REVIEW ARTICLE

Trans-anal minimally invasive surgery (TAMIS) versus rigid platforms for local excision of early rectal cancer: a systematic review and meta-analysis of the literature

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Abstract

Background Available platforms for local excision (LE) of early rectal cancer are rigid or flexible [trans-anal minimally invasive surgery (TAMIS)]. We systematically searched the literature to compare outcomes between platforms.

Methods PRISMA-compliant search of PubMed and Scopus databases until September 2022 was undertaken in this random-effect meta-analysis. Statistical heterogeneity was assessed using I^2 statistic. Studies comparing TAMIS versus rigid platforms for LE for early rectal cancer were included. Main outcome measures were intraoperative and short-term postoperative outcomes and specimen quality.

Results 7 studies were published between 2015 and 2022, including 931 patients (423 females); 402 underwent TAMIS and 529 underwent LE with rigid platforms. Techniques were similar for operative time (WMD 11.1, 95%CI − 2.6 to 25, p = 0.11), percentage of defect closure (OR 0.7, 95%CI 0.06–8.22, p = 0.78), and peritoneal violation (OR 0.41, 95%CI 0.12–1.43, p = 0.16). Rigid platforms had higher rates of short-term complications (19.1% vs 14.2, OR 1.6, 95%CI 1.07–2.4, p = 0.02), although no significant differences were seen for major complications (OR 1.41, 95%CI 0.61–3.23, p = 0.41). Patients in the rigid platforms group were 3-times more likely to be re-admitted within 30 days compared to the TAMIS group (OR 3.1, 95%CI 1.07–9.4, p = 0.03). Rates of positive resection margins (rigid platforms: 7.6% vs TAMIS: 9.34%, OR 0.81, 95%CI 0.42–1.55, p = 0.53) and specimen fragmentation (rigid platforms: 3.3% vs TAMIS: 4.4%, OR 0.74, 95%CI 0.33–1.64, p = 0.46) were similar between the groups. Salvage surgery was required in 5.5% of rigid platform patients and 6.2% of TAMIS patients (OR 0.8, 95%CI 0.4–1.8, p = 0.7).

Conclusion TAMIS or rigid platforms for LE seem to have similar operative outcomes and specimen quality. The TAMIS group demonstrated lower readmission and overall complication rates but did not significantly differ for major complications. The choice of platform should be based on availability, cost, and surgeon's preference.

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According to National Comprehensive Network Cancer and European Society of Medical Oncology guidelines, local excision (LE) may be used for treatment of early rectal cancer, defined as T1N0M0 cancer, when specific requirements are satisfied [1, 2]. The modalities used for LE include the traditional Parks' transanal excision for very distal lesions [3], transanal endoscopic microsurgery (TEM) [4] and transanal minimally invasive surgery (TAMIS) [5].

TEM was developed in the 1980s in Germany and involves a rigid platform (rectoscope) through which the lesion is resected using insufflation and custom designed instruments. Similar to TEM is the transanal endoscopic operation (TEO) [5], which was developed around the same time, again involving a rigid platform for resection of rectal lesions. The major difference between the two platforms is that TEO equipment is less costly than that of TEM [6, 7]. TAMIS involves a flexible, disposable platform [4] along with insufflation and standard laparoscopic instruments. We, therefore, aimed to perform a systematic review of the literature to compare the rigid and flexible (TAMIS) platforms in terms of intraoperative outcomes, postoperative morbidity, quality of the specimen and oncologic outcomes.

Material and methods

Review registration

This study has been registered in the PROSPERO register of systematic reviews (CRD42022357032) and was reported consistent with the PRISMA 2020 guideline [8]. Ethics approval and written consent to participate in the study were not required given that the study did not include patient information.

Search strategy and databases searched

A systematic search of PubMed and Scopus databases was performed through September 2022, by two authors (SMek, SMav). The terms "transanal minimally invasive surgery", "TEM", "TEO", "TES", "transanal endoscopic", "microsurgery", "operation", "platform", OR "tool", "port", "technique", "equipment", "instrument" combined with the Boolean operators AND/OR in order to detect all available studies comparing the two platforms. Following removal of duplicate studies, the abstract list generated by the above search was independently screened by three authors (ZG, SMek, SMav) for potentially relevant studies. After excluding irrelevant papers, a full-text evaluation of all remaining studies was undertaken for completeness and eligibility of reported data, according to the above exclusion criteria (Fig. 1). Any ensuing disagreements were resolved by a third reviewer (SDW).

Selection criteria

Studies deemed eligible for inclusion had to fulfill the following PICO criteria:

- P (patients): Adult patients undergoing transanal excision of suspicious rectal lesion
- I (intervention): Transanal excision using TAMIS platform
- C (comparator): Transanal excision using rigid platforms (TEM/TEO)
- O (outcome): Specimen quality, operative time, complication rate, recurrence rate, and length of stay.

We excluded studies that included patients younger than 18 years of age, reviews, editorials, clinical vignettes, case reports, animal studies, non-English text, and those with unavailable full-text or that had less than 10 patients.

Assessment of study quality and risk of bias

The risk of bias across the studies was assessed using the ROBINS-1 tool [9] by two independent authors (PA & ERO). Any conflict of interpretation between the two authors was resolved by a third author (ZG).

Outcomes

The primary outcome of this review was the specimen quality (fragmentation, R1 resection). Secondary outcomes included postoperative short-term (< 30 days) complications, blood loss, peritoneal violation, rate of defect closure, 30-day readmission, operative time, and oncological outcomes.

Data collection and analysis

Data of interest included year and quality of the publication, number of patients, sex, maximum diameter of the rectal lesion, complications, time of follow-up, and length of stay, among others. After a thorough full-text evaluation of the included studies, data of interest was extracted into excel spreadsheets (Microsoft, Redmond, Washington, USA) and subsequently cross-checked by two authors (SMek, SMav) for discrepancies.

An open-source, cross-platform software for advanced meta-analysis "openMeta [Analyst] ™" version 12.11.14 was used to conduct the meta-analysis of data. A meta-analysis was conducted to assess the odds ratio (OR) of specimen fragmentation, recurrence, and complications across the studies. Statistical heterogeneity was assessed using the

Fig. 1 Prisma flowchart
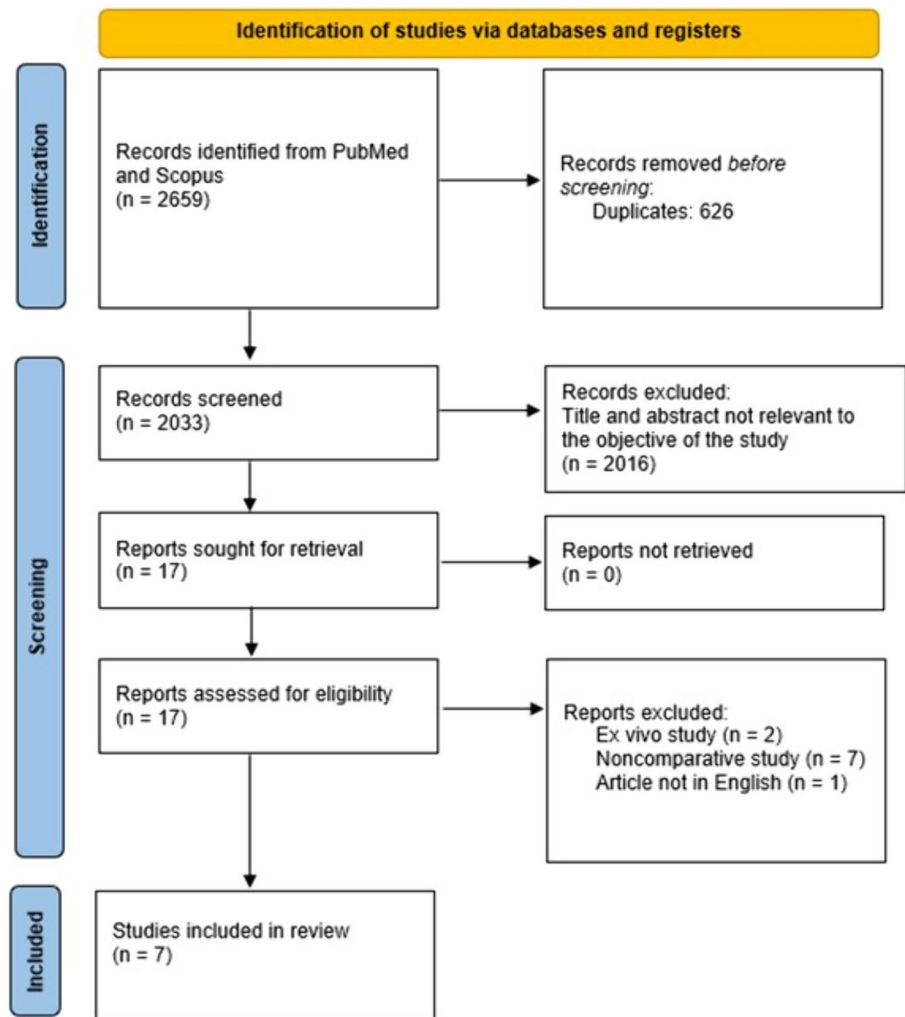
p-value of the Cochrane Q test and the Inconsistency (I^2) statistics (low if $I^2 < 25\%$, moderate if $I^2 = 25–75\%$, and high if $I^2 > 75\%$).

Definitions

Flexible platform: TAMIS. Includes use of laparoscopic instruments working through an elastic multiport device that is inserted into the anus.

Rigid platforms for transanal excision: TEM and TEO. Both use a rigid proctoscope and specialized equipment for the excision.

Short-term complications: All complications recorded ≤ 30 days postoperatively.

Minor Complications: Complications not requiring intervention under general anesthesia (Clavien-Dindo < IIIb according) [10].

Major Complications: Complications requiring intervention under general anesthesia (Clavien-Dindo ≥ IIIb) [10].

Salvage Surgery: Additional surgery to address residual or recurrent disease.

Results

Study and patient characteristics

A total of 7 [11–17] studies published between 2015 and 2022 were included in the analysis, which encompassed 931 patients [423 females; median age 63 (range 20–92) years]. 402 patients underwent TAMIS, while 529 underwent transanal excision with the use of rigid platforms (TEM and TEO). The median age and body mass index (BMI) were comparable between the two groups (Table 1). Three studies [12, 13, 15] report details on neoadjuvant radiation therapy that was given to 36 (6.8%) patients in the rigid platforms group and 23 patients (5.7%) in the TAMIS group. Only one study [17] involved 10 patients who underwent robotic TAMIS. The outcomes of the robotic TAMIS platform were

Table 1 Studies and patient characteristics

| Studies	Year	Total No patients	TEM/TEO		TAMIS	
			No females	Age (mean)	No females	Age (mean)
Molina et al. [14]	2015	78	42	61.4	N/A	61.4
Melin et al. [11]	2016	69	18	63.2	12	64.3
Lee et al. [13]	2017	428	97	65.9	74	65.0
Mege et al. [12]	2017	74	13	63	15	67
Van den Eynde et al. [16]	2019	121	41	63	45	69
Stipa et al. [15]	2022	132	30	66.8	29	67.1
Schwab et al. [17]	2022	29	7	56	9	NA

TEM/TEO transanal endoscopic microsurgery/transanal endoscopic operation, *TAMIS* trans-anal minimally invasive surgery

aggregated with conventional TAMIS and compared to the rigid platforms.

Intraoperative outcomes

There were no significant differences observed between TAMIS and rigid platforms in terms of blood loss [weighted mean difference (WMD) 1.13, 95% CI − 16.8 to 19.1, p = 0.9, I^2 = 97.9] or operative time (WMD 11.1, 95% CI − 2.6 to 25, p = 0.11, I^2 = 91.7) (Fig. 2). The odds of defect closure (OR 0.7, 95% CI 0.06–8.22, p = 0.78, I^2 = 73.2) and peritoneal violation (OR 0.41, 95% CI 0.12–1.43, p = 0.16, I^2 = 62.4) were similar between the two groups (Fig. 3). Only 4 studies [11, 13–15] provided information on conversion to an abdominal approach after a peritoneal violation. Eight (18.6%) out of 43 patients were converted to an abdominal approach after the peritoneal violation [5/30 (16.7%) in the rigid platforms group and 3/13 (23.1%) in the TAMIS group].
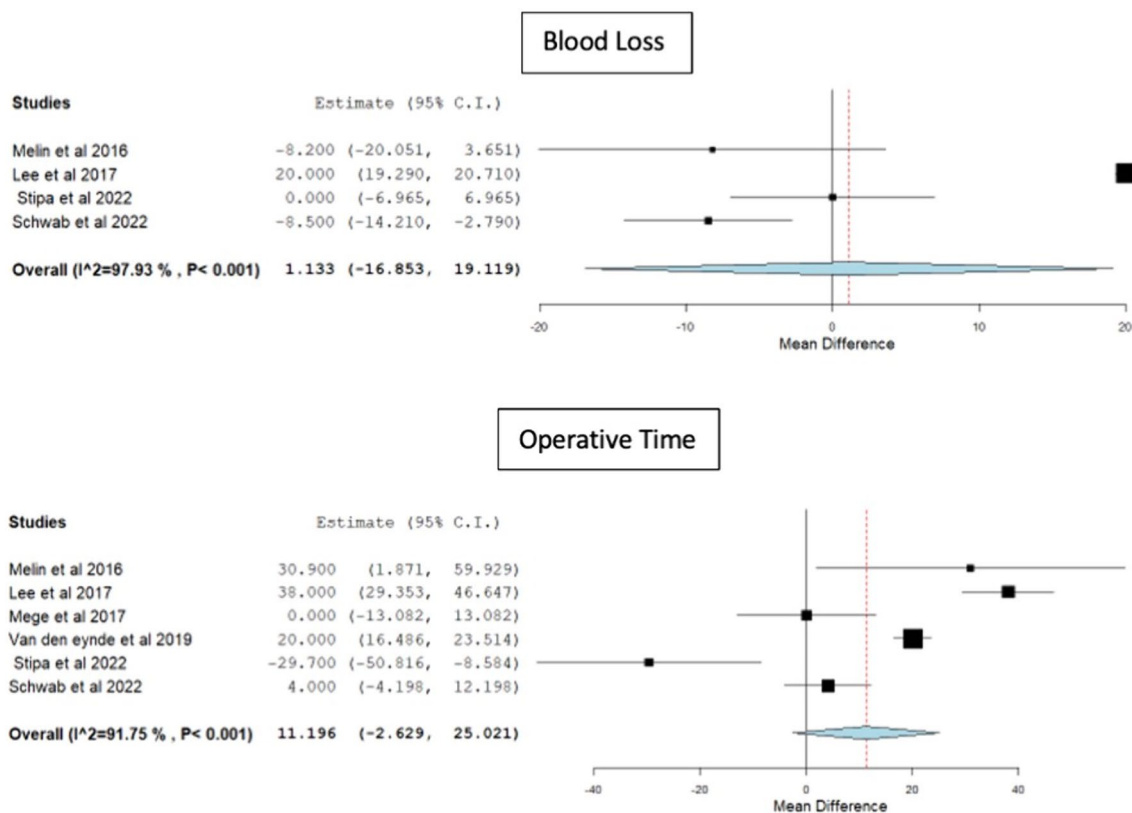
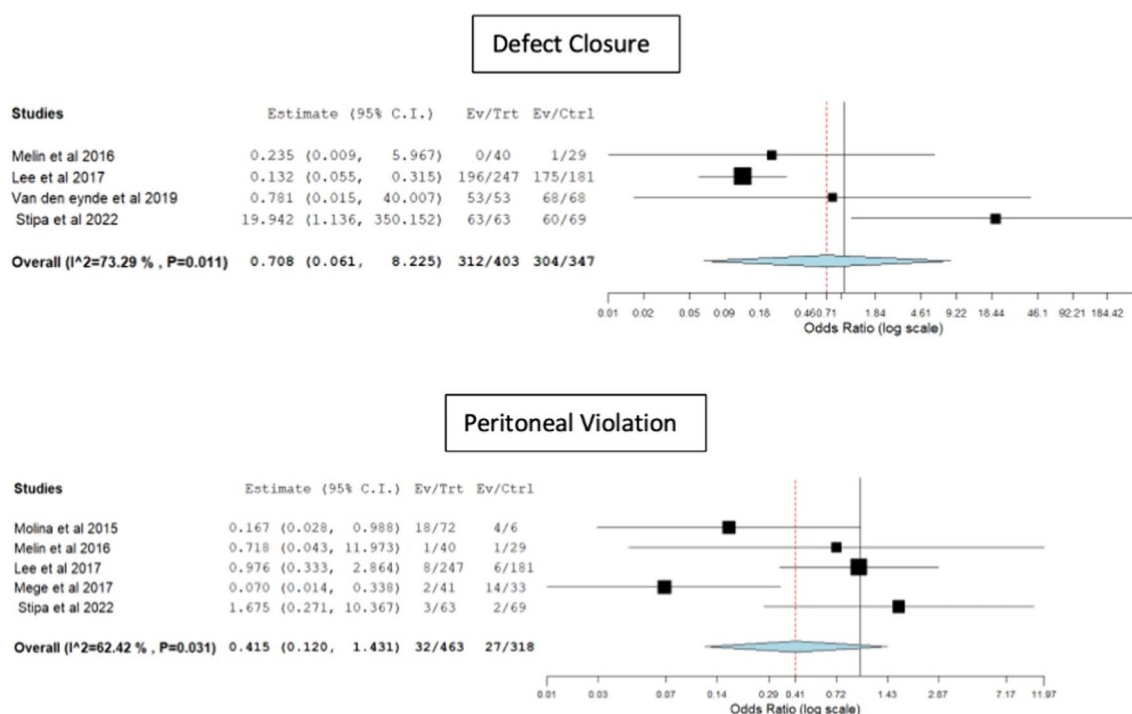**Fig. 2** Forest plots for blood loss and operative time

Fig. 3 Forest plots for defect closure and peritoneal violation

Short-term post-operative outcomes

Rigid platforms had a higher rate of short-term complications (19.1% vs 14.2, OR 1.6, 95% CI 1.07–2.4, p = 0.02, $I^2 = 0$). There were no significant differences between the two techniques in terms of minor (OR 1.52, 95% CI 0.99–2.36, p = 0.056, $I^2 = 0$) or major (OR 1.41, 95% CI 0.61–3.23, p = 0.41, $I^2 = 0$) complications (Fig. 4).

The re-admission rate within 30 days was higher in the rigid platforms group, with patients being 3-times more likely to be re-admitted compared to the TAMIS group (OR 3.1, 95% CI 1.07–9.4, p = 0.03, $I^2 = 0$) (Fig. 5).

Pathologic and oncological outcomes

The rates of positive resection margins (rigid platforms: 7.6% vs TAMIS: 9.34%, OR 0.81, 95% CI 0.42–1.55, p = 0.53, $I^2 = 27.6$) and specimen fragmentation (rigid platforms: 3.3% vs TAMIS: 4.4%, OR 0.74, 95% CI 0.33–1.64, p = 0.46, $I^2 = 0$) were similar in both groups (Fig. 6).

Analysis of oncological outcomes from three studies with a median follow-up of 14 months showed comparable rates of local recurrence (rigid platforms: 3.2% vs TAMIS: 3.9%, OR 0.8, 95% CI 0.33–1.94, p = 0.63, $I^2 = 0$). The rates of salvage surgery were 5.5% for rigid platforms and 6.2% for TAMIS (OR 0.8, 95% CI 0.4–1.8, p = 0.7, $I^2 = 0$).

Quality of the studies and certainty of evidence

All studies were deemed as serious risk of bias (Supplementary Table 1) according to ROBINS-1 tool [9] and therefore the quality of evidence provided for all outcomes in this meta-analysis was assessed as very low according to the GRADE approach (Supplementary Table 2) [18]

Discussion

Early rectal cancer with favorable histology is amenable to treatment with LE if specific criteria are met [1, 2]. Local excision for rectal cancer has traditionally been performed transanally. Historically, the initial approach to LE was the Parks' transanal excision. However, this option evolved to encompass both rigid (TEM and TEO) and flexible platforms (TAMIS). A meta-analysis of comparative non-randomized trials published in 2015 by Clancy et al. [19] demonstrated that TEM was associated with better outcomes in terms of specimen quality, which translated into a reduced rate of specimen fragmentation and a lower rate of positive microscopic margins (R1) when compared to classic transanal excision. Moreover, the authors noted that recurrence rates were lower in the TEM group [19].

The first platforms used for endoscopic transanal excision, developed in Germany during the 1980s, were rigid
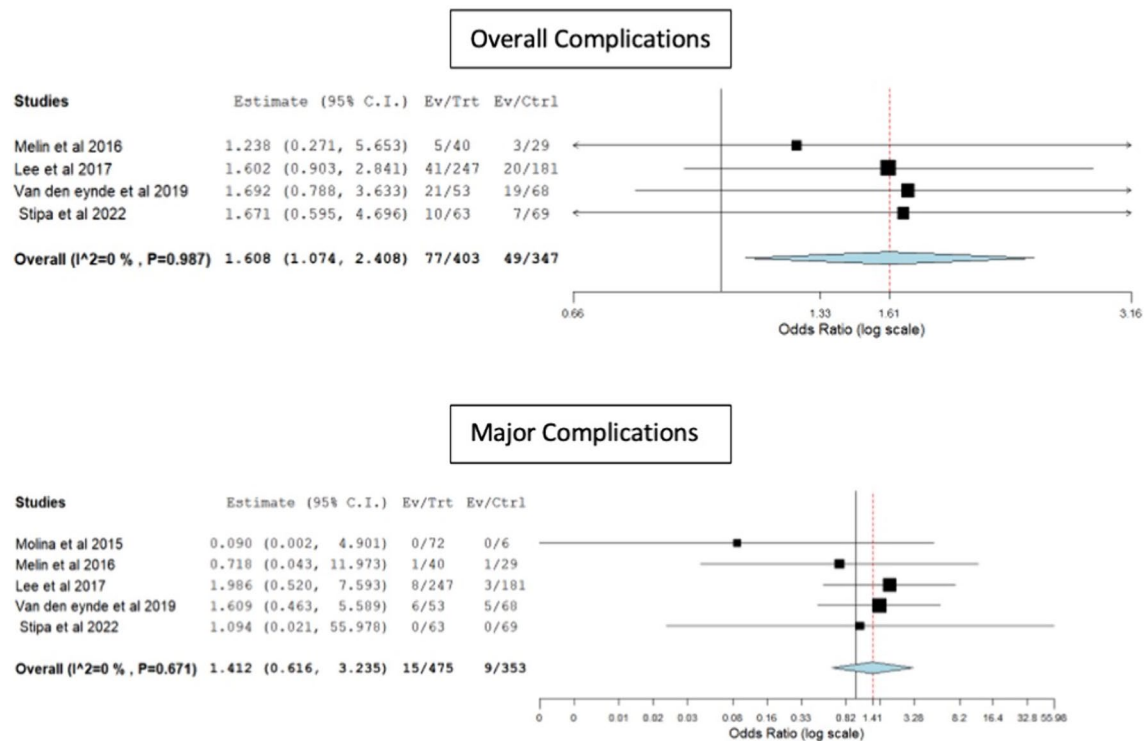
Overall Complications

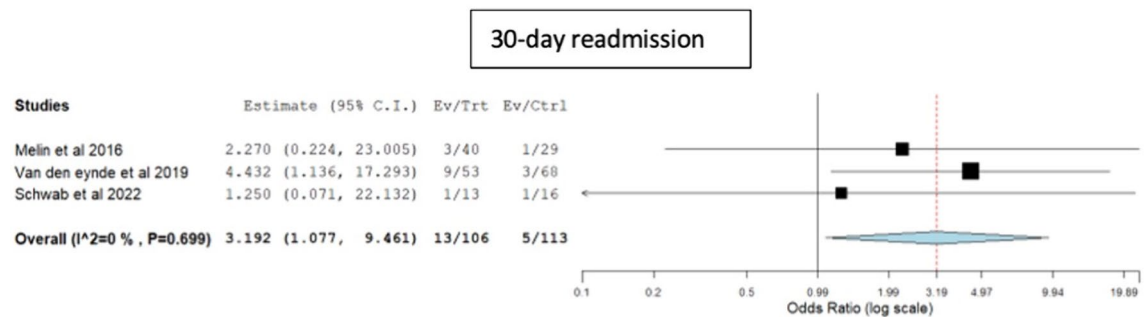| Studies	Estimate (95% C.I.)	Ev/Trt	Ev/Ctrl
Melin et al 2016	1.238 (0.271, 5.653)	5/40	3/29
Lee et al 2017	1.602 (0.903, 2.841)	41/247	20/181
Van den eynde et al 2019	1.692 (0.788, 3.633)	21/53	19/68
Stipa et al 2022	1.671 (0.595, 4.696)	10/63	7/69
Overall (I^2=0 % , P=0.987)	1.608 (1.074, 2.408)	77/403	49/347

Major Complications

Studies	Estimate (95% C.I.)	Ev/Trt	Ev/Ctrl
Molina et al 2015	0.090 (0.002, 4.901)	0/72	0/6
Melin et al 2016	0.718 (0.043, 11.973)	1/40	1/29
Lee et al 2017	1.986 (0.520, 7.593)	8/247	3/181
Van den eynde et al 2019	1.609 (0.463, 5.589)	6/53	5/68
Stipa et al 2022	1.094 (0.021, 55.978)	0/63	0/69
Overall (I^2=0 % , P=0.671)	1.412 (0.616, 3.235)	15/475	9/353

Fig. 4 Forest plots for overall and major complications

30-day readmission

Studies	Estimate (95% C.I.)	Ev/Trt	Ev/Ctrl
Melin et al 2016	2.270 (0.224, 23.005)	3/40	1/29
Van den eynde et al 2019	4.432 (1.136, 17.293)	9/53	3/68
Schwab et al 2022	1.250 (0.071, 22.132)	1/13	1/16
Overall (I^2=0 % , P=0.699)	3.192 (1.077, 9.461)	13/106	5/113

Fig. 5 Forest plot for 30-day readmission rate

in their design (TEM) [4]. Subsequently, a similar rigid platform was produced by Karl Storz and was introduced as TEO [20]. Both of these platforms shared similar properties including rigid resectoscopes with insufflation mechanisms and custom designed instruments. There are three major disadvantages with these platforms: [7] high cost as they require specialized equipment (insufflator, resectoscope, stereotactic scope, and angled instruments); length of the platform (longer than the flexible one by 10–15 cm) allows less triangulation of the working instruments; and the view is static given that the scope is fixed in a specific position. The latter two characteristics are what make the TEM and TEO procedures more technically demanding

[7]. In 2010 Atallah et al. [5] presented a novel transanal approach using the single-incision laparoscopic surgery port (SILS Port, Covidien). A tailor-made platform (GelPoint, Path Transanal Access Platform) was subsequently marketed to allow the use of standard laparoscopic instruments and insufflators.

The main aim of our study was to compare the intraoperative outcomes of the rigid and flexible platforms for transanal excision. We did not find any significant differences between the two platforms in terms of blood loss or operative time. The learning curve for TAMIS is a minimum of 14–24 cases to reach reported R0 resection rates according to Lee et al. [21], while the learning curve for TEM ranges
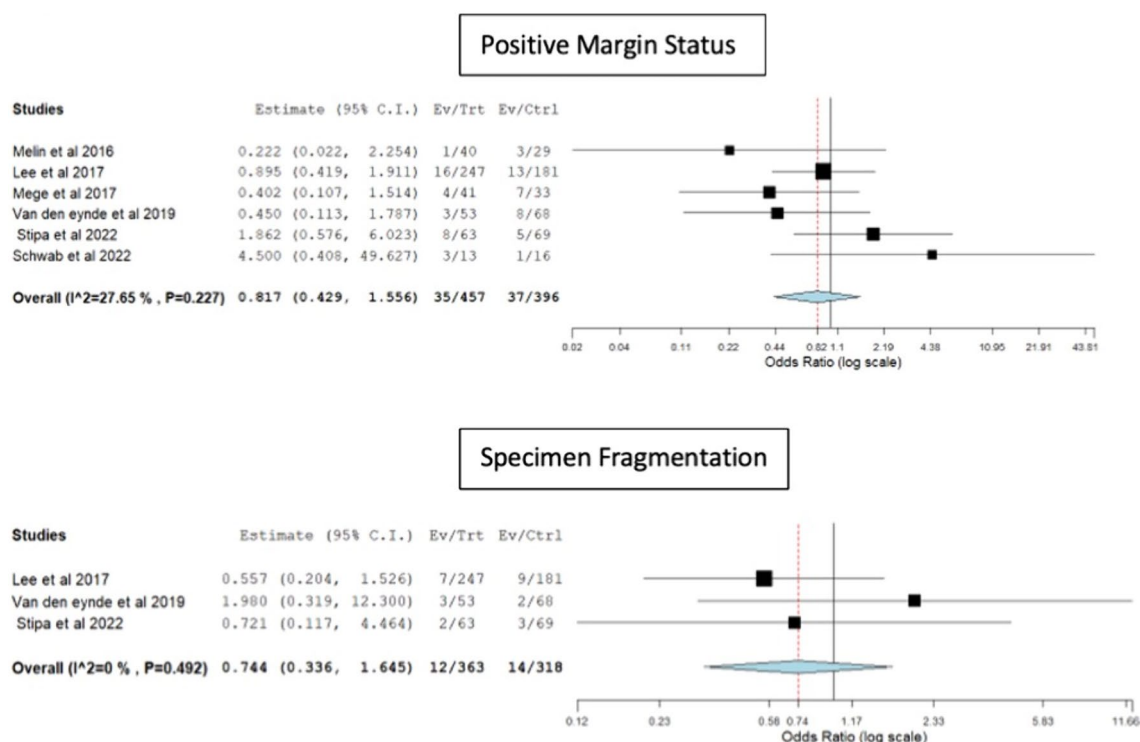
Fig. 6 Forest plots for positive resection margins and specimen fragmentation

in the literature from 4 [22] to more than 36 cases [23]. Interestingly, although TEM and TEO are considered more technically demanding and associated with a steeper learning curve, our study did not find any differences in defect closure, peritoneal violation, or specimen fragmentation. Although the median follow-up of our study was too short to make any definitive conclusions regarding oncologic outcomes, local recurrence rates were similar between the two platforms. Similarly, R1 resection rates and rates of salvage surgery were similar between the two platforms.

Common postoperative complications of both platforms reported in the literature are acute urinary retention (4.9%) and rectal bleeding (2.2%) [24]. According to the results of our study, the TAMIS group demonstrated lower rates of overall complications. Nevertheless, the two platforms did not significantly differ in terms of major complications (rigid platforms group: 3.1% versus TAMIS: 2.54%). The rigid platform group demonstrated a higher rate of minor complications (12.65%) compared to TAMIS (10%), although this difference did not reach statistical significance (OR 1.52, 95% CI 0.99–2.36, p = 0.056). This might explain the higher 30-day re-admission rate in the rigid platforms group (OR 3.1, 95% CI 1.07–9.4, p = 0.03).

Unfortunately, the studies included in this review did not report any data regarding cost or functional results. A systematic review by Marinello et al. [25] in 2020 showed some short-term deterioration in manometric results using

either platform but with no impairment in quality of life. Nevertheless, the authors state that these results should be interpreted with caution as the data were heterogeneous and pooled analysis was not feasible. Another case series [26] published later the same year, including only patients undergoing TAMIS with a 5-year follow-up, showed that the majority of the patients (approximately 73%) had no symptoms of low anterior resection syndrome after five years. Regarding cost-effectiveness, Yu et al. [27] using a Markov model, reported similar cost-effectiveness among TEM and TAMIS, even though the initial capital for obtaining TEM and TEO equipment is much higher than TAMIS.

The two platform types demonstrate comparable intraoperative outcomes and specimen quality. TAMIS seems to be associated with a lower readmission rate and overall complication rate. Nevertheless, our study has certain limitations. All studies were retrospective, thus amenable to selection bias and involving a relatively low number of patients. In addition, the surgeon's experience with each platform is not reported, which could be a significant confounding factor. Finally, although these procedures are better used for patients with early rectal cancer, they have also been employed for palliative reasons and for patients with more advanced disease who were not deemed eligible to undergo surgery. Thus, we did not focus on long-term oncologic outcomes.

Conclusion

The use of either TAMIS or rigid platforms for LE of early rectal cancer seem to have similar operative and short-term postoperative outcomes, except for a lower readmission rate and lower overall complication rate after TAMIS. Moreover, specimen quality did not differ between the two techniques. The certainty of evidence was very low, which unfortunately precluded our ability to recommend any one technique. Thus, the choice of platform should be based on its availability, costs, and surgeon's preference and experience.

Declarations

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