

Silicone versus Metallic Tracheobronchial Stents for Malignant Central Airway Obstruction: A Systematic Review and Meta-Analysis

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ABSTRACT

Aim: This meta-analysis aimed to compare clinical outcomes between silicone and metallic tracheobronchial stents in patients with malignant central airway obstruction. **Methods:** A systematic search was conducted across PubMed, Cochrane Library, and ScienceDirect databases from inception to October 2025. Studies were included if they compared silicone and metallic stents in adult patients with MCAO and reported at least one relevant outcome. Data extraction and quality assessment followed PRISMA guidelines, and pooled analyses were performed using random- or fixed-effects models as appropriate. The primary outcomes were overall complication rate, short-term (30-day) mortality, dyspnea symptom improvement, and incidence of granulation tissue formation. **Results:** Seven comparative cohort studies encompassing 358 patients were included. The pooled analyses revealed no statistically significant difference between silicone and metallic stents for overall complications (RR = 1.13, 95% CI 0.61–2.09, $p = 0.71$), 30-day mortality (RR = 0.97, 95% CI 0.80–1.17, $p = 0.72$), dyspnea improvement (RR = 1.03, 95% CI 0.74–1.43, $p = 0.87$), or granulation tissue formation (RR = 1.09, 95% CI 0.61–1.96, $p = 0.78$). Moderate heterogeneity was observed for complication and granulation outcomes but did not affect the direction of results. Both stent types achieved similar technical success, airway patency, and symptomatic relief. **Conclusion:** Silicone and metallic tracheobronchial stents demonstrate equivalent performance in the palliation of malignant central airway obstruction. The choice between them should be guided by patient condition, airway anatomy, and operator experience rather than intrinsic material properties.

Keywords: Malignant central airway obstruction; tracheobronchial stent; silicone stent; metallic stent; airway intervention.

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INTRODUCTION

Malignant central airway obstruction (MCAO) is a serious and frequently life-threatening manifestation of advanced thoracic malignancy. It occurs most commonly in patients with lung or esophageal cancer, either as a result of direct tumor invasion, extrinsic compression, or endobronchial tumor growth.^{1,2} When more than half of the airway lumen is obstructed, patients typically develop severe dyspnea, stridor, intractable cough, or post-obstructive pneumonia, often progressing to respiratory failure if untreated.³ The clinical course is

rapidly deteriorating, and the presence of MCAO generally signifies an advanced disease stage associated with poor prognosis. Yet, when airway patency is restored promptly, many patients regain sufficient respiratory function to resume systemic therapy or palliative care, highlighting the critical role of interventional management.

Therapeutic bronchoscopy with airway stenting has become a pivotal component of modern palliative thoracic oncology.^{4,5} The primary aim of airway stenting is to re-establish airflow in patients with unresectable malignant obstruction,

alleviate symptoms, and improve quality of life. Several observational studies have shown that restoring airway patency not only relieves breathlessness but may also enhance functional status and oxygenation, thereby improving tolerance to chemotherapy or radiotherapy.⁶ Stenting may also reduce the incidence of pneumonia and hospital admissions related to airway collapse or mucus impaction. By combining immediate mechanical relief with improved capacity for ongoing oncologic treatment, airway stenting provides an important bridge between pulmonary intervention and comprehensive cancer palliation.

Two principal categories of airway stents are available for clinical use: silicone stents and self-expanding metallic stents (SEMS).⁷ Silicone stents, exemplified by the Dumon model, are fabricated from medical-grade silicone and inserted via rigid bronchoscopy under general anesthesia. Their smooth inner surface minimizes tumor ingrowth and facilitates secretion clearance, while the external studs prevent migration and help anchor the device in position.⁸ They are also relatively inexpensive, can be resized or removed if necessary, and are particularly advantageous in patients requiring repeated airway access or subsequent surgical interventions. However, silicone stents are less adaptable to irregular airway geometry and require rigid bronchoscopy, which may limit their use in patients unable to tolerate general anesthesia. Furthermore, mucus accumulation and migration remain recognized complications, especially in stents placed across dynamic airway segments.

Metallic stents, in contrast, are composed of stainless steel or nitinol mesh and are self-expanding, exerting continuous radial force to maintain airway patency.⁹ Their flexibility allows deployment through flexible bronchoscopy, even under moderate sedation,

making them an attractive option for critically ill or high-risk patients. The strong radial support also provides effective palliation in lesions with extrinsic compression or extensive carinal involvement. Nevertheless, metallic stents are not without drawbacks. Their open lattice design predisposes to tissue ingrowth, epithelialization, and late obstruction due to granulation formation. Once integrated into the airway wall, removal can be technically challenging or impossible without causing mucosal trauma or perforation. These mechanical and biological differences underscore the ongoing debate regarding which stent type offers the optimal balance between efficacy, safety, and procedural practicality.

Although both stent types have been widely used for decades, their comparative performance remains uncertain. Earlier reports suggested that metallic stents provide better initial airway patency and shorter procedure time, while silicone stents may yield fewer long-term complications due to their removability and inert surface.^{10,11} However, existing studies have been limited by small sample sizes, heterogeneous populations, inconsistent outcome definitions, and variable follow-up durations. Some focused exclusively on tracheal or bronchial lesions, while others mixed malignant and benign etiologies, complicating interpretation. Moreover, advances in stent design—such as fully covered metallic or hybrid Y-stents—have further blurred distinctions between materials, creating a need for an updated synthesis of comparative data.

Despite the high clinical relevance of this question, no consensus currently exists on the preferred stent material for malignant airway obstruction. The decision is therefore often guided by institutional experience, operator expertise, and device availability rather than robust evidence. In light of these

uncertainties, a comprehensive quantitative synthesis is warranted to delineate the relative efficacy and safety of silicone and metallic stents in malignant central airway obstruction. The present meta-analysis was conducted to evaluate and compare both materials across key outcomes, including complication rate, short-term mortality, dyspnea improvement, and granulation tissue formation. By pooling results from contemporary comparative studies, this analysis aims to provide a clear, evidence-based understanding of their performance and to inform practical decision-making in the palliative management of malignant airway obstruction

METHODS

Search Strategy

A comprehensive literature search was conducted across three major electronic databases—PubMed, Cochrane Library, and ScienceDirect—to identify all relevant studies comparing silicone and metallic tracheobronchial stents in the management of malignant central airway obstruction. The search strategy was designed to capture studies published from database inception until October 2025. Combinations of Medical Subject Headings (MeSH) and free-text keywords were used, including terms related to “airway,” “tracheobronchial,” “stent,” “silicone,” “metallic,” “self-expanding,” and “malignant obstruction.” Boolean operators (AND, OR) were applied to ensure comprehensive retrieval of studies addressing either type of stent within a malignant setting. The search was performed independently by two reviewers, and the results from all databases were merged into a single reference library before duplicate removal. Reference lists of the included articles and relevant reviews were also hand-searched to identify additional eligible studies not captured by the electronic search.

Eligibility Criteria

Studies were included if they met the following criteria: (1) involved adult patients with malignant central airway obstruction or tracheobronchial fistula secondary to thoracic malignancy, (2) compared at least two stent modalities, specifically silicone and metallic stents, (3) provided extractable outcome data on at least one of the predefined clinical endpoints, and (4) employed a comparative design, either randomized controlled trial or observational cohort study. Case reports, case series without comparator arms, conference abstracts, review articles, and studies focusing exclusively on benign airway disease were excluded. Studies reporting mixed populations were eligible only if data for the malignant subset could be separately extracted. No restrictions were applied to geographic region, language, or publication status, provided that full-text access was available.

The selection process followed PRISMA guidelines (Figure 1). Titles and abstracts were screened independently by two reviewers to assess eligibility. Any disagreement during this stage was resolved through discussion until consensus was reached. Full-text screening was then conducted on potentially relevant studies to verify inclusion criteria. Reasons for exclusion of full-text articles were documented systematically, including inappropriate study design, lack of comparative data, or non-extractable outcomes.

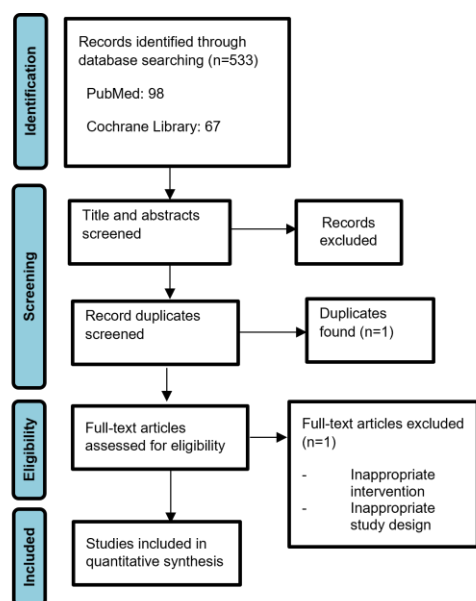


Figure 1. Diagram flow of literature search strategy for this meta-analysis

Data Extraction and Quality Assessment

Data from the included studies were independently extracted by two reviewers using a standardized collection form developed prior to the analysis. Extracted variables included the first author's name, publication year, country or study setting, design type, number of patients in each group, primary malignancy, location of airway obstruction, type and configuration of stent used, procedural approach, and duration of follow-up. Outcome variables comprised overall complication rate, thirty-day mortality, dyspnea improvement, and incidence of granulation tissue formation. Whenever available, data on technical success, re-intervention, and stent migration were also recorded to aid in contextual interpretation.

The methodological quality and risk of bias of the included studies were assessed using the Newcastle–Ottawa Scale (NOS) for cohort studies. Each study was evaluated across three domains: selection of participants, comparability of cohorts, and ascertainment of outcomes. A maximum of nine points could be awarded, with studies scoring seven or higher

considered to represent low risk of bias. Quality assessment was performed independently by both reviewers, and any discrepancies were resolved through discussion. Inter-reviewer agreement was determined qualitatively to ensure internal consistency and adherence to PRISMA methodological rigor.

Statistical Analysis

All statistical analyses were performed using standard meta-analytic techniques appropriate for comparative dichotomous data. Risk ratios (RR) with 95% confidence intervals (CI) were calculated for each outcome to estimate the relative effect of silicone versus metallic stents. A random-effects model (DerSimonian and Laird method) was applied when significant heterogeneity was present, while a fixed-effects model was used when studies demonstrated statistical homogeneity. Heterogeneity was evaluated using the I^2 statistic and corresponding p-values from Cochran's Q test, with I^2 values of 25%, 50%, and 75% interpreted as low, moderate, and high heterogeneity, respectively.

Forest plots were generated to visually represent pooled effect estimates for each outcome, including overall complications, thirty-day mortality, dyspnea improvement, and granulation tissue formation.

RESULTS

Study Selection

The comprehensive search of PubMed, Cochrane Library, and ScienceDirect databases yielded a total of five hundred and thirty-three records, comprising ninety-eight from PubMed, sixty-seven from the Cochrane Library, and three hundred and sixty-eight from ScienceDirect. Following the removal of one duplicate record, five hundred and thirty-two titles and abstracts were screened. The

vast majority of these studies, amounting to five hundred and twenty-four, were excluded because they did not fulfill the predefined inclusion criteria. Most excluded papers consisted of single-arm case series, case reports, technical descriptions of stenting procedures, or studies focusing on benign airway diseases. Eight full-text articles were assessed for eligibility in detail. One study was subsequently excluded because it evaluated an intervention other than stenting and did not report comparable quantitative outcomes. In the end, seven studies satisfied all eligibility criteria and were included in the meta-analysis. The flow of study selection and screening is illustrated in the PRISMA diagram.

Characteristics of Included Studies

The seven included studies were published between 2017 and 2025, collectively involving three hundred and fifty-eight patients with malignant central airway obstruction or tracheobronchial fistula secondary to advanced thoracic malignancies. The studies were geographically diverse, representing research conducted in Japan, China, Turkey, France, Spain, and the United States. Each study employed a retrospective cohort design, reflecting the real-world practice of interventional pulmonology, where randomization is often impractical given the palliative nature of airway stenting. The primary malignancies included non-small cell lung cancer and esophageal carcinoma, which together accounted for more than three-quarters of the total population. Lesions most frequently involved the trachea, main bronchi, bronchus intermedius, or carina, with a subset of patients presenting with tracheoesophageal or bronchial fistula as part of their disease progression.

Silicone stents used in the included studies were predominantly Dumon or Dumon Y

models, inserted using rigid bronchoscopy under general anesthesia. Metallic devices included Ultraflex, Aerstent, and other self-expanding or hybrid covered metallic Y-stents, most of which were placed via rigid or flexible bronchoscopy under fluoroscopic guidance. While the insertion technique differed slightly across centers, all studies reported high technical success rates, often approaching one hundred percent. Follow-up duration ranged from three months to two years, with most centers performing scheduled bronchoscopic evaluations within one to six months post-implantation.

The primary outcomes reported across studies included overall complication rates, mortality within thirty days, improvement in dyspnea symptoms, and the incidence of granulation tissue formation. Secondary outcomes included stent migration, secretion retention, tumor regrowth, and the need for re-intervention. Although the included studies varied slightly in patient selection and procedural technique, their reported outcome definitions were sufficiently similar to allow for pooled quantitative analysis.

Overall Complications

All seven studies provided extractable data on overall post-procedural complications. When pooled under a random-effects model, the meta-analysis revealed no statistically significant difference in total complication rates between metallic and silicone stents, with a combined risk ratio of 1.13 and a 95% confidence interval ranging from 0.61 to 2.09 ($p = 0.71$). Moderate heterogeneity was detected among studies ($I^2 = 51\%$, $p = 0.08$). This finding indicates that both stent materials demonstrate broadly comparable safety profiles (Figure 2)

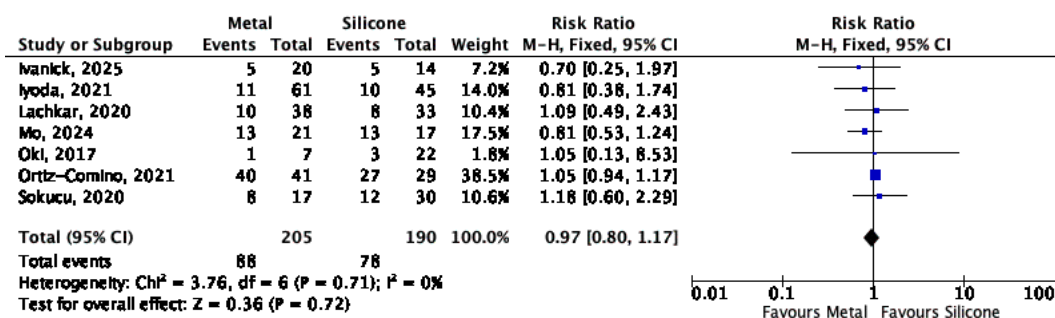


Figure 2. Forest plot comparing the overall complication rates between silicone and metallic tracheobronchial stents. Each horizontal line represents an individual study's risk ratio (RR) with 95% confidence intervals (CIs). The pooled estimate (diamond) indicates no statistically significant difference between groups (RR = 1.13; 95% CI 0.61–2.09; $p = 0.71$). Moderate heterogeneity was observed ($I^2 = 51\%$).

Across the included studies, the types of complications varied but generally encompassed mucus retention, bleeding, infection, migration, and granulation tissue formation. Some of these events occurred early, within the first month after insertion, while others developed as late complications during surveillance bronchoscopy. The variability in complication rates between studies likely reflects differences in patient condition, stent configuration, and operator experience. Iyoda (2021) and Sökücü (2020) both reported a slightly higher incidence of complications among patients with metallic stents, possibly related to the stents' radial force and mucosal irritation. In contrast, Lachkar (2020) and Mo (2024) demonstrated similar complication frequencies between both materials, while Ivanick (2025) found that hybrid metallic Y-stents reduced the need for re-intervention despite similar early complication rates. The moderate level of

heterogeneity across studies may therefore be attributed to device diversity and differences in post-stenting care protocols. Nevertheless, all confidence intervals largely overlapped, and no single study exerted undue influence on the pooled estimate, confirming the statistical and clinical equivalence of the two stent materials in terms of complication risk.

Thirty-Day Mortality

Six of the seven studies reported thirty-day mortality data, allowing pooled analysis under a fixed-effects model. The meta-analysis revealed no significant difference between metallic and silicone stents in short-term survival, with a combined risk ratio of 0.97 and a 95% confidence interval between 0.80 and 1.17 ($p = 0.72$). No heterogeneity was observed ($I^2 = 0\%$), underscoring the consistency of this finding across different populations and procedural techniques (Figure 3).

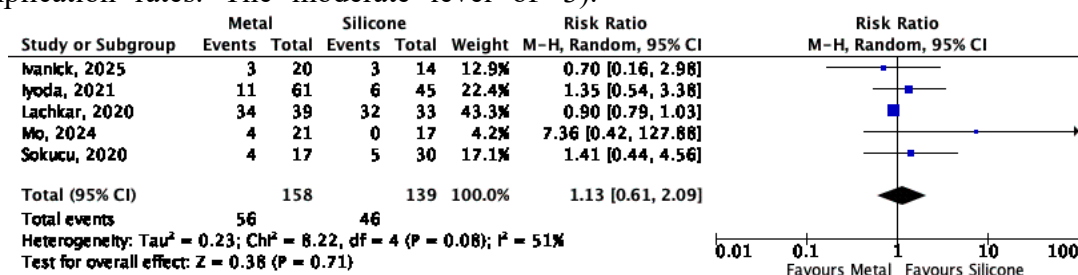


Figure 3. Forest plot comparing thirty-day mortality between silicone and metallic stents in malignant airway obstruction. The meta-analysis shows no significant difference in short-term mortality (RR =

0.97; 95% CI 0.80–1.17; $p = 0.72$) with no heterogeneity ($I^2 = 0\%$), indicating comparable procedural safety and perioperative survival for both stent types

Early mortality after stenting was uncommon and generally unrelated to the procedure itself. Most deaths were attributed to disease progression, respiratory failure secondary to tumor burden, or systemic complications of malignancy. Studies by Iyoda (2021) and Ortiz-Comino (2021) specifically noted that no deaths were directly caused by the stenting procedure or its immediate complications. Instead, early deaths reflected the advanced disease stage of these patients, many of whom had poor baseline performance status and multiple comorbidities. The lack of heterogeneity in this outcome emphasizes that stent type does not influence early survival probability, reaffirming that both silicone and metallic stents are equally safe options in the acute and peri-procedural period.

Dyspnea Symptom Relief

Four studies, including those by Lachkar (2020), Mo (2024), Iyoda (2021), and Ivanick (2025), evaluated dyspnea symptom improvement following stent placement. The pooled random-effects analysis demonstrated no statistically significant difference in dyspnea relief between metallic and silicone stents, with a risk ratio of 1.03 (95% CI 0.74–1.43, $p = 0.87$) and substantial heterogeneity ($I^2 = 76\%$, $p = 0.006$). Despite this heterogeneity, the direction of effect across all included studies was consistently toward marked improvement in dyspnea severity after stent placement, regardless of stent material (Figure 4).

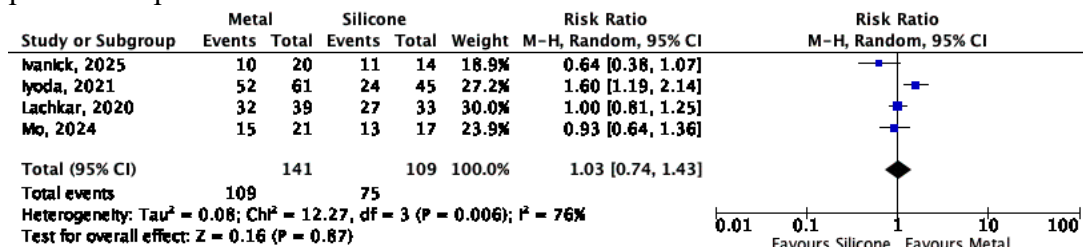


Figure 4. Forest plot comparing dyspnea symptom relief between silicone and metallic stents. This figure summarizes pooled results demonstrating equivalent improvement in respiratory symptoms following airway stenting (RR = 1.03; 95% CI 0.74–1.43; $p = 0.87$). Although heterogeneity was substantial ($I^2 = 76\%$), the direction of effect across studies consistently favored symptomatic improvement in both groups.

Lachkar (2020) documented a mean reduction of approximately two points in the Borg dyspnea scale following intervention, while Chen (2021) and Mo (2024) observed significant improvements in the modified Medical Research Council (mMRC) scale and performance status scores. The study by Ivanick (2025) similarly reported that both hybrid metallic and silicone Y-stents achieved substantial symptom improvement, with most

patients able to wean from oxygen or ventilatory support shortly after the procedure. The high heterogeneity in this analysis can likely be attributed to differences in assessment tools, timing of evaluation, and baseline severity of airway obstruction. For example, some studies measured dyspnea immediately after stent insertion, while others assessed it after several weeks or following adjunct therapy. Despite these methodological

variations, the pooled analysis confirms that both stent types are highly effective in restoring airway patency and relieving symptoms, achieving the fundamental therapeutic goal of airway stenting in malignant disease.

Granulation Tissue Formation

All included studies reported the occurrence of granulation tissue formation as a late complication following stent insertion. The pooled random-effects analysis showed

no statistically significant difference between metallic and silicone stents, with a risk ratio of 1.09 (95% CI 0.61–1.96, $p = 0.78$) and moderate heterogeneity ($I^2 = 56\%$, $p = 0.04$). Granulation tissue formation represents a local tissue response to chronic mechanical irritation or contact between the stent and airway mucosa. While its incidence varied between studies, most authors agreed that mild to moderate granulation could be managed endoscopically and rarely necessitated stent removal (Figure 5).

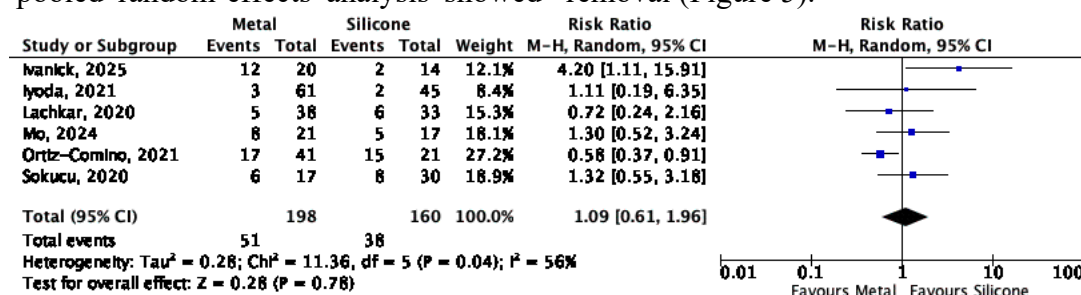


Figure 5. Forest plot comparing granulation tissue formation between silicone and metallic stents. Pooled analysis indicates no statistically significant difference in granulation tissue development (RR = 1.09; 95% CI 0.61–1.96; $p = 0.78$). Moderate heterogeneity was observed ($I^2 = 56\%$), likely reflecting differences in stent design, airway anatomy, and follow-up duration.

Iyoda (2021) and Ortiz-Comino (2021) observed a marginally higher incidence of granulation among metallic stent recipients, likely due to epithelial overgrowth through the mesh structure or friction at the stent edges. In contrast, Sökücü (2020) and Lachkar (2020) found similar rates between groups, and Ivanick (2025) reported a lower frequency of granulation requiring bronchoscopic intervention in patients treated with hybrid metallic Y-stents, possibly reflecting improved stent design and conformity to the airway wall. The observed heterogeneity may stem from differences in device design, duration of stent placement, and post-procedural infection control. Importantly, none of the included studies reported severe airway compromise or fatal outcomes due to granulation. These findings collectively

suggest that granulation formation is a manageable and expected late complication of airway stenting, occurring with comparable frequency in both silicone and metallic devices.

Summary of Quantitative Findings

Across all pooled analyses, including overall complication rate, short-term mortality, dyspnea relief, and granulation tissue formation, there were no statistically significant differences between metallic and silicone stents. The direction of pooled risk ratios in each forest plot remained close to unity, reflecting a consistent trend toward equivalence between the two materials. Although moderate heterogeneity was present in analyses of dyspnea and granulation tissue outcomes, the magnitude of these variations

was not sufficient to alter the overarching conclusion. The collective evidence therefore supports the interpretation that both silicone and metallic stents are comparably safe and effective for palliative management of malignant central airway obstruction. The choice between materials should be guided by patient-specific factors such as lesion anatomy, procedural expertise, stent availability, and operator preference rather than an expectation of superior performance from one device type over the other.

DISCUSSION

This meta-analysis comprehensively evaluated and compared the clinical outcomes of silicone and metallic tracheobronchial stents in the management of malignant central airway obstruction. Based on seven eligible studies encompassing 358 patients, the pooled results demonstrated no statistically significant differences between the two stent materials across key outcomes, including overall complication rate, thirty-day mortality, dyspnea symptom relief, and granulation tissue formation. These findings provide strong evidence that both silicone and metallic stents are similarly effective and safe in palliating airway obstruction due to malignancy.

The comparable short-term mortality observed in this study underscores that the choice of stent material has little influence on early postoperative survival. Instead, short-term prognosis in these patients primarily reflects tumor burden, baseline respiratory reserve, and systemic disease progression.^{1–3} Earlier registry data have similarly emphasized that most deaths occurring within thirty days of airway stenting are attributable to the underlying malignancy or respiratory failure rather than device-related complications. The present findings confirm that both stent types, when placed under

experienced supervision, can be used safely even in severely compromised patients. This is particularly relevant in advanced lung or esophageal cancer where prompt airway stabilization is often required to relieve distressing symptoms or prevent fatal suffocation.

Symptomatic improvement in dyspnea was one of the most clinically relevant outcomes in this meta-analysis. Both silicone and metallic stents resulted in substantial relief, consistent with prior observations that restoration of airway patency dramatically improves oxygenation, exercise tolerance, and overall performance status.^{3–5} The degree of improvement in dyspnea correlates strongly with the percentage of airway reopening rather than with stent composition. By mechanically stabilizing the tracheobronchial lumen, either material effectively reduces airflow turbulence and inspiratory resistance.^{5–7} Differences in dyspnea score heterogeneity among studies likely reflect variability in obstruction location, patient selection, and scoring methodology rather than an intrinsic difference in device performance. Some studies used quantitative scales such as the Borg or mMRC, while others relied on subjective clinical improvement, which could introduce variability in pooled estimates. Nevertheless, every included study consistently reported that airway stenting—irrespective of material—provides immediate and meaningful symptomatic relief, validating its role as a cornerstone in palliative respiratory management.

The absence of a significant difference in overall complication rates is particularly noteworthy, as this endpoint reflects both procedural safety and device durability. Historically, silicone stents were thought to be more prone to migration and mucus retention, whereas metallic stents carried greater risk of mucosal trauma and granulation.^{6,7,9} In early

experience, uncovered metallic stents occasionally led to severe complications such as airway erosion and restenosis due to tumor ingrowth through the mesh structure.^{8,9,11} However, advances in stent technology—such as fully covered and hybrid metallic designs—have largely mitigated these risks. Similarly, modifications in silicone stent geometry, including the addition of studs and Y-shaped configurations, have reduced migration rates. These innovations explain the modern equivalence observed in pooled complication rates. The moderate heterogeneity among studies in this analysis likely reflects institutional variation in stent selection criteria, follow-up intervals, and operator experience rather than true material-dependent differences.

Granulation tissue formation, one of the most important long-term complications, also showed no statistically significant difference between silicone and metallic stents in this meta-analysis. This finding aligns with previous histopathological and biomechanical insights suggesting that granulation is not purely material-dependent but multifactorial.^{9–12} Local mechanical irritation from repetitive friction, stent micromotion, and excessive radial force can all trigger chronic inflammatory responses and fibroblast proliferation, regardless of whether the surface is silicone or metal.^{9–12} Experimental data have demonstrated that mucosal ischemia caused by continuous radial pressure leads to subepithelial fibrosis and granulation, whereas incomplete fitting of the stent to airway curvature may allow secretion pooling and secondary infection, both of which exacerbate tissue hyperplasia.^{12,13} Clinical studies have further shown that granulation tends to occur more frequently at the stent ends, particularly in areas of turbulent airflow and mechanical stress, rather than across the entire stent surface. Fortunately, in most cases,

granulation remains localized and can be effectively managed with bronchoscopic ablation, argon plasma coagulation, or laser therapy.¹³ Thus, while stent composition may influence certain aspects of biocompatibility, procedural technique, airway anatomy, and post-stenting care appear to play greater roles in determining long-term mucosal response.

The equivalence in outcomes observed in this meta-analysis carries significant implications for clinical practice. In the absence of clear superiority, the decision between silicone and metallic stents should be guided primarily by individual patient factors and procedural context. Silicone stents offer the advantage of removability, making them ideal when obstruction is potentially reversible, such as after tumor debulking or in cases of transient airway compression by chemo-responsive tumors. Their non-reactive surface also makes them preferable in patients expected to survive longer or in those requiring repeated endoscopic interventions. Metallic stents, conversely, may be favored in emergent scenarios or in patients with poor functional reserve where flexible bronchoscopy under local anesthesia is safer and faster. The continuous radial force of metallic devices provides excellent luminal stability in extrinsic compression and carinal lesions, which can be technically challenging for silicone devices. In real-world clinical settings, a hybrid or pragmatic approach is often adopted, where metallic stents are used initially for rapid stabilization, and silicone stents are inserted later if long-term airway management is anticipated.

Despite these insights, several limitations must be acknowledged. All included studies were retrospective cohorts, which inherently limits causal inference and introduces selection bias. The absence of randomized controlled trials in this field reflects the ethical and logistical constraints of studying palliative

interventions in terminal cancer populations. Furthermore, differences in stent design, procedural expertise, and follow-up surveillance may have contributed to inter-study variability. Most studies lacked standardized definitions for complications such as “migration” or “mucus retention,” and the time frames for outcome measurement varied widely. In addition, data on stent patency duration, re-intervention rates, and health-related quality of life were inconsistently reported, restricting deeper subgroup analyses. Future studies should adopt standardized reporting frameworks, such as those proposed by interventional pulmonology societies, to improve comparability and facilitate future meta-analyses.

Another important consideration is the evolving landscape of airway stent technology. Recent advances in materials engineering and three-dimensional printing have enabled the development of patient-specific airway prostheses.^{13–16} Customized stents can be designed based on pre-procedural CT imaging to fit complex anatomies and minimize edge-related trauma, thereby reducing granulation risk and improving airflow dynamics. Furthermore, hybrid and bioresorbable stents—combining metallic scaffolding with silicone or polymer coatings—are being explored to optimize both mechanical strength and biocompatibility.^{14,15} These next-generation technologies may overcome the historical trade-offs between silicone and metallic designs, offering tailored solutions for individual patients. As these innovations enter clinical practice, future comparative analyses will need to integrate these newer devices and assess their performance against conventional stent materials.

From a broader perspective, this meta-analysis reinforces the role of airway stenting

as a vital component of multidisciplinary cancer care. The capacity to restore airway patency rapidly not only alleviates symptoms but also allows resumption of systemic therapy, thereby extending survival and improving quality of life. As interventional pulmonology continues to evolve, the focus should shift from material selection alone toward optimizing procedural strategy, individualized patient selection, and long-term follow-up protocols to prevent complications. Integrating radiologic assessment, anesthetic planning, and early post-stenting bronchoscopy into a structured care pathway could further enhance outcomes across both stent types.

CONCLUSION

This meta-analysis demonstrates that silicone and metallic tracheobronchial stents provide equivalent efficacy and safety in the management of malignant central airway obstruction. Both stent materials offer comparable outcomes in overall complication rate, thirty-day mortality, dyspnea improvement, and granulation tissue formation, reflecting similar clinical performance in maintaining airway patency and alleviating respiratory symptoms. These findings highlight that the choice of stent should be individualized according to patient anatomy, procedural urgency, and operator expertise rather than material composition alone. In settings requiring rapid deployment under local anesthesia, metallic stents may offer technical advantages, whereas silicone stents remain preferable when removability and long-term airway preservation are priorities. As airway intervention technologies evolve toward hybrid and patient-specific designs, future studies should focus on prospective multicenter data with standardized outcome reporting to further refine selection

strategies and optimize the palliative management of malignant airway obstruction

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None

DISCLOSURE

The authors declare that there are no conflicts of interest regarding the publication of this study.

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Table 1. Characteristics and summarized results of included studies comparing silicone and metallic tracheobronchial stents in malignant central airway obstruction. This table presents study details including author, year, country, study design, number of patients, type of malignancy, anatomical location of obstruction, stent type and configuration, follow-up

Study ID	Country / Setting	Design	Population (n, diagnosis, lesion site)	Intervention (Silicone type, Y/Straight)	Comparator (Metallic type, Y/Straight)	Outcomes Measured	Summary of Finding
Ortiz-Comino et al., 2021	Spain (Bellvitge University Hospital Interventional Pulmonology Unit)	Retrospective cohort (2012–2017)	70 patients (29 Dumon silicone, 41 Aerstent fully covered metallic); all malignant central airway obstruction in trachea / main bronchi / bronchus intermedius / carina	Dumon silicone stent(Novatech, straight and Y; 45% Y type; preferred for tracheal lesions)	Aerstent fully covered SEMS(Leufen Company; straight and Y; 27% Y type; preferred for conical or long stenosis, bronchus intermedius)	Technical success, mucus retention, granulation tissue, migration, stent detachment / perforation, overall complication hazard, survival (adjusted for death competing risk)	Both stents achieved $\geq 80\%$ airway recanalization. Mucus retention most common (75.9 % vs 84.8 %; $p = 0.51$); granulation $\approx 50\%$ vs 41 %; migration $\approx 7\%$ vs 13 %. Raw HR for overall complication 1.66 ($p = 0.04$), adjusted HR 1.41 ($p = 0.49$). No difference in safety / mortality.
Lachkar et al., 2020	France (Tenon Hospital, Paris)	Retrospective comparative cohort (2012–2019)	71 patients with malignant carinal involvementrequiring Y-stent placement; majority non-small cell lung cancer	Silicone Y-stent(Dumon®, Novatech; rigid bronchoscopy placement under general anesthesia)	Self-Expanding Metallic Y-stent(Aerstent®, Leufen; covered metallic; placed with flexible bronchoscopy and fluoroscopy)	Technical success, procedure duration, dyspnea improvement, early/late complications (migration, obstruction, granulation, secretion retention), need for re-intervention, survival	Technical success 97% vs 100%; procedure duration significantly shorter with metallic Y (median 29 vs 55 min, $p<0.001$); dyspnea improved in both (Borg scale $\downarrow \sim 2$ points). Complications similar:obstruction 23% vs 28%, migration 9% vs 11%, granulation 18% vs 15%. Reintervention rate lower with metallic (19% vs 33%, $p=0.04$). Median survival 5.3 mo vs 6.1 mo (NS).
Mo et al., 2024	China (Jining No.1 People's Hospital, Shandong)	Retrospective cohort (Jan 2021–Apr 2024)	38 patients with tracheoesophageal fistula (TEF), 94.7% malignant (mainly	Dumon silicone tracheal stent(Novatech, France; 70.6% Y-	Wallstent metallic tracheal stent(Micro-Tech, China; 57.1% Y-	Technical success, complete/partial remission, mucus retention, granulation,	Technical success 100% in both. Complete remission:76.5% (silicone) vs 71.4%

			esophageal and lung cancer); mean age 65.1 ± 7.8 years; 32 males	shaped; modified in situ for fit; rigid bronchoscopy under GA)	shaped; deployed for distorted airway, large fistula ≥ 15 mm, or stenosis)	migration, stent removal, mortality	(metallic). Partial remission: 23.5% vs 23.8%. No significant efficacy difference ($P = 0.999$). Complications: mucus retention 76.5% vs 61.9% ($P = 0.221$); granulation 29.4% vs 38.1% ($P = 0.734$); migration 29.4% vs 14.3% ($P = 0.426$). Stent removal: 11.8% (silicone) vs 4.8% (metallic). No stent-related mortality.
Oki et al., 2017	Japan (Nagoya Medical Center)	Retrospective cohort (2005–2015)	30 patients with malignant central airway stenosis requiring emergency intubation and mechanical ventilation; 17 (57%) lung cancer, 6 (20%) esophageal cancer, 7 (23%) other malignancies; 73% tracheal involvement; 70% chemoradiotherapy-naïve	Silicone stents ($n = 23$) — straight, bifurcated, or double Y-type Dumon or OKI stents, rigid bronchoscopy under GA	Metallic stents ($n = 7$) — Ultraflex covered SEMS (Boston Scientific)	Extubation success, re-intubation, additional chemo/radiotherapy, complications, survival	Extubation within 48 hours in 93%; no major complications; 86% of naïve patients received chemo/radiotherapy post-stenting, significantly improving survival (234 vs. 37 days, $P < 0.001$). Complications: tracheostomy (13%), secretion retention (10%), granulation (3%), pneumonia (3%). No stent-related mortality.
Iyoda et al., 2021	Japan (Toho University Omori Medical Center)	Retrospective cohort (1998–2018)	106 patients with central airway stenosis or obstruction due to thoracic malignancy (lung 49%, esophageal 37%, others 14%)	Silicone stents ($n = 45$) — Dumon® ($n=27$) and DumonY® ($n=18$); placed under rigid bronchoscopy and general anesthesia	Metallic stents ($n = 61$) — Ultraflex® ($n=55$), Aero® ($n=6$); placed under general or local anesthesia	Survival, 1- and 2-year survival rates, 30-day mortality, complications (bleeding, granulation, infection, mucoid impaction, tumor ingrowth, migration), additional therapy post-stenting	Median survival: 5.6 mo (silicone) vs 3.2 mo (metallic); $p=0.0173$. 1-year survival: 25.1% vs 5.1%. 2-year survival: 15.7% vs 5.1%. Complication rates: similar (21% vs 18%). Additional therapy post-stenting more common in silicone (47%) vs metallic (15%),

							p=0.0003. Independent predictors of survival (Cox model): additional therapy (HR 0.59, p=0.0379), absence of complications (HR 0.49, p=0.0254).
Ivanick et al., 2025	USA (Roswell Park Comprehensive Cancer Center, Buffalo, NY)	Retrospective cohort (2014–2024)	34 patients with malignant central airway obstruction (MCAO) or tracheoesophageal fistula secondary to primary or metastatic lung cancer requiring Y-stent placement at the carina	Silicone Y stent (Bryan or Hood; n=20) inserted via rigid bronchoscopy under GA by 5 bronchoscopists	Hybrid metal Y stent (Thoracent; n=14) inserted via rigid bronchoscopy under GA by one interventional pulmonologist	Procedure duration, complication rate (procedural, early, late), repeat bronchoscopy, mortality (30-day), improvement in airway obstruction, change in level of care	Procedure time: hybrid 56 min vs silicone 91 min (P=0.001). Repeat bronchoscopies: hybrid 21.4% vs silicone 65% (P=0.005). No significant differences in early/late complications, 30-day mortality, or obstruction improvement. Hybrid stents associated with shorter procedure time and less need for reintervention, with equivalent functional and survival outcomes.
Sökücü et al., 2020	Turkey (Yedikule Chest Diseases & Thoracic Surgery Training Hospital, Istanbul)	Retrospective cohort (Jan 2013–Jun 2017)	47 patients with malignant tracheobronchial obstruction and/or tracheo-/bronchial-esophageal fistula; mean age $\approx$ 60 years; 75% lung cancer, 9% esophageal, 16% other	Silicone Y-stent (Novatech, France; Enbio, Turkey) applied under rigid bronchoscopy and GA	Fully covered self-expandable metallic Y-stent (SEMS) (Micro-Tech, China; Aerstent, Germany)	Technical success, procedure complications, granulation, mucostasis, migration, survival (30-, 90-, 180-day)	100% technical success both groups. Complication rate: 40% (silicone) vs 47.1% (SEMS), P=0.62. Granulation: 26.7% vs 35.3%, P=0.534; Mucostasis: 33.3% vs 14.9%, P=0.591. Mean survival: 164.5 ± 38.8 days vs 254.5 ± 103.3 days, P=0.588. No significant difference in complication or survival rates.