difference |
|------------------|-------|-------|------------------------|------|-----------------|
| De'Angelis       | 2     | 32    | 0 32 19.8 5.33 (0.25, 111.50) | 2015 |                 |
| Lelong           | 0     | 34    | 1 38 17.9 0.36 (0.01, 9.19) | 2016 |                 |
| Rubinkiewicz     | 0     | 35    | 1 35 17.9 0.32 (0.01, 8.23) | 2018 |                 |
| Mege             | 1     | 34    | 1 34 23.6 1.00 (0.06, 16.67) | 2018 |                 |
| Roodbeen         | 0     | 41    | 3 41 20.8 0.13 (0.01, 2.65) | 2018 |                 |

Total (95% CI) 176 180 100.0 0.62 (0.16, 2.44)
Total events 3 6
Heterogeneity: $t^2 = 0.00, \chi^2 = 3.37, df = 4 (p = 0.51); I^2 = 0%$
Test for overall effect: $Z = 0.68 (p = 0.50)$

Figure 5. Cont.
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Table A: Quality of mesorectum

| Study            | TaTME | LaTME | Weight | Mean difference | Year | Mean difference |
|------------------|-------|-------|--------|-----------------|------|-----------------|
| Fernandez-Hevia  | 6     | 37    | 14.7   | 12.8            | 2014 | –0.40 (–3.13, 2.33) |
| De’Angelis       | 17.06 | 7.14  | 18.63  | 8.7             | 2015 | –1.57 (–5.86, 2.72) |
| Rasulov          | 21    | 22    | 12.3   | 6.6             | 2016 | –0.70 (–3.48, 2.08) |
| Lelong           | 14    | 7     | 12.2   | 12.4            | 2016 | 2.00 (–0.88, 4.88) |
| Chouillard       | 10.8  | 18.3  | 9.9    | 6.6             | 2016 | –1.50 (–6.89, 3.89) |
| Chen             | 16.7  | 50    | 17.4   | 12.7            | 2016 | –0.70 (–3.48, 2.08) |
| Chang            | 22.8  | 19.5  | 8.6    | 6.3             | 2016 | –3.30 (–2.34, 8.94) |
| Roodbeen         | 18    | 41    | 32.5   | 16.8            | 2016 | 4.00 (2.59, 5.41) |
| Mege             | 14    | 14    | 8      | 8.7             | 2016 | 0.00 (–4.30, 4.30) |
| Chen YT          | 20.8  | 18.8  | 8.1    | 10.8            | 2016 | 2.00 (–1.45, 5.45) |

Total (95% CI): 299 301 100.0 1.15 (0.65, 2.04)

Heterogeneity: $t^2 = 0.21; \chi^2 = 11.19, df = 8 (p = 0.019); P = 28%$

Test for overall effect: Z = 0.50 ($p = 0.62$)

Table B: Harvested lymph nodes

| Study            | TaTME | LaTME | Weight | Odds ratio | Year | Odds ratio |
|------------------|-------|-------|--------|------------|------|------------|
| Fernandez-Hevia  | 34    | 37    | 13.7   | 1.65       | 2014 | 0.10, 4.12 |
| De’Angelis       | 27    | 32    | 13.7   | 1.80       | 2015 | 0.52, 6.25 |
| Rasulov          | 15    | 22    | 13.0   | 0.76       | 2015 | 0.21, 2.75 |
| Lelong           | 34    | 34    | 3.1    | 4.43       | 2016 | 0.22, 101.99 |
| Chouillard       | 14    | 8     | 10.5   | 3.06       | 2016 | 0.68, 13.79 |
| Rubinkiewicz     | 31    | 29    | 12.1   | 1.60       | 2016 | 0.41, 6.26 |
| Roodbeen         | 39    | 41    | 8.7    | 2.71       | 2018 | 0.49, 14.84 |
| Persiani         | 40    | 56    | 14.7   | 1.20       | 2018 | 0.37, 3.88 |
| Mege             | 18    | 34    | 16.5   | 0.29       | 2018 | 0.10, 0.85 |

Total (95% CI): 299 301 100.0 1.15 (0.65, 2.04)

Heterogeneity: $t^2 = 0.21; \chi^2 = 22.95, df = 9 (p = 0.006); P = 61%$

Test for overall effect: Z = 0.86 ($p = 0.39$)

Table C: Stoma

| Study            | TaTME | LaTME | Weight | Odds ratio | Year | Odds ratio |
|------------------|-------|-------|--------|------------|------|------------|
| Fernandez-Hevia  | 32    | 37    | 17.5   | 1.49       | 2014 | 0.43, 5.22 |
| Chen             | 46    | 50    | 17.8   | 1.14       | 2016 | 0.33, 3.89 |
| Chouillard       | 14    | 18    | 10.6   | 0.54       | 2016 | 0.08, 3.45 |
| Rasulov          | 22    | 22    | 4.6    | 5.23       | 2016 | 0.24, 115.38 |
| Chang            | 21    | 23    | 4.6    | 0.18       | 2017 | 0.01, 4.03 |
| Mege             | 31    | 31    | 12.2   | 1.00       | 2018 | 0.19, 173.47 |
| Persiani         | 45    | 46    | 9.0    | 21.77      | 2018 | 2.73, 173.47 |
| Roodbeen         | 28    | 41    | 23.7   | 1.53       | 2018 | 0.62, 3.77 |

Total (95% CI): 271 319 100.0 1.49 (0.74, 3.04)

Heterogeneity: $t^2 = 0.34; \chi^2 = 10.76, df = 7 (p = 0.15); P = 35%$

Test for overall effect: Z = 1.11 ($p = 0.27$)

Figure 6. Forest plots describing oncological outcomes: quality of mesorectum (A), number of harvested lymph nodes (B), and temporary stoma (C) between TaTME and LaTME
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Figure 7. Forest plot describing oncological outcome of local recurrence

| Study or subgroup | TaTME | LaTME | Weight (%) | Risk ratio M-H, random, 95% CI | Year |
|-------------------|-------|-------|------------|-------------------------------|------|
| De’Angelis        | 32    | 32    | 32.4       | 0.50 (0.05, 5.24)              | 2015 |
| Lelong            | 34    | 38    | 49.3       | 1.12 (0.17, 7.51)              | 2016 |
| Chen YT           | 34    | 34    | Not estimable |                               | 2018 |
| Mege              | 17    | 17    | 18.2       | 3.00 (0.13, 68.84)             | 2018 |
| Total (95% CI)    | 117   | 121   | 100.0      | 1.03 (0.27, 3.93)              |      |
| Total events      | 4     | 4     |            |                               |      |

Heterogeneity: $\tau^2 = 0.00; \chi^2 = 0.82, df = 2 (p = 0.66); I^2 = 0%$

Test for overall effect: $Z = 0.04 (p = 0.96)$

Figure 8. Funnel plot showing publication bias based on overall complication rate

References

1. Ries LA, Wingo PA, Miller DS, et al. The annual report to the nation on the status of cancer, 1973-1997, with a special section on colorectal cancer. Cancer 2000; 88: 2398-424.
2. Jacobs M, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). Surg Laparosc Endosc 1991; 1: 144-50.
3. Kearney DE, Coffey JC. A Randomized trial of laparoscopic versus open surgery for rectal cancer. N Engl J Med 2015; 373: 194.
4. 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: 767-74.
5. Pedziwiatr M, Malczak P, Mizera M, et al. There is no difference in outcome between laparoscopic and open surgery for rectal cancer: a systematic review and meta-analysis on short- and long-term oncologic outcomes. Tech Coloproctol 2017; 21: 595-604.
6. Malczak P, Mizera M, Torbicz G, et al. Is the laparoscopic approach for rectal cancer superior to open surgery? A systematic review and meta-analysis on short-term surgical outcomes. Videosurgery Miniinv 2018; 13: 129-40.
7. Heald RJ, Husband EM, Rayll RD. The mesorectum in rectal cancer surgery: the clue to pelvic recurrence? Br J Surg 1982; 69: 613-6.
8. Enker WE, Thaler HT, Cranor ML, Polyak T. Total mesorectal excision in the operative treatment of carcinoma of the rectum. J Am Coll Surg 1995; 181: 335-46.
9. Bach SF; Hill J, Monson JR, et al. A predictive model for local recurrence after transanal endoscopic microsurgery for rectal cancer. Br J Surg 2009; 96: 280-90.
10. Enker WE. Potency, cure, and local control in the operative treatment of rectal cancer. Arch Surg 1992; 127: 1396-401; discussion 1402.
11. Sylla P, Rattner DW, Delgado S, Lacy AM. NOTES transanal rectal cancer resection using transanal endoscopic microsurgery and laparoscopic assistance. Surg Endosc 2010; 24: 1205-10.
12. Zhang H, Zhang YS, Jin XW, et al. Transanal single-port laparoscopic total mesorectal excision in the treatment of rectal cancer. Tech Coloproctol 2013; 17: 117-23.
13. Heald RJ. A new solution to some old problems: transanal TME. Tech Coloproctol 2013; 17: 257-8.
14. 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. Lancet Oncol 2016; 20: 3210-5.
15. Lelong B, de Chaisemartin C, Meillat H, et al. A multicentre randomised controlled trial to evaluate the efficacy, morbidity and functional outcome of endoscopic transanal proctectomy versus laparoscopic proctectomy for low-lying rectal cancer (ETAP-GRECCAR 11 TRIAL): rationale and design. BMC Cancer 2017; 17: 253.
16. Xu W, Xu Z, Cheng H, et al. Comparison of short-term clinical outcomes between transanal and laparoscopic total mesorectal excision for the treatment of mid and low rectal cancer: a meta-analysis. Eur J Surg Oncol 2016; 42: 1841-50.
17. Ma B, Gao P, Song Y, et al. Transanal total mesorectal excision (TaTME) for rectal cancer: a systematic review and meta-analysis of oncological and perioperative outcomes compared with laparoscopic total mesorectal excision. BMC Cancer 2016; 16: 380.
18. Rubinkiewicz M, Czerwinska A, Zarzycki P, et al. Comparison of short-term clinical and pathological outcomes after transanal versus laparoscopic total mesorectal excision for low anterior rectal resection due to rectal cancer: a systematic review with meta-analysis. J Clin Med 2018; 7: 448.

19. Zhang X, Gao Y, Dai X, et al. Short- and long-term outcomes of transanal versus laparoscopic total mesorectal excision for mid-to-low rectal cancer: a meta-analysis. Surg Endosc 2018; doi: 10.1007/s00464-018-6527-z.

20. Jiang HP, Li YS, Wang B, et al. Pathological outcomes of transanal versus laparoscopic total mesorectal excision for rectal cancer: a systematic review with meta-analysis. Surg Endosc 2018; 32: 2632-42.

21. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000; 283: 2008-12.

22. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009; 339: b2700.

23. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003; 327: 557-60.

24. 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: 221-7.

25. De’Angelis N, Portigliotti L, Azoulay D, Brunetti F. Transanal total mesorectal excision for rectal cancer: a single center experience and systematic review of the literature. Langenbecks Arch Surg 2015; 400: 945-59.

26. Chen CC, Lai YL, Jiang JK, et al. Transanal total mesorectal excision versus laparoscopic surgery for rectal cancer receiving neoadjuvant chemoradiation: a matched case-control study. Ann Surg Oncol 2016; 23: 1369-76.

27. Chouillard E, Regnier A, Vitte RL, et al. Transanal NOTES total mesorectal excision (TME) in patients with rectal cancer: is anatomy better preserved? Tech Coloproctol 2016; 20: 537-44.

28. Lelong B, Meillat H, Zemmour C, et al. Short- and mid-term outcomes after endoscopic transanal or laparoscopic transabdominal total mesorectal excision for low rectal cancer: a single institutional case-control study. J Am Coll Surg 2017; 224: 917-25.

29. Rasulov AO, Mamedli ZZ, Gordeyev SS, et al. Transanal total mesorectal excision for rectal cancer: a single center experience and systematic review of the literature. Langenbecks Arch Surg 2015; 400: 945-59.

30. Chang TC, Kiu KT, Chang TC. Comparison of the short-term outcomes in lower rectal cancer using three different surgical techniques: transanal total mesorectal excision (TME), laparoscopic TME, and open TME. Asian J Surg 2018; doi: 10.1016/j.asjsur.2018.09.008.

31. Roodbeen SX, Penna M, Mackenzie H, et al. Transanal total mesorectal excision (TaTME) versus laparoscopic TME for MRI-defined low rectal cancer: a propensity score-matched analysis of oncological outcomes. Surg Endosc 2018; doi: 10.1007/s00464-018-6530-4.

32. Nowakowski M, Wierdak M, et al. Transanal total mesorectal excision for rectal cancer: a case-matched study comparing TaTME versus standard laparoscopic TME. Cancer Manag Res 2018; 10: 5239-45.

33. Klek S, Pisarska M, Milian-Ciesielska K, et al. Early closure of the protective ileostomy after rectal resection should become part of the Enhanced Recovery After Surgery (ERAS) protocol: a randomized, prospective, two-center clinical trial. Videosurgery Miniinv 2018; 13: 435-41.

34. Nowakowski MM, Rubinkiewicz M, Gajewska N, et al. Defunctioning ileostomy and mechanical bowel preparation may contribute to development of low anterior resection syndrome. Videosurgery Miniinv 2018; 13: 306-314.

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