

Double Opposing Z-Plasty Outcome in Treatment of VPI: Updated Meta-Analysis Study

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Abstract

Background: The incomplete closure of the velopharyngeal port, which is the passageway between the oro- and nasopharynx, is referred to as velopharyngeal insufficiency (VPI).

Aim: To assess the functional results of the double opposing Z-plasty procedure for the management of VPI. This assessment was achieved through an updated meta-analysis of the recently published articles from the last years (2018-2024).

Methods: This research was dependent on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations and guidelines. The authors searched for recent clinical trials, cohort trials, and prospective and retrospective comparative cohort research for this study.

Results: In this meta-analysis focusing on the impact of Double Opposing Z-Plasty on speech intelligibility in cases with velopharyngeal insufficiency, the findings highlight a modest improvement. The pooled estimate from a continuous random-effects model is 0.795 with a 95% confidence interval varying from 0.383 to 1.206, demonstrating statistically significant results (*p*-value under 0.001). The meta-analysis on the necessity for revision surgery following double opposing Z-plasty in the management of velopharyngeal insufficiency demonstrates a relatively low overall proportion of cases requiring further surgical intervention.

Conclusion: The findings suggest that Double Opposing Z-Plasty is a valuable option for VPI but emphasize the need for standardized success criteria, long-term follow-up, and further research to improve patient selection and surgical techniques.

Keywords: Double opposing Z-Plasty, VPI, Speech Intelligibility

1. Introduction

The incomplete closure of the velopharyngeal port, which is the passageway between the oro- and nasopharynx, is referred to as velopharyngeal insufficiency. The palatopharyngeus and superior constrictor muscles approach the pharyngeal wall toward the midline through phonation, whereas the levator veli palatini muscle raises the velum backward and upward. Normal speech articulation and resonance are disrupted when there is insufficient closure during phonation, allowing air to partially pass through the nose.¹

Inadequate closure of the velopharyngeal port during speaking and/or swallowing results in velopharyngeal dysfunction, which can cause nasal regurgitation of food or liquid, loud nasal air emissions, and/or hypernasal speech. Three categories can be used to describe this dysfunction: velopharyngeal insufficiency (VPI),

which occurs when the velopharyngeal valve is structurally abnormal; velopharyngeal incompetence, which occurs when neurophysiological disorders cause insufficient movement; and velopharyngeal mislearning, which occurs when the components are positioned incorrectly during articulation.²

The palate's two main functions are to guarantee velopharyngeal competence (the soft palate) and to provide mechanical support and growth centering for the maxilla (the hard palate). The main muscles responsible for velopharyngeal competence are the levator veli palatini, which typically have a medial, downward, and forward motion. This makes it easier for the soft palate to migrate posteriorly, laterally, and cranially during closure. These muscles link to the posterior margin of the hard palate and run sagittally in individuals with cleft palates, making it difficult for them to move effectively upward, laterally, or posteriorly.³

Accepted 20 August 2025.
Available online 30 September 2025

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<https://doi.org/10.21608/aimj.2025.398454.2584>

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In order to enhance speech outcomes for patients with cleft palates, a number of surgical methods have been improved during the last 30 years. Dissecting and retro-positioning the levator muscle is crucial, according to surgeons.⁴

Furlow palatoplasty (double opposed Z-plasty), overlapping intravelar veloplasty with oral Z-plasty, sphincter pharyngoplasty, pharyngeal flap, and palatal lengthening with a buccal flap are described surgical techniques for treating VPI.⁵

Furlow was the first to publish this palatal repair method. By increasing velar length and creating the proper palatal muscle sling, this approach results in less scarring and no bare region on the hard palate.⁶

Furlow palatoplasty can be used for large clefts, although it has drawbacks, such as a greater risk of fistulas. Intravelar veloplasty (IVVP), which combines straight-line closure with direct muscle restoration, has demonstrated promising outcomes in replicating the palatal muscular sling; nevertheless, because of the unavoidable contracture, it frequently results in an increased incidence of VPI. No surgical approach has reached 0% VPI despite improvements.⁷

The goal of this work was to evaluate the functional outcomes of the double opposing Z-plasty procedure for the management of velopharyngeal insufficiency; this assessment was achieved through an updated meta-analysis of the recently published articles from the last years (2018-2024).

2. Patients and methods

This research was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations and guidelines. The authors searched for recent clinical trials, cohort trials, and prospective and retrospective comparative cohort research for this study. After the search results were acquired, they were carefully screened to see if they qualified for inclusion using systematic review management software (EndNote). To enable a thorough selection process, the PRISMA flowchart was applied to the search results, incorporating predetermined inclusion/exclusion criteria. The Research Committee of the Faculty of Medicine at Al-Azhar University in Cairo gave its approval to this work. The PRISMA flowchart was applied to the search results, incorporating predefined inclusion/exclusion criteria to facilitate a rigorous selection process.

Search question:

What are the outcomes of double opposing Z-

plasty in the treatment of velopharyngeal insufficiency in terms of speech improvement, complication rates, and surgical success?

Figure (1): PRISMA 2020 flow diagram

Search strategy and information sources

Authors developed a search strategy utilizing the following keywords: ("Velopharyngeal Insufficiency" OR VPI) AND ("Double Opposing Z-Plasty" OR "Secondary Furlow Palatoplasty") AND ("surgical outcomes" OR "speech improvement" OR "complication rates"). Authors systematically searched PubMed, MEDLINE, Science Direct, Scopus, Web of Science, and Google Scholar databases for relevant articles using these search terms. The reference lists of correlated reviews and original articles have been searched for any relevant research.

Study selection

The authors conducted both title and abstract screening, followed by full-text screening. The eligible articles were selected based on the following criteria:

Population: Patients undergoing secondary surgery for Velopharyngeal Insufficiency (VPI).

Intervention: Cases managed with the double opposing Z-plasty surgical technique.

Outcomes: Successful surgical outcomes, improvement in speech quality, incidence of major complications, fistula formation, and need for revision surgery.

Study Design: Involving case-control studies, randomized controlled trials, cross-sectional analyses, cohort studies, and prospective studies.

Eligibility criteria

The preliminary selection of research was implemented depending on the abstracts and titles. Next, two investigators independently screened the full text of each chosen research study utilizing the following criteria:

Inclusion criteria:

Publication from January 2018 to February 2025, Studies with the English language, Studies must clearly define and measure clinical results, like velopharyngeal competence, speech improvement, and frequency of oronasal fistulas or complications. Studies must have received ethical approval from a recognized institutional review board or ethics committee to ensure adherence to ethical standards in research. Inclusion of randomized controlled trials (RCTs), cohort studies, and systematic reviews to provide robust evidence, Studies comparing postoperative outcomes of the secondary procedure and only the secondary Furlow DOZ procedure.

Exclusion criteria: languages other than English, duplicates, nonclinical outcome studies, book chapters, editorials, case reports, textbooks,

research with three cases, and poster conferences or published oral abstracts.

Quality assessment and avoidance of bias:

Types of bias:

Pre-trial bias: Sources of pre-trial bias encompass errors in case recruitment and the design of research. These errors might result in fatal flaws in the data that cannot be compensated for throughout the analysis.

Bias during study design: involve chronology bias, interviewer bias, transfer bias, recall bias, outcome misclassification, and performance bias.

Bias after trial: involves citation bias and confounding.

The potential for bias in every research study that was involved was evaluated by two independent authors utilizing the Newcastle-Ottawa Scale for cohort studies. The tool has eight items divided into three subscales, with a maximum total score of nine; scores of seven or higher denote high-quality articles, while scores below five signify low-quality research.⁸

Study Selection

Research was mostly included or excluded based on the title and abstract. Titles have been stored utilizing EndNote by Clarivate and Mendeley by Scopus, with data extraction performed systematically in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Summary measures have been pooled using a random-effects model meta-analysis.

Data extraction

The research retrieved three categories of data from the involved articles: the demographic characteristics of the case, the baseline values, and the values of the results prior to treatment. The second category involved the extraction of results for analysis. The last category was quality evaluation data inside observational research. The data collection process was performed using Microsoft Excel. In our literature review, authors searched multiple databases, identifying 3006 studies initially. After removing 1038 duplicates and ineligible references, the authors screened 1968 studies. Further assessment narrowed it down to 136, excluding 119 for various reasons, and ultimately included six studies in our meta-analysis.

Data synthesis and analysis

The authors conducted this meta-analysis utilizing Review Manager Software (EndNote, 2021), while statistical analyses were carried out using Open Meta Analyst (AHRQ, CEBM; Brown University, United States of America). Our research included a dichotomy. The authors utilized a ninety-five percent confidence interval (CI), risk ratio (RR), and a ninety-five percent confidence interval to assess dichotomous data. When the data were homogeneous, the fixed-

effects model was utilized; when the data were heterogeneous, the random-effects model was applied. The authors utilized the I^2 and p-value from the chi-square tests to evaluate the consistency among the research.⁹ values of $P < 0.1$ or I^2 above 50% were significant signs of heterogeneity.

Types of included interventions:

Double opposing z-plasty procedure (secondary)

3. Results

Table 1 presents a detailed overview of various studies examining the surgical Furlow Palatoplasty technique Double-Opposing Z-Plasty as a secondary procedure, specifically targeting conditions such as Velopharyngeal Insufficiency (VPI). The studies are meticulously cataloged by author, publication year, and study design, with methodologies ranging from cohort studies to retrospective analyses and case-control studies. Each entry details the number of cases and the specific surgical interventions employed, for a total of 464 participants across 6 studies. The techniques include innovative approaches such as the comparison of secondary Furlow procedures and the use of advanced rating systems like CAPS-A-AM to evaluate outcomes like hypernasality. This compilation of research provides invaluable insights into the efficacy of different surgical methods in treating cleft palates and related anomalies, significantly contributing to the enhancement of clinical strategies and patient care outcomes.

Table 1. Studies' characteristics

AUTHOR	YEAR	STUDY DESIGN	NO. OF CASES (DOUBLE-Z PLASTY)	TECHNIQUES INCLUDED IN THE STUDY
AHTI et al. ¹⁰	2020	Retrospective	109	Double-Opposing Z-Plasty for UCLP as Secondary procedure
ARUN K. GOSAIN et al. ¹¹	2018	Retrospective	15	Double-Opposing Z-Plasty for VPI following primary Furlow Palatoplasty
BONANTHAYA et al. ¹²	2021	Retrospective	92	Secondary Furlow Palatoplasty alone for VPI
CHENG et al. ¹³	2020	Case-control	83	Furlow Double-Opposing Z-Plasty in Palatal Re-Repair (Secondary)
PREZELSKI et al. ¹⁴	2024	Retrospective	110	Double-Opposing Z-Plasty for secondary surgical management of

				VPI; use of CAPS-A-AM rating system to evaluate hypernasality outcomes
SITZMAN et al. ¹⁵	2023	Retrospective	32	Comparison of Secondary Furlow procedure

Main outcomes Speech Intelligibility

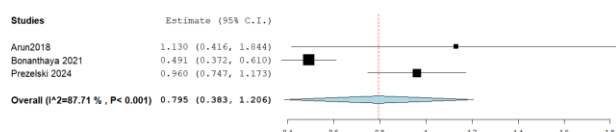


Figure 2. Speech Forest plot

In this meta-analysis focusing on the impact of Double Opposing Z-Plasty on speech intelligibility in cases with velopharyngeal insufficiency, the findings highlight a modest improvement. The pooled estimate from a continuous random-effects model is 0.795 with a 95% confidence interval varying from 0.383 to 1.206, demonstrating statistically significant findings (p -value < 0.001). The analysis includes data from three studies: Arun 2018 (weighted 18.862%), Bonanthaya 2021 (weighted 42.091%), and Prezelski 2024 (weighted 39.047%). Despite the significant outcome, there is considerable heterogeneity ($I^2 = 87.714\%$ and heterogeneity p -value < 0.001), suggesting variation in speech intelligibility improvements across studies. This variability emphasizes the need to consider individual differences in the surgical response and perhaps indicates different study methodologies or patient populations (Figure 2).

Nasopharyngoscopy Score

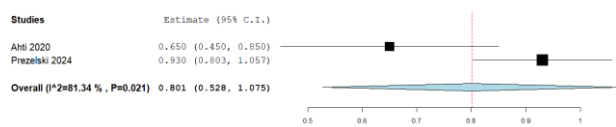


Figure 3. Nasopharyngoscopy Score Forest plot

In the updated meta-analysis on the outcomes of Double Opposing Z-Plasty in treating VPI, the focus on nasopharyngeal scores reveals a statistically significant improvement. The analysis, based on data from two studies—Ahti 2020 and Prezelski 2024, which are weighted 46.032% and 53.968% respectively—shows a pooled estimate of 0.801 with a 95% confidence interval from 0.528 to 1.075. The significance of these findings is underscored by a p -value of less than 0.001. Although the outcomes are promising, there is notable heterogeneity in the

results ($I^2 = 81.341\%$ and heterogeneity p -value = 0.021), indicating variability in the effectiveness of the treatment across different studies. This suggests that while the procedure generally improves nasopharyngeal function, individual results may vary, possibly due to differences in surgical technique or patient characteristics. (Figure 3)

Velopharyngeal Competence (Success Rate)

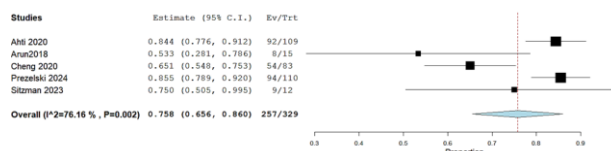


Figure 4. Velopharyngeal Competence (success rate) Forest plot

The meta-analysis concerning the overall success rate of Double Opposing Z-Plasty in the management of velopharyngeal insufficiency demonstrates substantial effectiveness across multiple studies. The pooled estimate of success is 75.8% with a 95% confidence interval from 65.6% to 86.0%, demonstrating strong evidence of the procedure's efficacy (p -value < 0.001). This analysis incorporates results from five studies: Ahti 2020 (weighted 27.232%), Arun 2018 (weighted 10.658%), Cheng 2020 (weighted 23.582%), Prezelski 2024 (weighted 27.447%), and Sitzman 2023 (weighted 11.082%). Despite the positive overall findings, the analysis also reveals significant heterogeneity ($I^2 = 76.162\%$ and heterogeneity p -value = 0.002), suggesting that the success rates vary considerably across the included studies. This variation might be influenced by differences in patient selection, surgical techniques, or postoperative care protocols, highlighting areas for potential improvement and standardization in clinical practice. (Figure 4)

Complication Rate

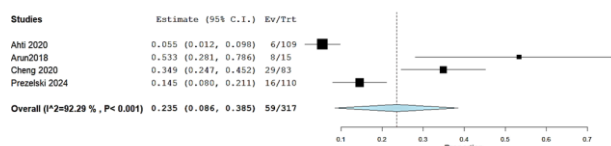


Figure 5. Complication Forest plot

The meta-analysis examining complications associated with Double Opposing Z-Plasty for the management of velopharyngeal shows a notable proportion of adverse outcomes. The combined results from the studies conducted by Ahti 2020 (29.246%), Arun 2018 (16.170%), Cheng 2020 (26.265%), and Prezelski 2024 (28.318%) indicate an overall complication rate of 23.5%, with a 95% confidence interval varying from 8.6% to 38.5%.

This estimate is statistically significant, with a p-value of 0.002, recommending that complications are a considerable concern. The standard error of the estimate is 0.076, reflecting the precision of this pooled estimate. However, there is very high heterogeneity among the included researches, as evidenced by an I^2 value of 92.291% and a heterogeneity p-value of less than 0.001, indicating significant variability in complication rates across studies. This high level of heterogeneity suggests that factors such as surgical technique, patient selection, or postoperative care might influence the incidence of complications and should be considered in clinical practice and future research. (Figure 5)

Revision procedure

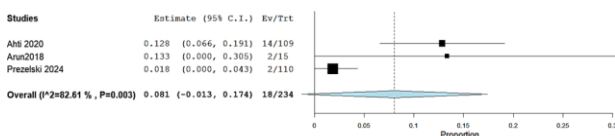


Figure 6. Revision procedure Forest plot

The meta-analysis on the necessity for revision surgery following Double Opposing Z-Plasty in the management of VPI demonstrates a relatively low overall proportion of cases requiring further surgical intervention. The data from three studies—Ahti 2020, Arun 2018, and Prezelski 2024—with respective weights of 37.853%, 17.931%, and 44.216%, yield an overall revision surgery rate of 8.1%, with a 95% confidence interval spanning from -1.3% to 17.4%. The p-value of 0.091 suggests that this outcome is statistically insignificant, indicating no strong proof of a widespread need for revision surgeries following the initial procedure. However, the analysis also reveals considerable heterogeneity, with an I^2 value of 82.608% and a heterogeneity p-value of 0.003, which suggests that the rates of revision surgery can vary significantly between studies. This variability might be attributed to differences in surgical techniques, patient selection, or criteria for considering a revision necessary, pointing to areas that could benefit from further research and standardization in clinical practice. (Figure 6)

Acceptable Level of Hypernasality

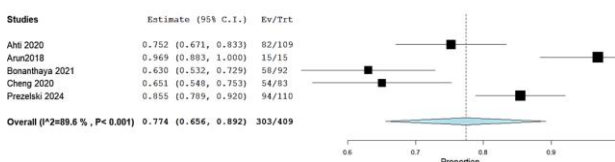


Figure 7. Acceptable Level of Hypernasality Forest plot

The meta-analysis evaluating the impact of Double Opposing Z-Plasty on reducing hypernasality in cases with velopharyngeal insufficiency indicates significant improvement in speech outcomes. The pooled estimate of patients achieving acceptable hypernasality levels post-procedure is 77.4%, with a 95% confidence interval from 65.6% to 89.2%. This significant result, reflected by a p-value of less than 0.001, highlights the effectiveness of the surgical technique. The studies included in the analysis—Ahti 2020, Arun 2018, Bonanthaya 2021, Cheng 2020, and Prezelski 2024—contributed fairly evenly to the model, with weights ranging from 19.195% to 20.990%. Despite the strong overall effect, there is considerable heterogeneity ($I^2 = 89.601\%$ and heterogeneity p-value < 0.001), suggesting that outcomes may vary significantly across different patient populations or surgical practices. This variability underscores the need for further research to identify factors that affect the success rates of this procedure, ensuring optimal results across diverse clinical settings. (Figure 7)

4. Discussion

In cases having Double Opposing Z-Plasty for velopharyngeal insufficiency, ages varied from 2.8 to 35 years, with a significant pooled estimate (7.063, 95% CI: 6.047–8.079, $p < 0.001$). Despite the procedure's effectiveness, high heterogeneity ($I^2 = 82.06\%$) suggests age-related variability in outcomes. The timing of surgery remains controversial. Early intervention can boost social confidence and speech development, especially before school age.¹⁶ However, delaying surgery in cases of maxillary hypoplasia may prevent growth restriction, and some techniques (like pharyngeal flaps) show better success in older children due to easier anatomical manipulation.¹⁷

The meta-analysis shows that Double Opposing Z-Plasty significantly improves speech intelligibility in VPI patients, with a pooled estimate of 0.795 (95% CI: 0.383–1.206, $p < 0.001$). The analysis included data from three studies: Arun K Gosain et al.¹¹ [18.86% weight], Bonanthaya et al.¹² (42.09% weight), and Prezelski et al.¹⁴ [39.05% weight], reflecting a balanced contribution across research sources. Despite the statistically significant improvement, the results showed substantial heterogeneity ($I^2 = 87.71\%$, $p < 0.001$), indicating considerable variation in speech outcomes. This variability may stem from differences in surgical techniques, patient age at surgery, severity of VPI, or variations in postoperative speech therapy. Furthermore, factors such as anatomical differences, surgeon expertise, and follow-up duration could influence individual responses to the procedure.

The current updated meta-analysis highlights a

significant improvement in nasopharyngoscopy scores following Double Opposing Z-Plasty for velopharyngeal insufficiency. The pooled estimate is 0.801 (95% CI: 0.528–1.075, $p < 0.001$), based on data from Ahti et al.¹⁰ (46.03% weight) and Prezelski et al.¹⁴ (53.97% weight).

Regarding the success rate of Double Opposing Z-Plasty in managing velopharyngeal insufficiency, the meta-analysis demonstrates a high overall effectiveness. The pooled success rate is 75.8% (95% CI: 65.6%–86.0%, $p < 0.001$), providing strong evidence for the procedure's efficacy. The analysis includes data from five studies: Ahti et al.¹⁰ (27.23% weight), Arun K Gosain et al.¹¹ (10.66% weight), Prezelski et al.¹⁴ (27.45% weight), and Sitzman et al.¹⁵ (11.08% weight). Notably, the highest success rate was reported by Prezelski et al.¹⁴ (85%), while the lowest rate was observed in Arun K Gosain et al.¹¹ (53%), reflecting variability across patient populations and clinical practices.

Despite the encouraging overall success, significant heterogeneity was detected ($I^2 = 76.16\%$, $p = 0.002$), suggesting substantial variability between studies. This variability may stem from multiple factors, including differences in patient selection criteria, surgical techniques, and postoperative management. For example, younger patients or those with milder anatomical abnormalities might experience better outcomes, whereas complex cases with severe tissue deficiencies or limited access to speech therapy may present lower success rates. Variations in surgeon expertise, institutional protocols, and monitoring period could additionally contribute to the detected differences in results.

Interestingly, the success rate in this analysis is slightly lower than that reported in an earlier meta-analysis by Kurnik et al.,¹⁸ which found an 82% success rate for Double Opposing Z-Plasty.

The complication rate associated with Double Opposing Z-Plasty for treating velopharyngeal insufficiency presents a significant concern, with a pooled estimate of 23.5% (95% CI: 8.6%–38.5%, $p = 0.002$). This highlights the potential risks of the procedure, even though it remains an effective treatment for restoring velopharyngeal competence. Notably, complication rates vary widely across studies, with Ahti et al.¹⁰ reporting the lowest rate (5.5%).

The meta-analysis evaluating the need for revision surgery following Double Opposing Z-Plasty for velopharyngeal insufficiency suggests that the procedure has a relatively low revision rate, reinforcing its durability as a long-term solution. The pooled revision rate is 8.1% (95% CI: -1.3% to 17.4%), based on contributions from Ahti et al.¹⁰ (37.85% weight),

These findings are consistent with previous research. A systematic review by Timbang et

al.,¹⁹ stated a mean failure rate of 9.7% for Furlow Double Opposing Z-Plasty, aligning closely with the revision rate observed in this analysis. Moreover, a systematic review and meta-analysis by Chernov et al.,²⁰ demonstrated that syndromic kids have elevated revision rates and are significantly less likely to achieve normal resonance after the first operation compared to non-syndromic kids. This highlights the impact of underlying patient characteristics on surgical outcomes and the importance of individualized treatment approaches.

4. Conclusion

This meta-analysis demonstrates that Double Opposing Z-Plasty is an effective and durable surgical intervention for treating velopharyngeal insufficiency, with high success rates in achieving acceptable levels of hypernasality (77.4%) and a relatively low need for revision surgery (8.1%). The pooled complication rate of 23.5% highlights that while the procedure carries some risk, most complications are minor and manageable with appropriate postoperative care. However, the substantial heterogeneity across studies underscores the influence of factors like surgical expertise, patient selection, and access to multidisciplinary care on outcomes. These findings support Double Opposing Z-Plasty as a valuable treatment option for VPI but emphasize the need for standardized success criteria, long-term follow-up protocols, and further research to refine patient selection and optimize surgical techniques for more consistent results across clinical settings.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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