

Engineering Better Airways: A Critical Review of Fenestrated vs. Conventional Silicone Stents

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The Clinical Question

Do fenestrated silicone stents reduce complication rates compared to conventional stents in the management of benign central airway stenosis?



Take Home Message

Compared to conventional silicone stents, fenestrated stents may offer longer potency, fewer complications, and improved biomechanical performance, without compromising the stent's structural integrity when managing benign central airway stenosis. However, prospective randomized studies are needed to confirm efficacy and durability.

Background

Surgical resection or reconstruction remains the gold standard for treatment of benign central airway stenosis; however, many patients are not candidates for surgery due to significant comorbidities. For these patients, rigid bronchoscopy with silicone airway stenting provides a safe and effective alternative.

Despite their efficacy, silicone stents are often limited by complications such as migration, granulation, and mucus retention, which can necessitate frequent interventions and lead to premature stent removal. While some researchers have explored the use of many innovative stents designed to prevent stent migration, granulation tissue formation, and mucus retention, silicone stents are still the most used stents currently. These complications highlight the need to optimize silicone stent design to improve durability and reduce associated complications.



Study design

Study design:

- Retrospective observation cohort study conducted at a single center

Primary outcome:

- Technical success and rate of complications defined by stent migration, patency time, granulation tissue formation, and mucous retention.

Secondary Outcome(s):

- To evaluate the biomechanical and fluid dynamics performance of conventional silicone stems and fenestrated silicone stems

Intervention(s):

- Fenestrated versus conventional silicone stems **in the management of benign central airway stenosis**

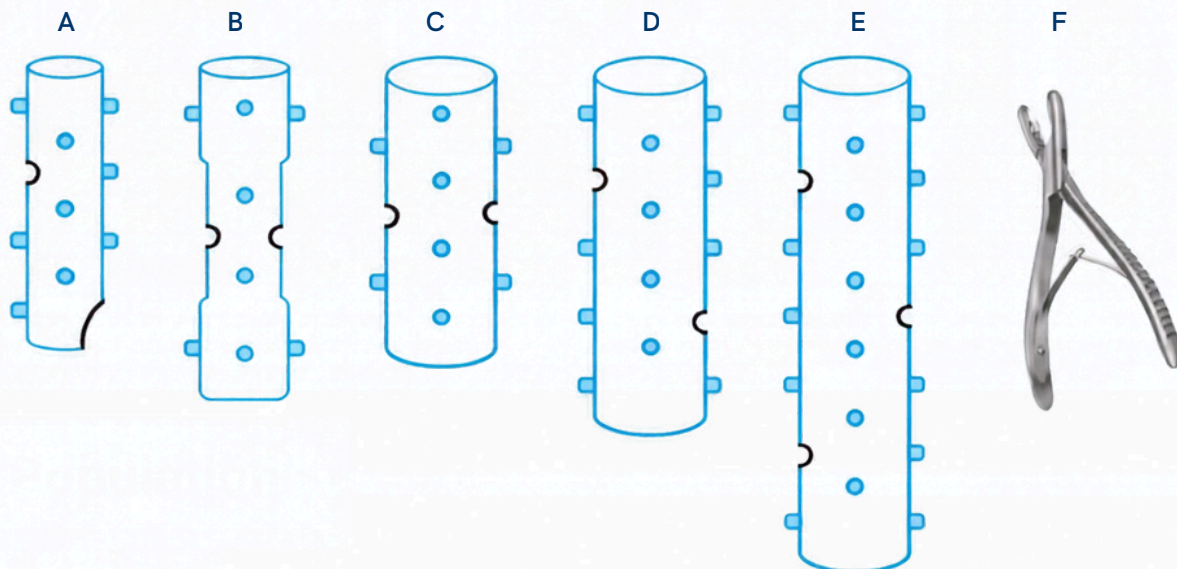


FIGURE 1 | Fenestrated silicone stent and the fenestrating forces. (A) Fenestrated silicone stent for mainstem bronchi. (B) Fenestrated ST. (C) Fenestrated silicone stent for trachea with length ~40mm. (D) Fenestrated silicone stent for trachea with length ~40mm and ~60mm. (E) Fenestrated silicone stent for trachea with length ~60mm. (F) DUTAU cepcs.



Population

INCLUSION CRITERIA:

- patients with inoperable benign central airway stenosis who underwent either fenestrated or conventional silicone stent placements between January 2019 and December 2023 from the Interventional Pulmonology Unit of the First affiliated Hospital of Guangzhou Medical University were reviewed retrospectively.

EXCLUSION CRITERIA

- treated with Y silicone stents
- more than one stent was placed at the same time
- patients with malignant airway stenosis, fistula, relapsing polychondritis, or airway stenosis of unknown etiology
- lack of video or images of the entire stent to determine the stent type.

BASELINE CHARACTERISTICS

- Unmatched cohort showed differences in age, stenosis cause, stenosis location, cryotherapy, and stent type but after propensity score matching the groups matched in all covariates, except for high-frequency electrocautery and laser usage.
- The median follow-up was 315 days (IQR 154.5–523.0) and 215.0 days (IQR 105.0–367.0) in the conventional silicone stent, 301 days (IQR 115.0–597.5) and 350.0 days (IQR 174.0–583.0) in the fenestrated silicone stent cohort before ($p = 0.856$) and after PSM ($p = 0.072$).

BASELINE CLINICAL CHARACTERISTICS AFTER PSM

Variable	Conventional Stent (n=35)	Fenestrated Stent (n=35)
Age (mean $\pm$ SD, years)	42.37 $\pm$ 16.08	41.71 $\pm$ 14.44
Male sex, n (%)	16 (45.7%)	17 (48.6%)
Never smoking, n (%)	29 (82.9%)	28 (80.0%)
Stenosis cause, n (%)		
Post-tuberculosis	16 (45.7%)	19 (54.3%)
Post-intubation	11 (31.4%)	4 (11.4%)
Post-tracheostomy	4 (11.4%)	8 (22.9%)
Transplant-related	4 (11.4%)	4 (11.4%)
Stenosis location, n (%)		
Trachea	15 (42.9%)	15 (42.9%)
Left main bronchus	15 (42.9%)	15 (42.9%)
Right main bronchus	5 (14.3%)	5 (14.3%)



Outcomes

Primary outcomes

- Stent insertion was successful in all cases and achieved at least 80% free lumen of airway.
- In the matched cohort, the recurrent obstruction rate was 82.8% and 60% in the conventional and fenestrated groups, respectively ($p = 0.034$).
- The median patency time was 154.0 days (IQR 49.0–315.0) and 334.0 days (IQR 119.0–549.5) in the conventional and fenestrated groups, respectively ($p = 0.046$).

Secondary outcomes looking at biomechanical performance

- Equivalent stress results between fenestrated and conventional stent (equivalent structural integrity)
- Total deformation was overall reduced (improved structural stability in fenestrated group)
- Localized deformation increased in perforated regions (targeted flexibility)
- Slightly higher overall turbulent intensity in fenestrate stents (may facilitate sputum clearance). This was assessed using computational fluid dynamics (CFD) simulations based on 3D models of the stents in ANSYS Workbench.

Adverse events

- No major procedure-related complications were observed during the procedure or within the subsequent 24 h.
- No deaths occurred during the follow-up time.
- Among 118 patients included in the study, 84 patients underwent at least one complication of migration, granulation, and mucus retention (58 conventional vs. 26 fenestrated, $p < 0.001$)
- In the matched cohort, 54/70 patients underwent complication (31 conventional vs. 23 fenestrated, $p = 0.023$).
- In the matched cohort, the median time to complication was 18.0 days (IQR 3.0–61.0) and 131.0 days (IQR 56.0–301.0) in the conventional group and fenestrated group, respectively ($p < 0.001$).
- Adjusted Hazard ratio by specific complications (fenestrated silicone stent risk compared to conventional silicone stent):
 - migration (before PSM: aHR 0.28 [0.09–0.87]; $p = 0.028$; after PSM: aHR 0.14 [0.04–0.68]; $p = 0.013$)
 - granulation (before PSM: aHR 0.44 [0.24–0.83]; $p = 0.011$; after PSM: aHR 0.29 [0.13–0.64]; $p = 0.002$)
 - mucus retention (before PSM: aHR 0.49 [0.26–0.92]; $p = 0.027$; after PSM: aHR 0.44 [0.20–0.94]; $p = 0.035$)
- In the PSM matched cohort, 15/35 (42.9%) and 21/35 (60.0%) stents were removed in the conventional and fenestrated groups, respectively.
- 12/15 (80%) and 8/21 (38.1%) stents were removed due to complications in the conventional and fenestrated groups, respectively ($p = 0.013$).

STUDY STRENGTHS

- Follows clinically important complications of silicone stents in the management of benign central airway stenosis.
- Use of propensity score matching to reduce baseline confounding variables.
- Integrates clinical outcomes with biomechanical validation to provide mechanistic explanations for observed clinical differences.

STUDY LIMITATIONS

- Potential inherent biases in allocation to treatment arms (i.e. patients assessed to have challenging airway conditions, history of repeated airway intervention, or a propensity for granulation tissue formation received fenestrated stents)
- Retrospective design limits causal inference.
- Small sample size after propensity matching leads to reduced statistical power.
- Non-randomized treatment allocation allows for potential residual confounding variables.
- Single-center study limits generalizability.
- Biomechanical modeling dependent on assumptions; limited external validation.
- Fenestrated stents were manually modified, raising reproducibility and regulatory concerns.
- Limited reporting of long-term functional outcomes and quality-of-life measures.

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Suggested Reading

- 1 Bhora FY, Ayub A, Forleiter CM, et al. Treatment of benign tracheal stenosis using endoluminal spray cryotherapy. *JAMA Otolaryngol Head Neck Surg*. 2016 Nov 1;142(11):1082–1087. doi: 10.1001/jamaoto.2016.2018. PMID: 27532803.
- 2 Fortin M, Lacasse Y, Elharrar X, et al. Safety and efficacy of a fully covered self-expandable metallic stent in benign airway stenosis. *Respiration*. 2017;93(6):430–435. doi: 10.1159/000472155. PMID: 28448981.
- 3 Agrawal A, Baird BJ, Madariaga MLL, et al. Multi-disciplinary management of patients with benign airway strictures: a review. *Respir Med*. 2021 Oct;187:106582. doi: 10.1016/j.rmed.2021.106582. PMID: 34481304

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