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Meta-Analysis

Bougie versus balloon endoscopic dilatation for benign oesophageal strictures in children: a systematic review and meta-analysis of efficacy and safety outcomes

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ABSTRACT

Endoscopic dilatation is the standard treatment for benign esophageal strictures in children. Both bougie and balloon dilatation techniques are widely used; however, comparative evidence regarding their efficacy and safety remains limited. Balloon dilatation provides controlled radial expansion under direct visualization, whereas bougie dilatation is less expensive, reusable, and widely available. We performed a systematic review and meta-analysis to compare the efficacy and safety of bougie versus balloon endoscopic dilatation in children with benign esophageal strictures. A systematic review and meta-analysis were conducted according to the PRISMA 2020 guidelines. PubMed/MEDLINE, Embase, Scopus, Web of Science, Cochrane CENTRAL, and Google Scholar were searched from database inception to May 31, 2026. Comparative studies involving children (<18 years) undergoing bougie or balloon dilatation for benign esophageal strictures were included. The primary outcome was esophageal perforation. Secondary outcomes included treatment success and the number of dilatation sessions required. Random-effects meta-analysis was performed using odds ratios (ORs) for dichotomous outcomes and mean differences (MDs) for continuous outcomes. Nine comparative studies published between 2001 and 2025 met the inclusion criteria. Seven studies comprising 4,889 dilatation procedures contributed to the perforation analysis. Eleven perforations occurred during 2,607 bougie dilatations and 19 during 2,282 balloon dilatations (per procedure analysis). There was no significant difference in perforation risk between the two techniques (OR, 0.64; 95% confidence interval [CI], 0.30–1.37; p=0.25), with no heterogeneity (I^2=0%). Five studies contributed data on the number of dilatation sessions. Bougie dilatation required significantly more sessions than balloon dilatation (MD, 1.63 sessions; 95% CI, 0.07–3.18; p=0.04), although heterogeneity was substantial (I^2=81%). Sensitivity analysis excluding an outlier study confirmed this finding with reduced heterogeneity (MD, 2.12 sessions; 95% CI, 1.26–2.97; p<0.00001). Reported treatment success rates ranged from 67% to 98% and were consistently high with both techniques. Bougie and balloon dilatation demonstrate comparable safety and overall efficacy for the treatment of benign esophageal strictures in children, with no statistically significant difference in perforation risk. However, balloon dilatation appears to reduce the procedural burden by requiring approximately two fewer dilatation sessions than bougie dilatation. Both techniques remain effective treatment options, and the choice should be guided by operator expertise, resource availability, and institutional preference. Further prospective multicenter studies are warranted to identify patient subgroups that may benefit preferentially from one technique.

Keywords: Oesophageal stricture, Balloon dilatation, Endoscopy, Gastrointestinal, Child, Infant, Adolescent

INTRODUCTION

Benign esophageal strictures are an important cause of dysphagia, feeding difficulties, recurrent vomiting, malnutrition, poor growth and impaired quality of life in children. The underlying etiologies include anastomotic strictures following esophageal atresia repair, caustic ingestion, congenital esophageal stenosis, gastroesophageal reflux disease and inflammatory disorders such as eosinophilic esophagitis. If left untreated, these strictures may result in severe nutritional compromise and the need for major reconstructive surgery. Endoscopic dilation has become the cornerstone of treatment for pediatric benign esophageal strictures and has largely replaced surgical intervention in most cases. The primary therapeutic goals are restoration of esophageal patency, improvement of swallowing and oral intake, optimization of nutritional status, and prevention of recurrent stricture formation. Although repeated procedures are often required, long-term outcomes are generally favorable.

The first comparative pediatric studies evaluating endoscopic dilation techniques were reported by Lang et al who demonstrated that both bougie and balloon dilation could be performed safely and effectively in children with benign esophageal strictures.[1] During the same period, Poddar et al. reported favorable outcomes following repeated endoscopic dilation.[2]

Over the following decade, experience with both techniques increased. Reinders et al reported durable long-term outcomes following repeated esophageal dilation procedures and demonstrated the feasibility of managing complex strictures using endoscopic techniques.[3] Subsequently, Gurfinkel et al reported high rates of technical success and low complication rates with both balloon and bougie dilation, further supporting the role of endoscopic management in pediatric practice.[4]

Despite the widespread acceptance of endoscopic dilation, uncertainty remains regarding the optimal dilation technique. Bougie dilators exert both radial and longitudinal forces while traversing the stricture and can frequently dilate long-segment narrowing in a single pass. In contrast, balloon dilators provide controlled circumferential radial expansion under endoscopic or fluoroscopic guidance.

Balloon dilation offers precise control over the dilation diameter but may require fluoroscopy and is associated with higher equipment costs. Conversely, bougie dilation is inexpensive, reusable, and widely available, particularly in resource-limited settings.

In a comprehensive review of pediatric esophageal strictures, Vandenplas emphasized the widespread use of both Savary-Gilliard bougies and through-the-scope balloon dilators while highlighting the lack of high-quality evidence supporting the superiority of either technique.[5] Similarly, Ghiselli et al concluded that both approaches appeared effective and safe but noted the absence of robust comparative pediatric evidence.[6] More recent studies have continued to evaluate comparative outcomes. Mark et al prospectively assessed balloon and bougie dilation and demonstrated comparable efficacy and safety between the two modalities.[7] Isa et al subsequently reported favorable outcomes with endoscopic dilation in children with benign strictures.[8] Abdullah et al further demonstrated low complication rates and satisfactory clinical outcomes in a large pediatric cohort.[9]

The strongest prospective comparative evidence to date has been provided by Devarapalli et al who performed a propensity score–matched analysis comparing balloon and bougie dilation in children with benign esophageal strictures and reported no significant differences in treatment success, recurrence, perforation rates, or the number of dilation sessions required.[10] More recently, Fakıoglu et al highlighted important procedural differences between techniques, including shorter procedure times and lower fluoroscopy requirements with bougie dilation, while Zhang et al continued to demonstrate comparable efficacy and safety outcomes between the two approaches.[11,12]

Although individual studies generally suggest similar outcomes, the available evidence remains limited by retrospective study designs, small sample sizes, heterogeneous patient populations, and inconsistent outcome reporting. To date, no systematic review and meta-analysis has comprehensively synthesized the available comparative pediatric evidence. Therefore, we performed a systematic review and meta-analysis to compare the efficacy and safety of bougie and balloon dilation for benign esophageal strictures in children. The primary outcome was esophageal perforation while secondary outcomes included the number of dilation sessions required, treatment success and other procedure-related complications.

METHODS

Study selection

All retrieved citations were imported into a reference management software package, and duplicate records were removed. Two reviewers independently screened the titles and abstracts for eligibility. Potentially relevant studies underwent full-text review. Disagreements were resolved through discussion and consensus.

Search strategy

This systematic review and meta-analysis were conducted in accordance with the PRISMA 2020 Statement and prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO; CRD420261421212).

A comprehensive literature search was performed in the following electronic databases from inception through May 31, 2026: PubMed/MEDLINE, Embase, Scopus, Web of Science, the Cochrane Central Register of Controlled Trials (CENTRAL), and Google Scholar. In addition, the reference lists of eligible studies and relevant review articles were manually screened to identify additional studies.

The search strategy combined controlled vocabulary terms (MeSH and Emtree) with free-text keywords related to esophageal strictures, pediatric populations, and endoscopic dilation techniques. The following search strategy was used for PubMed and adapted for the other databases: ("Esophageal Stenosis"[Mesh] OR "Esophageal Stricture*" OR "Oesophageal Stricture*" OR "Benign Esophageal Stricture*" OR "Benign Oesophageal Stricture*")

AND

("Child"[Mesh] OR "Infant"[Mesh] OR "Adolescent"[Mesh] OR child* OR pediatric OR paediatric OR infant* OR adolescent*)

AND

(("Balloon Dilatation" OR "Balloon Dilation" OR "Balloon Catheter*" OR "Through-the-Scope Balloon*" OR TTS Balloon*)

OR

("Bougie" OR "Savary" OR "Savary-Gilliard" OR "Wire-guided Bougie" OR "Bougie Dilatation" OR "Bougie Dilation"))

AND

(endoscop* OR dilatat* OR dilation OR dilatation)

No restrictions were placed on the publication date.

Eligibility criteria

Studies were included if they: included children younger than 18 years of age with benign esophageal strictures; compared bougie dilation and balloon dilation; reported at least one outcome of interest, including treatment success, perforation, number of dilation sessions, recurrence, or procedure-related complications; and were randomized controlled trials, prospective cohort studies, retrospective cohort studies, or case-control studies.

Studies were excluded if they: included only adult patients; evaluated a single dilation technique without a comparator group; were case reports, review articles, editorials, conference abstracts without extractable data, or animal studies; and did not provide sufficient outcome data for extraction.

Data extraction

The following data were extracted from each study: author and year of publication; country of study; study design; etiology of the stricture; number of patients in the balloon and bougie groups; age and sex distribution; number of dilation sessions; treatment success; perforation events; and other procedure-related complications.

Risk of bias assessment

The methodological quality of the included non-randomized studies was assessed using the Newcastle–Ottawa Scale (NOS). Studies scoring 7–9 points were considered high quality, those scoring 5–6 points were considered moderate quality, and those scoring fewer than 5 points were considered low quality.

Statistical analysis

Meta-analysis was performed using a random-effects model (DerSimonian–Laird method). Mean differences (MDs) with 95% confidence intervals (CIs) were calculated for continuous outcomes, whereas odds ratios (ORs) with 95% CIs were calculated for dichotomous outcomes. Statistical heterogeneity was assessed using the I^2 statistic, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively.

RESULTS

Study selection

The database search yielded 356 records, with an additional four records identified through citation searching and hand-searching, resulting in a total of 360 records. After the removal of 41 duplicate records, 319 records underwent title and abstract screening. Of these, 308 records were excluded. Full-text assessment was performed for 11 articles, all of which were successfully retrieved.

Two studies were excluded because of the lack of a direct comparison or insufficient extractable outcome data, leaving nine studies for inclusion in the qualitative and quantitative synthesis (meta-analysis) (Figure 1).

Study characteristics

The nine included studies were published between 2001 and 2025 and consisted predominantly of retrospective cohort studies, with one prospective comparative study. Collectively, the studies evaluated children undergoing endoscopic dilation for benign esophageal strictures arising from diverse etiologies, including esophageal atresia repair, caustic ingestion, congenital esophageal stenosis, gastroesophageal reflux-related strictures, and other benign causes.

The studies originated from multiple geographic regions, including Europe, Middle East and South Asia, providing a broad representation of current pediatric practice. Sample sizes varied considerably, ranging from 28 to 102 patients. The largest comparative cohort was reported by Abdullah et al whereas the most recent study was published by Zhang et al. The characteristics of the included studies are summarized in Table 1.

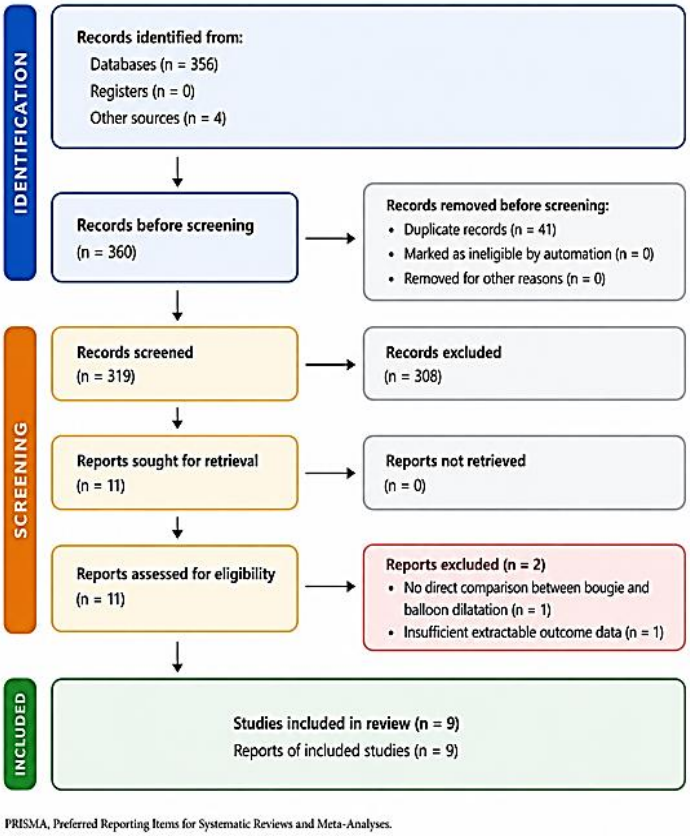


Figure 1: PRISMA 2020 flow diagram illustrating the study selection process for the systematic review and meta-analysis.

Study	Selection (max 4 stars)	Comparability (max 2 stars)	Outcome (max 3 stars)	Total (max 9 stars)	Overall risk of bias
Lang 2001	★★★☆☆	★★☆☆	★★★☆☆	5/9	Moderate
Reinders 2014	★★★☆☆	★★☆☆	★★★☆☆	6/9	Moderate
Gurfinkel 2015	★★★☆☆	★★☆☆	★★★☆☆	6/9	Moderate
Mark 2019	★★★☆☆	★★☆☆	★★★☆☆	7/9	Low
Isa 2021	★★★☆☆	★★☆☆	★★☆☆☆	5/9	Moderate
Abdullah 2022	★★★☆☆	★★☆☆	★★★☆☆	6/9	Moderate
Devarapalli 2023	★★★★☆	★★☆☆	★★★☆☆	8/9	Low
Fakıoglu 2023	★★★☆☆	★★☆☆	★★★☆☆	6/9	Moderate
Zhang 2025	★★★☆☆	★★☆☆	★★★☆☆	6/9	Moderate

NOS domains: Selection = maximum 4 stars; Comparability = maximum 2 stars; Outcome = maximum 3 stars.
Total score: 7–9 stars = low risk (good quality); 4–6 stars = moderate risk (fair quality); 0–3 stars = high risk (poor quality).
Judgements reflect non-randomized evidence, controlling for confounding, outcome ascertainment and follow-up completeness.
★★★★ = 4 stars (high) ★★★ = 3 stars (moderate) ★★ = 2 stars (limited) ★ = 1 star (very limited) ☆ = 0 stars (none)

Figure 2: Risk of bias assessment of included studies (Newcastle-Ottawa Scale).Bougie versus balloon dilatation for benign oesophageal strictures in children.

Table 1: Characteristics of included studies.

Study	Year	Design	Arm	N	Age (years, mean±SD)	Male (%)	No. of dilatation sessions
Lang	2001	Retrospective	Bougie	12	0.88±7.30	66.0	178
Lang	2001	Retrospective	Balloon	16	3.42±7.27	50.0	30
Reinders	2014	Retrospective	Bougie	NR	NR	NR	81
Reinders	2014	Retrospective	Balloon	NR	NR	NR	305
Gurfinkel	2015	Retrospective	Bougie	12	NR	NR	61
Gurfinkel	2015	Retrospective	Balloon	23	NR	NR	129
Mark	2019	Prospective	Bougie	37	14.5 (median reported)	59.5	56
Mark	2019	Prospective	Balloon	66	3.0 (median reported)	54.5	190
Isa	2021	Retrospective	Bougie	21	NR	NR	76
Isa	2021	Retrospective	Balloon	3	NR	NR	8
Abdullah	2022	Retrospective	Bougie	29	5.17±3.30	75.0	187
Abdullah	2022	Retrospective	Balloon	73	6.75±4.76	64.0	326
Devarapalli	2023	Retrospective	Bougie	54	1.41±1.46	65.0	856
Devarapalli	2023	Retrospective	Balloon	23	3.03±2.76	65.0	560
Fakıoglu	2023	Retrospective	Bougie	NR	NR	NR	235
Fakıoglu	2023	Retrospective	Balloon	NR	NR	NR	212
Zhang	2025	Retrospective	Bougie	19	5.80±1.90	47.4	124
Zhang	2025	Retrospective	Balloon	18	6.70±1.40	66.7	90

Table 2: Outcomes of included studies comparing bougie and balloon oesophageal dilatation in children.

Study	Arm	N	Mean dilatation sessions±SD	Perforation rate (%)	Success (%)	Chest pain (%)	Increase in diameter (mean±SD)
Lang	Bougie	12.0	7.9±2.3	0.0	–	–	–
Lang	Balloon	16.0	3.3±4.4	2.0	–	–	–
Reinders	Bougie	–	8.3± –	0.0	–	–	–
Reinders	Balloon	–	7.16± –	0.0	–	–	–
Gurfinkel	Bougie	12.0	–	1.63	87.0	–	–
Gurfinkel	Balloon	23.0	–	1.55	67.0	–	–
Mark	Bougie	37.0	2.0±1.0	1.8	–	17.9	4.6±2.0
Mark	Balloon	66.0	10.0±8.5	0.6	–	6.3	5.3 ± 2.3
Isa	Bougie	21.0	–	0.0	71.0	–	–
Isa	Balloon	3.0	–	0.0	33.0	–	–
Abdullah	Bougie	29.0	6.44±1.13	1.07	–	–	–
Abdulah	Balloon	73.0	4.47±1.12	1.23	–	–	–
Devarapalli	Bougie	54.0	5.0±3.7	0.35	–	–	–
Devarapalli	Balloon	23.0	4.0±2.96	0.54	–	–	–
Fakıoglu	Bougie	–	–	0.4	88.0	–	–
Fakıoglu	Balloon	–	–	0.9	98.0	–	–
Zhang	Bougie	19.0	8.8±2.4	0.0	78.9	–	–
Zhang	Balloon	18.0	6.5±1.1	0.0	83.3	–	–

Risk of bias assessment

Risk of bias was assessed using the Newcastle–Ottawa Scale (NOS). Overall, the methodological quality of the included studies was moderate to high. Two studies achieved high-quality scores (≥7 stars), whereas the remaining studies were classified as moderate quality. No study was judged to be at high risk of bias. The principal limitations were the retrospective study design, lack of randomization, and potential selection bias inherent to observational studies. The comparability domain

generally scored well because most studies evaluated similar pediatric populations undergoing comparable therapeutic interventions.

Perforation rate

Seven studies involving 4,889 dilation procedures contributed to the perforation analysis. A total of 11 perforations occurred during 2,607 bougie dilation procedures compared with 19 perforations during 2,282 balloon dilation procedures. Random-effects meta-analysis demonstrated no significant statistical difference in perforation risk between bougie and balloon dilation (OR, 0.64; 95% CI, 0.30–1.37; P=0.25). Statistical heterogeneity was absent (I^2=0%), indicating highly consistent findings across studies. Although perforations occurred numerically less frequently following bougie dilation (0.42% vs. 0.83%), the difference did not reach statistical significance.

The pooled estimate suggested a numerical trend toward fewer perforations with bougie dilation; however, the confidence interval crossed unity, precluding a definitive conclusion regarding the superiority of either technique. Overall, both modalities demonstrated excellent safety profiles, with very low perforation rates.

Number of dilation sessions

Five studies comprising 347 children (151 treated with bougie dilation and 196 treated with balloon dilation) reported the number of dilation sessions required. Random-effects meta-analysis demonstrated that bougie dilation was associated with a significantly greater number of sessions than balloon dilation (MD, 1.63 sessions; 95% CI, 0.07–3.18; P=0.04). There was substantial between-study heterogeneity (I^2=81%), reflecting considerable variation in reported outcomes across studies.

Children treated with bougie dilation required, on average, approximately 1.6 additional dilation sessions compared with those treated with balloon dilation. However, the substantial heterogeneity (I^2=81%) suggested considerable variation among the included studies. One study (Mark et al) reported results in the opposite direction, favoring bougie dilation, and appeared to be an outlier contributing substantially to the observed heterogeneity.

Visual inspection of the funnel plot did not reveal obvious asymmetry. However, because only five studies contributed to this outcome, the ability to reliably assess publication bias was limited. Therefore, the possibility of small-study effects cannot be excluded. The apparent statistical significance was driven largely by the inclusion of the study by Mark et al which reported substantially more dilation sessions in the balloon group (12.67±25.19) than in the bougie group (2.33±2.96). This study exhibited an unusually large standard deviation and effect estimate and was likely responsible for much of the observed heterogeneity.

A sensitivity analysis excluding the outlying study by Mark et al was performed because of its markedly divergent effect estimate and unusually large variance. Four studies involving 244 children (114 treated with bougie dilation and 130 treated with balloon dilation) were included. The pooled analysis demonstrated that bougie dilation required significantly more sessions than balloon dilation (MD, 2.12 sessions; 95% CI, 1.26–2.97; P<0.00001). Heterogeneity decreased from considerable to moderate (I^2=49%), indicating that the excluded study accounted for much of the between-study variability.

Treatment success

Technical success was reported inconsistently across studies. Reported success rates ranged from 67% to 98%. There is no standard definition - Clinical parameters like resolution of dysphagia, age-appropriate oral feeding skills do not get mentioned. Gurfinkel et al reported success rates of 87% for bougie dilation and 67% for balloon dilation, whereas Fakıoglu et al observed success rates of 88% and 98%, respectively.

Zhang et al demonstrated comparable success rates of 78.9% and 83.3%. Because outcome definitions varied substantially among studies and sufficient extractable data were unavailable in several cohorts, quantitative pooling of treatment success was not considered methodologically appropriate.

Publication bias

Visual inspection of the funnel plot for perforation outcomes demonstrated reasonable symmetry without evidence of major publication bias. Interpretation of the funnel plot was undertaken with caution because fewer than 10 studies contributed to the analysis, limiting the reliability of this assessment.

Other clinical outcomes

Several clinically relevant outcomes could not be quantitatively pooled because of inconsistent reporting across studies but provide important insights into the practical differences between bougie and balloon dilation. Bougie dilation was associated with significantly shorter procedure times than balloon dilation. In the Turkish cohort, bougie sessions lasted a mean of 26.2±11.8 minutes compared with 42.6±13.7 minutes for balloon dilation, reflecting the ability of Savary-Gilliard bougies to dilate long-segment or multiple strictures in a single pass. Bougie dilation was also associated with substantially lower fluoroscopy requirements, with radiographic guidance needed in only 14% of procedures compared with the routine use of fluoroscopy during balloon dilation.

Patient comfort, however, may favor balloon dilation. Mark et al reported a higher incidence of transient chest or throat discomfort following bougie dilation (21%) than following balloon dilation (6.8%). These symptoms were generally mild and self-limited. Long-term nutritional outcomes were encouraging regardless of the dilation modality used. Successful treatment resulted in significant improvements in growth parameters, including weight-for-age and height-for-age z-scores. Importantly, no significant differences were observed between bougie and balloon dilation with respect to subsequent growth and nutritional recovery, suggesting that restoration of esophageal patency rather than the choice of dilator is the principal determinant of long-term clinical benefit.

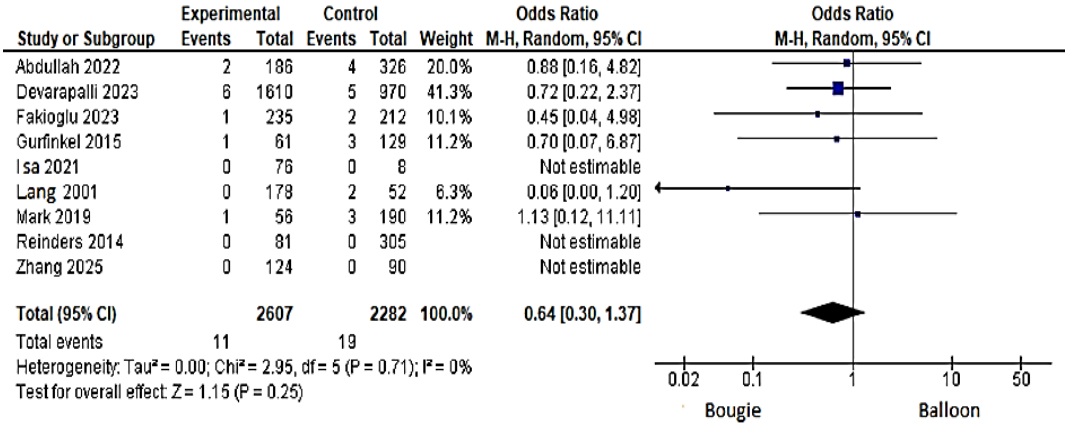


Figure 3 :Forest plot (random effects model) perforation rate between bougie and balloon dilatation.

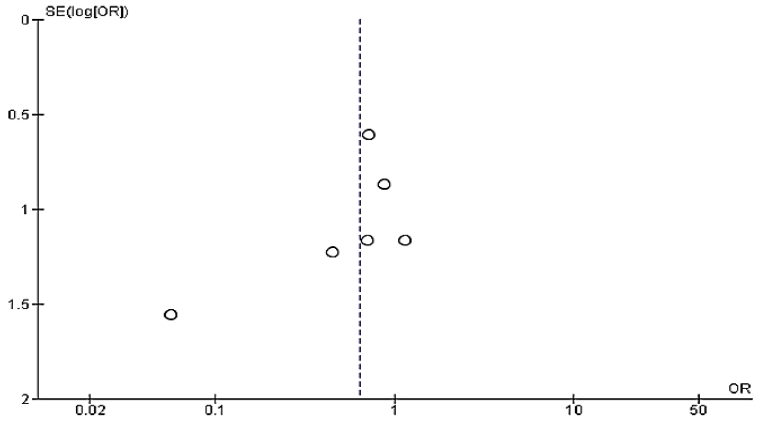


Figure 4 : Funnel plot: perforation rate between bougie and balloon dilatation.

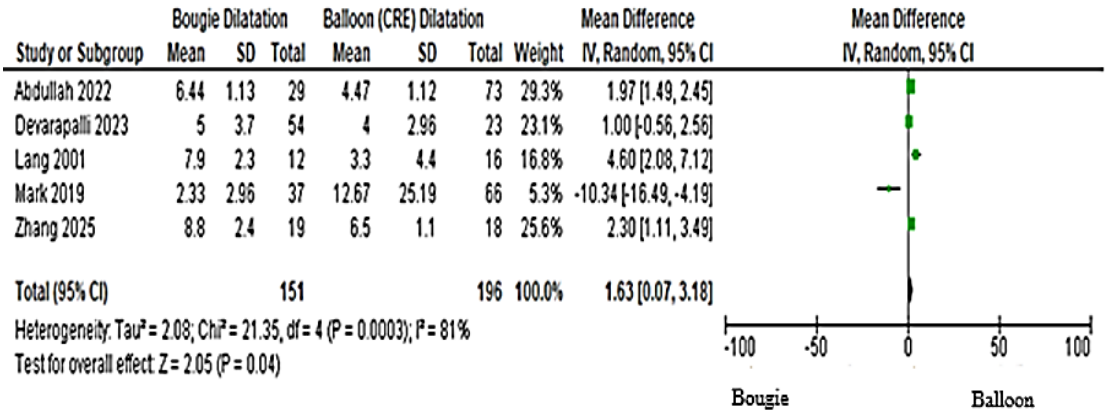


Figure 5 : Forest plot (random effects model) Mean number of dilatation sessions between Bougie and Balloon groups.

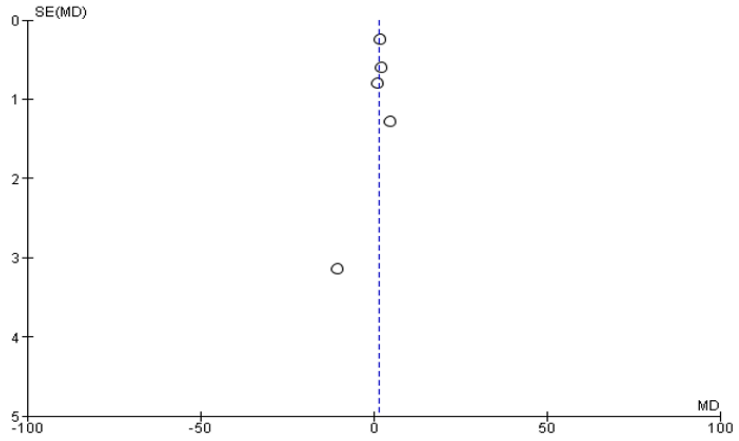


Figure 6: Funnel plot (random effects model) mean number of dilatations between bougie and balloon groups.

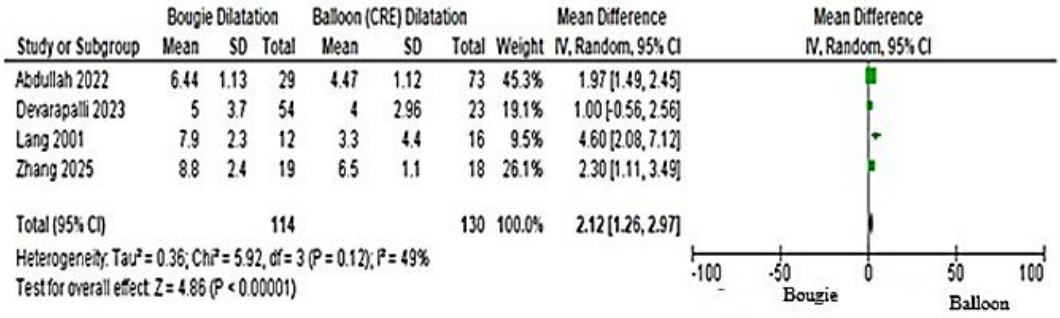


Figure 7: Forest plot following sensitivity analysis excluding study by Mark (2019).

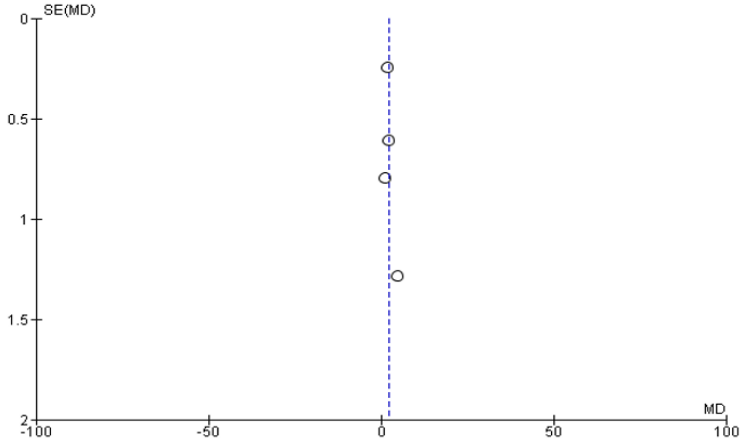


Figure 8: Forest plot following sensitivity analysis excluding study by Mark (2019).

DISCUSSION

This systematic review and meta-analysis represent the first comprehensive synthesis of comparative pediatric evidence evaluating bougie versus balloon dilation for benign esophageal strictures. Across nine comparative studies spanning more than two decades and nearly 5,000 dilation procedures, we found no significant differences between the two techniques with respect to perforation risk. Balloon dilatation appears to reduce the procedural burden by requiring approximately two fewer dilatation sessions than bougie dilatation. These findings suggest that both bougie and balloon dilation are effective and safe treatment modalities for benign esophageal strictures in children.

Several limitations should be acknowledged. All included studies were observational, and most were retrospective,

introducing the potential for selection bias and residual confounding. Definitions of treatment success varied substantially among studies, preventing formal quantitative synthesis. Significant heterogeneity was present. Subgroup analysis based on etiology was difficult as data related to etiology was not consistently mentioned in several studies. Next, length of stricture whether short or long was also not accessible by data extraction for many studies, hence analysis was limited to the outcomes reported.

The evolution of pediatric esophageal dilation has progressed steadily over the past two decades. Early reports by Lang et al and Poddar et al established endoscopic dilation as an effective alternative to surgical reconstruction.[1,2] Subsequent studies by Reinders et al and Gurfinkel et al confirmed durable long-term efficacy and low complication rates with both modalities.[3,4] Collectively, these investigations established endoscopic dilation as the standard of care but were unable to determine whether one technique was superior.

The principal finding of the present meta-analysis is the absence of a significant difference in perforation risk between balloon and bougie dilation. Historically, balloon dilation has often been perceived as safer because it applies controlled radial forces directly to the stricture, whereas bougie dilators generate both radial and longitudinal forces during passage. This theoretical concern has contributed to the widespread perception that bougie dilation may be associated with a greater risk of perforation. However, our pooled analysis demonstrated no significant difference in perforation risk between the two techniques and revealed no measurable heterogeneity among studies. These findings suggest that perforation risk is more strongly influenced by stricture characteristics, procedural technique, and operator experience than by the choice of dilator itself.

The low perforation rates observed across all included studies are consistent with the findings reported by Reinders et al, Abdullah et al, Devarapalli et al, Fakıoglu et al and Zhang et al.[3,9-12] Importantly, Devarapalli et al whose propensity score–matched analysis represents the highest-quality comparative evidence currently available, likewise demonstrated equivalent perforation rates between the two techniques.[10] By pooling all available pediatric data, the present study substantially increases the statistical power for assessing rare adverse events.

Sensitivity analysis excluding the study by Mark et al markedly reduced heterogeneity (I^2, 81% to 49%) and yielded a more robust estimate, demonstrating that children undergoing bougie dilation required approximately two additional dilation sessions compared with those undergoing balloon dilation. The excluded study reported unusually high variability and findings that differed from those of the remaining studies, suggesting that differences in patient characteristics, stricture etiology, or local treatment protocols may have contributed to its discordant results. The consistency observed among the remaining studies strengthens the evidence supporting balloon dilation as the technique requiring fewer procedures.

Several clinically relevant secondary observations emerged from the included studies. Fakıoglu et al reported significantly shorter procedure durations with bougie dilation and substantially lower fluoroscopy requirements.[11] These findings may be particularly relevant in children with recurrent strictures requiring repeated interventions, for whom cumulative anesthesia and radiation exposure are important considerations. Fakıoglu et al also demonstrated that a proportion of planned balloon procedures required conversion to bougie dilation because of technical difficulties or an inability to traverse tight strictures, suggesting a potential technical advantage of bougies in selected clinical scenarios.[11]

Patient comfort may represent one area in which balloon dilation offers a modest advantage. Mark et al. reported higher rates of transient chest or throat discomfort following bougie dilation than following balloon dilation.[7] However, these symptoms were generally mild and self-limited and did not affect overall treatment success. Successful dilation was associated with significant improvements in nutritional status and growth. Devarapalli et al demonstrated improvements in both weight-for-age and height-for-age z-scores following treatment, although no significant differences were observed between the two dilation modalities.[10] These findings suggest that restoration of esophageal patency, rather than the choice of dilator, is the principal determinant of long-term nutritional recovery.

Our findings are consistent with recommendations from contemporary reviews and expert guidance. Vandenplas emphasized that neither technique has demonstrated clear superiority and that procedural selection should be guided by local expertise and equipment availability.[5] The present meta-analysis provides quantitative evidence supporting this recommendation and reinforces the concept that both modalities should be considered acceptable first-line therapeutic options.

Despite these limitations, this study has several important strengths. It represents the first systematic review and meta-analysis specifically comparing bougie and balloon dilation in children, was conducted in accordance with the PRISMA 2020 recommendations, incorporated a comprehensive search strategy, and synthesized evidence from nearly 5,000 procedures. The absence of heterogeneity in the primary safety outcome further strengthens the reliability of the pooled findings.

CONCLUSION

Current evidence demonstrates that bougie and balloon dilation provide comparable efficacy and safety for the

treatment of benign esophageal strictures in children. No significant differences were identified in perforation risk. Balloon dilatation appears to reduce the procedural burden by requiring approximately two fewer dilatation sessions than bougie dilatation. Given these comparable outcomes, the choice of dilation technique should be guided by operator experience, equipment availability, institutional preference, and cost considerations. Future prospective multicenter studies with standardized outcome reporting are needed to determine whether specific stricture etiologies or patient subgroups derive greater benefit from one modality than the other.

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Ethical approval: Not required

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