

META-ANALYSIS

Submucosal tunnel endoscopic resection versus endoscopic mucosal dissection for submucosal masses in esophageal muscularis propria: a systematic review and meta-analysis

Rayyan Fahad H. Altemani[1*], Muflih Abdullah S. Albalawi[2], Yazeed Saeed M. Alqahtani[2], Yousef Ali H. Alaenzi[2], Sager Loaie H. Algorashi[2], Abdullah Majed H. Alruwaili[2], Abdulmohsen Mohmmed M. Alamri[2], Marwan Fahad H. altemani[2], Mohammed Abdullah M. Albalawi[3]

ABSTRACT

Introduction: Esophageal submucosal tumors (SMTs), predominantly leiomyomas, are mostly benign but may pose diagnostic and treatment challenges. Traditionally managed by surgery, minimally invasive approaches like submucosal tunneling endoscopic resection (STER) and endoscopic submucosal dissection (**ESD)** now offer safer, less traumatic alternatives. This review compares their safety, efficacy, and outcomes for tumors from the esophageal muscularis propria (MP).

Methods: This systematic review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, searching Medline, Cochrane, and Web of Science up to September 2025. Eligible English studies compared STER and ESD for esophageal SMTs from MP. Four reviewers extracted data, quality was assessed using the NIH tool, and Review Manager Software 5.3 conducted analyses with heterogeneity and bias assessments.a)

Results: This meta-analysis of three retrospective cohort studies (ESD n = 208, STER n = 201) found no significant difference in operating duration [MD = 2.89, 95%CI (-20.84, 26.62), p = 0.81]. STER was associated with shorter hospital stay [MD = -2.25, 95%CI (-2.37, -2.13), p < 0.00001] and lower complication risk [OR = 0.34, 95%CI (0.14, 0.78), p = 0.01].

Conclusion: ESD and STER show similar operating times; however, STER reduces hospital stay and complications, suggesting greater safety and efficiency, though larger, diverse studies are required to validate and guide clinical decisions.

Keywords: Esophageal submucosal tumors, submucosal tunnel endoscopic resection, endoscopic mucosal dissection.

Introduction

Esophageal submucosal tumors (SMTs) are relatively uncommon, with leiomyomas representing the predominant type, comprising approximately 70% to 80% of cases [1]. These tumors are twice as common in men as in women, and nearly 80% are located in the middle and lower segments of the esophagus [2]. Dysphagia is the most frequently reported symptom, often accompanied

Correspondence to: Rayyan Fahad H. Altemani
*Internal Medicine Department, The University of Utah, Salt Lake City, USA.
Email: rayyan.temani@gmail.com
Full list of author information is available at the end of the article.
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by chest discomfort and pain [3]. SMTs are growths that arise from the layer of tissue located beneath the gastrointestinal mucosa. Although the majority of tumors originating from the esophageal muscularis propria (MP) are benign, assessing their biological behavior can be challenging, as some may exhibit malignant potential. The increasing use of gastrointestinal endoscopy and endoscopic ultrasonography has led to a rise in the detection of esophageal tumors originating from the MP [4]. Previously, surgical resection was considered the standard treatment for the majority of patients [5]. However, postoperative management often involves prolonged follow-up, which can contribute to both financial strain and psychological stress for patients.

Surgical procedures, particularly thoracoscopic enucleation, were the standard approach for removing esophageal SMTs arising from the MP layer [6]. Submucosal tunneling endoscopic resection (STER) is primarily utilized for resecting lesions in the upper gastrointestinal tract that originate from the MP. This technique involves creating a submucosal tunnel to excise the tumor while preserving mucosal integrity, thereby lowering the risk of perforation. During the procedure, the vascular architecture of the wound is clearly visualized, which helps minimize bleeding from inadvertent vessel injury. Moreover, since STER is performed within the esophageal lumen, it avoids manipulation of the surrounding mediastinal structures, reducing the risk of tissue damage [7].

The rapid advancement of minimally invasive and endoscopic techniques has led to their widespread adoption in clinical practice, largely due to their benefits of reduced patient trauma and faster postoperative recovery. Innovative endoscopic techniques, such as endoscopic submucosal dissection (ESD), have emerged as promising alternatives for the treatment of esophageal tumors originating from the MP [8]. Emotional distress, such as anxiety and frustration, along with limited awareness and financial constraints, are significant obstacles preventing patients from seeking timely cancer prevention treatments, often resulting in disease progression. Consequently, endoscopic techniques have become the preferred option over surgical resection for managing submucosal esophageal tumors [9]. The aim of this systematic review and meta-analysis aims to compare the safety, efficacy, and clinical outcomes of STER versus ESD in the management of SMTs originating from the esophageal MP.

Methods

This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to ensure transparency, completeness, and reproducibility of the research process and findings.

Search strategy

We systematically searched Medline, Cochrane, and Web of Science from inception to September 2025, without restrictions on publication date. A sestematic search was done by using a keywords and MeSH terms related to the title: [("Esophagus" OR esophagus OR oesophagus OR esophageal OR oesophageal) AND ("SMT*" OR "submucosal mass*" OR SMT OR leiomyoma OR "gastrointestinal stromal tumor*" OR GIST] AND ["STER" OR "Endoscopic Submucosal Tunnel Dissection") AND ("ESD")].

Inclusion and exclusion criteria

Studies were selected based on the following inclusion criteria: studies published without time frame limitations up to September 2025, articles published in English language, studies involving SMTs of the esophagus originating from the MP, and studies directly comparing STER and ESD. Studies involving non-esophageal SMTs, Animal studies, or purely laboratory-based research, and Duplicate publications or overlapping patient cohorts were excluded.

Data extraction and risk of bias assessment

Data extraction was performed independently by four reviewers, with a fifth reviewer available to resolve disagreements. The extracted information included author's name, year of publication, study design, sample size, patient demographics, and the method used to measure outcomes. It assesses various domains such as the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. All the included studies were evaluated using NIH tool. Studies may be evaluated using a numerical scale to assess methodological rigor. A score between 10 and 14 denotes good quality. Scores from 7 to 9 represent fair quality, while those ranging from 0 to 6 are classified as poor quality, reflecting significant limitations.

Statistical analysis

Review Manager Software version 5.3 was used for statistical analysis. For continuous variables, mean differences and 95% confidence intervals were calculated. For dichotomous variables, risk ratios and 95% confidence intervals were calculated. Beyond that, I^2 statistic and X^2 test were performed to determine the heterogeneity of the studies. High heterogeneity is I^2 equal to 75% or more. Mean differences were employed as the measure of effect size for continuous outcomes, while median values and event numbers were used for ordinal and dichotomous outcomes, respectively. Heterogeneity was assessed using the I^2 statistic, considering a value above 50% as indicative of substantial heterogeneity. A two-sided p-value less than 0.05 was deemed statistically significant. To assess publication bias, both Begg's funnel plots and the Egger test were employed, with p-values calculated for each assessed outcome.

Results

Characteristics of the included studies

Three studies (ESD; n = 208, STER; n = 201) were included in our systematic review and meta-analysis

[10-12]. All the included studies were retrospective cohort studies and were conducted in China. Mean age of patients in ESD group ranged from 51 to 61 years and from 49 to 56 years in STER group. 56.25% of participants in ESD group were males, and 110 54.7% in STER group.

Meta analysis

Operating duration

All the studies reported the outcome [10-12]. Our analysis showed no difference between the groups in operating duration [MD = 2.89, 95%CI (-20.84, 26.62), $p = 0.81$], with high heterogeneity 82% Figure 1.

Hospital stay

All the studies reported the outcome[10-12]. Our analysis showed that STER is significantly associated with lower hospital stay duration [MD = -2.25, 95%CI (-2.37, -2.13), $p < 0.00001$], with no heterogeneity 0% Figure 2.

Complication/adverse events

All the studies reported the outcome [10-12]. Our analysis showed that STER is significantly associated with lower risk of adverse events [OR = 0.34, 95%CI (0.14, 0.78), $p = 0.01$], with no heterogeneity 0% Figure 3.

Quality assessment

The quality appraisal of the included cohort studies, conducted using the NIH assessment tool, demonstrated that all three studies achieved a "good" rating, reflecting methodological rigor and reliable evidence strength Table 1.

Discussion

This systematic review and meta-analysis aimed to compare the effectiveness of ESD and STER in patients undergoing gastrointestinal procedures. The analysis revealed no significant difference between the two techniques in operating duration, suggesting that both methods are comparable in terms of procedural time. However, STER was associated with a significantly shorter hospital stay and a reduced risk of adverse events compared to ESD, making it a potentially more favorable option for patient recovery and overall hospital efficiency. The similarity in operating duration between ESD and STER aligns with earlier studies, indicating that both methods are technically similar and do not result in major time disparities. The shorter hospital stay associated with STER is noteworthy, reinforcing findings from prior research that this technique might lead to quicker patient recovery. The reduction in complications with STER further supports its role as a safer and more

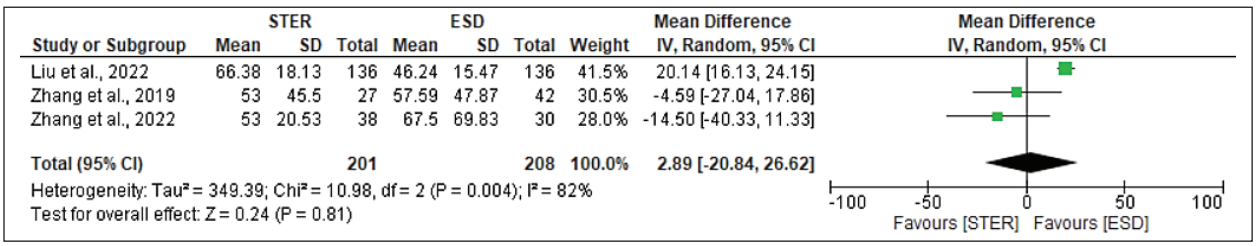

Figure 1. *Pooled meta-analysis for operating duration.*

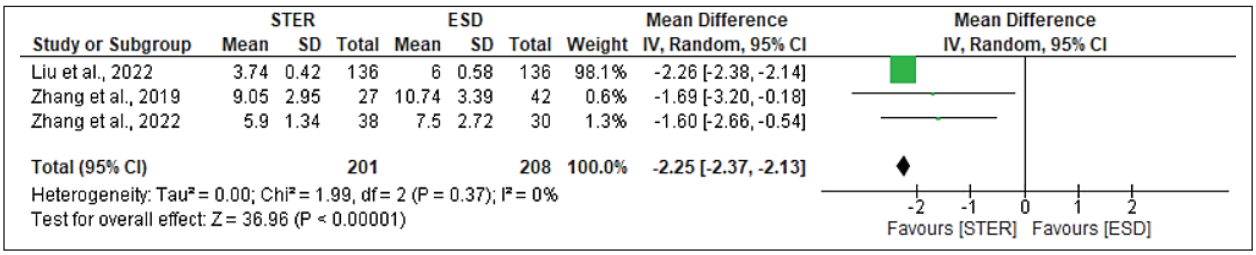

Figure 2. *Pooled meta-analysis for hospital stay.*

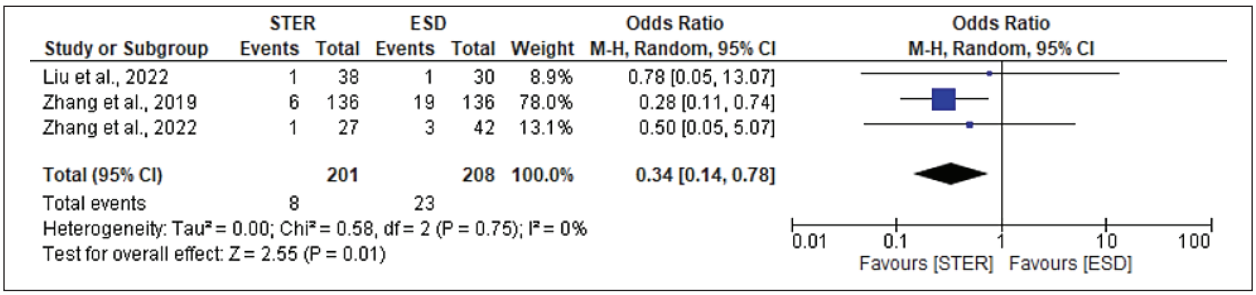

Figure 3. *Pooled meta-analysis for complication/adverse events.*

Table 1. *Characteristics of the included studies.*

Study	Country	Design	Patients		Mean age		Male, Female		Conclusion
			ESD	STER	ESD	STER	ESD	STER	
Zhang et al. [18]	China	Cohort	30	38	61.40 ± 10.26	56.87 ± 8.96	14, 16	17, 21	In conclusion, our study shows that STER can safely and effectively treat submucosal intrinsic esophageal muscle tumors with fewer complications, such as bleeding and perforation, while offering the advantages of shorter hospital stay, lower hospital costs, and lesser trauma than ESD.
Liu et al. [11]	China	Cohort	136	136	51.58 ± 5.29		80, 56	75, 61	STER is an effective method for the treatment of submucosal masses in esophageal MP, which can exhibit a good effect with faster postoperative recovery and higher safety, thereby being worthy of clinical application and promotion. Tumor size, lesion level, adhesion, and surgical approaches are all related factors affecting the effect of STER treatment.
Zhang et al. [12]	China	Cohort	42	27	51.87 ± 9.13	49.93 ± 10.40	23, 19	18, 9	STER is a feasible, safe, and effective approach for the resection of esophageal MP tumors £40 mm. We recommend STER as a potent alternative for these tumors.

efficient approach, though more diverse and larger-scale studies would help confirm these promising trends.

A recent meta-analysis by Liu et al. [13] involving 315 patients indicated that STER was significantly faster than ESD, with a mean difference of 5.06 minutes (95% CI: 3.31-6.80; $p < 0.01$), and associated with lower rates of major complications and postoperative esophageal stricture. However, no significant differences were observed in en bloc and curative resection rates between the two techniques [13]. Similarly, a study by Liu et al. [14] involving seven studies concluded that STER is as safe as and more effective than ESD, especially for gastric lesions. The study found that STER had a higher en bloc resection rate for early superficial gastric lesions and a faster dissection speed, with no significant differences in bleeding and perforation rates between the groups [14]. In contrast, our analysis revealed no significant difference in operating duration between ESD and STER [MD = 2.89, 95% CI (-20.84, 26.62), $p = 0.81$], which aligns with the findings of Liu et al. [15] who reported no significant difference in operation time between the two techniques for esophageal lesions. However, our study observed that STER was associated with a significantly shorter hospital stay and a lower risk of adverse events compared to ESD, which is consistent with the findings of Liu et al. [15] who reported a lower incidence of complications in elderly patients undergoing STER for upper gastrointestinal SMTs. The discrepancies observed in operating duration between our study and previous research may be attributed to differences in study design, patient populations, and institutional practices. For instance, the studies included in our analysis were all conducted in China, which may limit the generalizability of our findings to other populations with different demographics or healthcare systems. Additionally, variations in surgical techniques and patient characteristics across studies may have influenced the results.

The 2024 European Society of Gastrointestinal Endoscopy guidelines on endoscopic resection of early gastrointestinal neoplasia suggest that STER may offer advantages in terms of shorter hospital stays and reduced complication rates compared to ESD, particularly for lesions located in the upper gastrointestinal tract. However, the guidelines emphasize the need for further high-quality, multicenter randomized controlled trials (RCTs) to confirm these benefits and to establish standardized protocols for patient selection and procedural techniques [16].

Similarly, the 2023 Asia-Pacific Consensus on ESD and Endoscopic Resection for Early Gastrointestinal Neoplasia highlights that while STER has shown promising results, its adoption should be considered on a case-by-case basis, considering factors such as lesion location, size, and the operator's expertise. The consensus underscores the importance of a tailored approach to treatment, with a recommendation for further research to refine patient selection criteria and to assess long-term outcomes associated with STER [17].

One of the primary strengths of this analysis is the inclusion of high-quality retrospective cohort studies, which provide a solid foundation of data for comparison. The studies selected were all well-designed, adding confidence to the findings. However, a key limitation lies in the fact that all the included studies were conducted in China, which may limit the generalizability of the results to other populations with different demographics or healthcare systems. Additionally, the significant heterogeneity observed in the operating duration analysis raises concerns. Variability in surgical techniques or patient characteristics across studies may have influenced this result, which was not fully accounted for in the meta-analysis. Future research should prioritize multicenter randomized controlled trials to enhance the quality of evidence comparing ESD and STER. Such trials, particularly those spanning different geographic locations, would provide more robust insights into the generalizability of these findings across diverse patient populations. Additionally, studies examining the long-term outcomes of both procedures, such as recurrence rates, quality of life post-procedure, and cost-effectiveness, could provide a more comprehensive understanding of the true clinical benefits of STER over ESD. More detailed exploration of patient selection criteria and potential factors that influence recovery times would be instrumental in refining clinical decision-making.

Conclusion

In conclusion, both ESD and STER appear comparable in terms of operating duration, but STER offers significant advantages in reducing hospital stay and the risk of complications. These findings suggest that STER may be a more efficient and safer option for patients, though further large-scale, diverse studies are needed to confirm these outcomes and improve clinical decision-making.

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Conflicts of interest

The authors declare no conflicts of interest.

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Consent to participate

Not applicable.

Consent for publication

Not applicable.

Ethics approval

Not applicable.

Availability of data and material

All data are available within the manuscript and its supplemental files. See Supplementary material online.

Code availability

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None.

Author details

Rayyan Fahad H. Altemani[1], Muflih Abdullah S. Albalawi[2], Yazeed Saeed M. Alqahtani[2], Yousef Ali H. Alaenzi[2], Sager Loaie H. Algorashi[2], Abdullah Majed H. Alruwaili[2], Abdulmohsen Mohmmed M. Alamri[2], Marwan Fahad H. altemani[2], Mohammed Abdullah M. Albalawi[3]

1. Internal Medicine Department, The University of Utah, Salt Lake City, USA
2. Internal Medicine Department, King Salman Armed Forces Hospital, Tabuk, Saudi Arabia
3. Internal Medicine Department, University of Tabuk, Tabuk, Saudi Arabia

Supplementary content (If any) is available online.

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