

Surgical Treatment of Velopharyngeal Insufficiency Following Primary Palatoplasty

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Running title: Speech Result of Palatoplasty Techniques

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Objective: Identify a better surgical method for primary palatoplasty in a specific cleft type and evaluate outcomes of velopharyngeal insufficiency correction surgery. **Methods:** A pre-post study design was conducted by collecting data from cleft patients' medical charts used at the National Center for Maternal and Child Health in Mongolia. The Veau classification was used for the type of palatal clefts. **Results:** 335 cleft palate patients were included in this study. Of the participants, 133 patients were diagnosed with VPI after primary palatoplasty. Of 75.9%, they underwent secondary palatoplasty with a soft palate Z plasty method and 24.1% by a pharyngeal flap technique. The result of the NPS examination postoperatively is as follows: the adequate velopharyngeal function was 97% for the soft palate Z plasty method and 84.4% for the pharyngeal flap technique. (P= 0.021). **Conclusion:** The Furlow and Mongolian techniques are superior for maintaining velopharyngeal function after primary palatoplasty. For correcting velopharyngeal insufficiency, the secondary soft palate Z plasty and a superior-based pharyngeal flap demonstrate good speech results after surgery. **Keywords:** Cleft palate, Nasopharyngoscopy, Primary palatoplasty, Surgical technique, Velopharyngeal insufficiency.

Introduction

Cleft lip and/or palate (CLP) are the most common congenital malformations affecting the head and neck region. The incidence of congenital cleft of the lip and/or palate has been reported within a live birth among 500-2500 worldwide.¹ In the case of Mongolia, it is noted as one for 654 live births.² In Mongolia, a total of 3132 newborns were accorded with congenital malformations between 2019-2023 among 356035 live births. Among all newborns with congenital malformation, non-syndromic CLP was 479, syndromic CLP was 68, and 547 (17.2%) of CLP cases have been reported.³ 65.6% of all CLP cases involved cleft of the palate.² The main purpose of primary cleft palate surgery is to build everyday oral competence and restore normal speech function, hearing, and feeding with the lowest retardation of maxillary growth.⁴ To develop everyday speech, a child must have velopharyngeal competence, defined as the ability to completely close the velopharyngeal

sphincter that separates the oro and nasopharynx.⁵ In recent years, the most commonly used surgical techniques can be divided into three main groups regarding a cleft closure by the involving oral mucosa, surrounding tissues, the difference of surgical procedures on the palatal soft tissue, and the timing at intervention; two flap palatoplasty, Furlow double-opposing Z plasty (DOZ), and the two-step palatoplasty.

Our study's main difference is that it evaluated the primary surgical methods for each type of congenital cleft palate to determine which procedure was more suitable. The authors believe that improving primary surgical outcomes and reducing the secondary surgical burden of patients with cleft palates is very important.

Three main complications noted following primary palatoplasty, which needs secondary surgical correction, are oronasal fistula, maxillary growth disturbance, and velopharyngeal dysfunction. Therefore, velopharyngeal insufficiency (VPI) is a condition in which the soft palate and velum are unable to close the nasopharyngeal space completely, leading to air leakage through the nose as well as producing hypernasality and affecting speech intelligibility.⁶ When necessary, VPI is treated by speech therapy and surgery.⁴ The incidence of secondary palatoplasty for correcting VPI after primary palatoplasty ranges from 4.9% to 86%.⁷⁻¹⁰ The cause of VPI is multifactorial and not fully understood.¹¹ Several studies' results confirmed that this complication's rate depends on the type of clefts and its severity, the surgical technique, and the timing of primary palatoplasty.^{4,12} Several surgical techniques exist for managing VPI, and the ideal method is disputed. Today's most common procedures are the pharyngeal flap (PF) and the repair of the soft palate muscle by the DOZ.¹¹ The age at which surgical intervention for velopharyngeal dysfunction management does not affect subsequent speech normalization; therefore, speech-correcting surgery can be performed at any age. Still, it is often done before school age to avoid poor speech's negative social and psychological consequences.¹³

Therefore, we analyzed the frequency of primary and secondary palate surgeries in children with congenital cleft palate. Our study aims to identify a better primary cleft palate repair method and secondary VPI palatoplasty for velopharyngeal function.

Materials and Methods

Study Design and Setting

A pre-and post-treatment study design was conducted on patients with congenital cleft palate who underwent primary repair using four different palatoplasty techniques. To compare outcomes, three surgeons in the Department of Maxillofacial Surgery at NCMCH performed two secondary palatal correction procedures between 2006 and 2020. The Veau system was used for the classification of palatal clefts. This study design was developed based on recent surgery studies.¹⁴ Postsurgical nasopharyngoscopy was performed for the evaluation of velopharyngeal function of all patients, and the "Golding-Kushner" scale for nasopharyngoscopy results was used for assessing the patient's velopharyngeal function and its association with cleft types and the primary palatoplasty and secondary procedures.¹⁵

Surgical Methods and Speech Assessment

The techniques used in the primary palatoplasty were random and as follows;

1. Furlow DOZ
2. Mongolian palatoplasty
3. Bardach two flap palatoplasty (BP)
4. von Langenbeck procedure (vLP).

The Mongolian palatoplasty (MP) for primary palate repair was described in 1999 by the surgeons of the researcher's center. It differs from traditional soft palate closure techniques, which can be summarized as follows. The top of the uvula on both sides was pulled and rotated to the oral side, followed by a triangular dissection in the nasal mucosa and a triangular-shaped wound by removing the nasal mucosa. After that, the soft palate and the uvula were connected by the nasal flat surface, not by the edge facing each other, and they were sutured. In doing so, both sides of the soft palate were more closely approximated and could be pushed back more.¹⁶ Inadequate velopharyngeal function was confirmed objectively by a speech pathologist using nasopharyngoscopy. We have used two kinds of surgical techniques for secondary speech surgery (VPI correction surgery) as a DOZ and pharyngeal flap (PF), and we have chosen them based on the nasopharyngoscopy finding following an agreement between the surgeon and speech pathologist. When a closure ratio is 0.85-0.9, the subject is a candidate for DOZ; if the ratio is 0.8 or less, a PF is recommended.

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Surgery Outcome Measurement

The primary outcome measure was the postoperative NPS score. The NPS outcomes were evaluated using the Golding-Kushner scale and classified as completely and incompletely closed. Based on the NPS score, a second surgery was performed, and the pre-and post-secondary outcomes were also compared.

Statistical Analysis

Statistical analysis was performed using IBM SPSS 26 software. The summary statistics for patients undergoing primary and secondary surgery were frequency and percentages. The median was calculated as a non-normal distribution of children's age. Pearson's chi-squared test compared surgical techniques regarding velopharyngeal function and NPS evaluation after VPI corrective surgery. McNemar's test was employed to assess pre- and post-operative NPS evaluations. A P-value of less than 0.05 was considered statistically significant in all analyses.

Ethics

The study was approved by the Research Ethics Monitoring Committee of the Mongolian National University of Medical Sciences (approval number 2020/ 3-01) and the Ethics Subcommittee of the National Center for Maternal and Child Health (approval number 46).

Results

This study included 335 patients who received palatoplasty at the Department of maxillo-facial surgery of the National Center for Maternal and Child Health of Mongolia between 2006 and 2020. The median age at primary palate repair was 23(9-37) months. There were 56, 42, 177, and 60 patients with Veau-I, Veau-II, Veau-III, and Veau-IV types, respectively (Table 1).

Table 1: General characteristics of participants

Characteristics		Frequency (n)	Percentage (%)
Gender	Male	183	54.6
	Female	152	45.4
Area	Ulaanbaatar	153	45.7
	Rural	182	54.3
Cleft types	Veau I	56	16.7
	Veau II	42	12.5
	Veau III	177	52.8
	Veau IV	60	17.9
Primary surgical techniques	Furlow DOZ	47	14.0
	MP	148	44.2
	BP	106	31.6
	vLP	34	10.2
Total		335	100

DOZ-Furlow double-opposing Z plasty, MP-Mongolian Palatoplasty, BP- Bardach two flap Palatoplasty, vLP- von Langenbeck Palatoplasty

Primary Palatoplasty Technique

All clefts were closed using various techniques and a single-step procedure. BP (n=108) and MP (n=148) were the most frequently used techniques. Other techniques used were vLP (n=34) and Furlow DOZ (n=65). NPS assessment of adequate velopharyngeal function was as followed by Furlow DOZ in 89.4% of cases, MP in 62.2% of cases but by BP only in 48.1% and vLP in 47.1% (P< 0.0001) (Table 2).

Secondary Palatoplasty Correction Surgery Technique

Of the 335 children studied, 133 were found to have a VPI after primary palatoplasty, which needed a secondary speech correction in this study. 54.9% were male and 45.9% were from rural areas. Regarding the type of cleft, the majority (54.9%) were children with VPI after primary palatoplasty due to unilateral combined cleft lip and palate (Veau-III type). (Table 3)

Table 2: Comparison of three different surgical techniques in velopharyngeal function

Variables	Surgical techniques										P-value*
	DOZ		MP		BP		vLP		Total		
	n	%	n	%	n	%	n	%	n	%	
Velopharyngeal closure											<0.0001
Complete	42	89.4	92	62.2	51	48.1	16	47.1	202	60.0	
Incomplete	5	10.6	56	37.8	55	51.9	18	52.9	133	40.0	

DOZ-, Furlow double-opposing Z plasty, MP-Mongolian Palatoplasty, BP- Bardach two flap Palatoplasty, vLP- von Langenbeck Palatoplasty,
*Pearson's chi-square

Table 3: General characteristics of children with velopharyngeal insufficiency

Variables	Frequency (n)	Percentage (%)	95 % CI	
			Lower	Upper
Gender				
Male	73	54.9	49.3	59.9
Female	60	45.1	40.1	50.7
Area	Area	Area	Area	Area
Ulaanbaatar	72	54.1	49.0	59.6
Rural	61	45.9	40.4	51.0
Type of clefts				
Veau-I	12	9.0	7.0	21.0
Veau-II	18	13.5	9.3	16.4
Veau-III	73	54.9	47.5	58.1
Veau-IV	30	22.6	14.1	26.3

Veau-I: Soft palate cleft, Veau-II: Hard and soft palate cleft, Veau-III: Unilateral cleft lip and palate, Veau-IV: Bilateral cleft lip and palate, CI - Confidence interval

Table 4: Comparison of re- and post-operative Nasopharyngoscopy (NPS) evaluation

Variable	Pre-operative n (%)	Post-operative n (%)	P-value*
Severity of VPI			<0.0001
Normal	0 (0.0)	57(42.8)	
Mild	84 (63.2)	75(56.4)	
Moderate	26 (19.5)	1(0.8)	
Severe	23 (17.3)	0(0.0)	

*McNemar's test, P-value <0.0001, VPI- velopharyngeal insufficiency, n-case number/frequency

The median age at VPI correcting surgery was 94(57-131) months. The redo Furlow DOZ performed 75.9% of the total VPI correcting surgeries and 24.1% by the PF. 17.3% and 20.0% of the pre-operative scales of NPS were assessed as moderate. The parameters were improved after surgery, there was no severe VPI, and moderate VPI was reduced to 1% (P< 0.0001). (Table 4)

Postoperative NPS scales were improved in 97.0% of the Furlow DOZ group and 84.4% in the PF group (P= 0.021). (Figure 1)

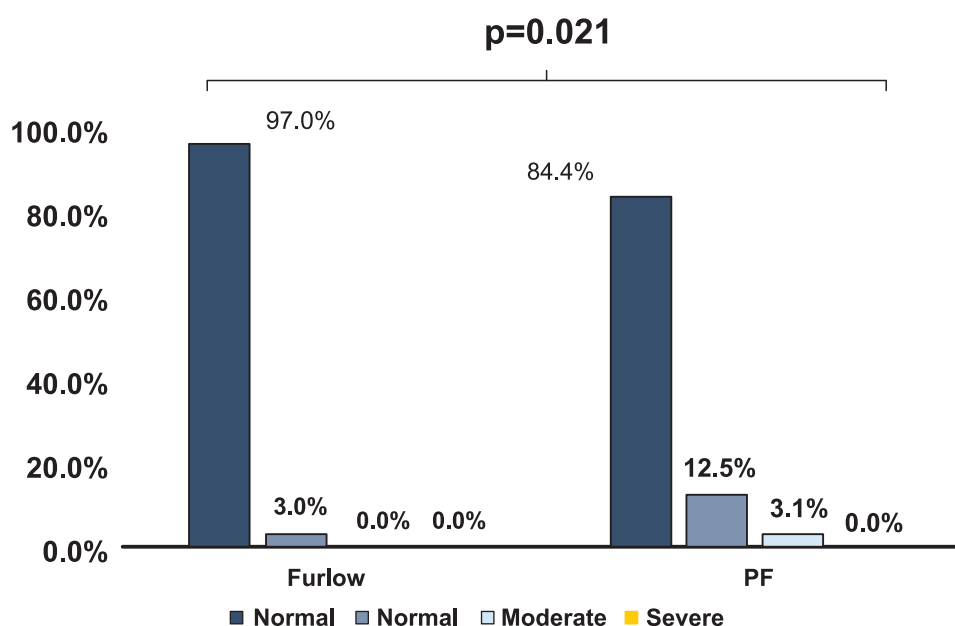


Figure 1. Nasopharyngoscopy (NPS) evaluation after VPI correcting surgery
Pearson’s chi-square test

Discussions

Identifying the best result for primary palatoplasty is still controversial today, as it is connected with the time at repair, cleft type, and surgical methods.¹⁷ Recent literature advocates the early repair, around one year of the patient, to facilitate normal speech development. The main goal of primary cleft palate repair is to restore the function of the soft palate by closing the defect, allowing normal speech and feeding, and avoiding leading to maxillary growth disturbance.

The technique used for primary palate repair varies depending on the cleft type and the extent and width of the cleft.¹⁸ We can divide primary palatoplasty techniques into three groups by the age at repair, the closure of hard and soft palate defects, and the lengthening palate as follows:

1. Two flap palatoplasty (Veau-Wardill-Kilner and Bardach techniques)
2. Two-step palatoplasty
3. Furlow double opposing Z-plasty.

The idea of elevating the full-thickness mucosa of the hard palate from the palatal bone was initially described in 1859 by Bernhard von Langenbeck. He used one long relaxing incision close to the gingiva on both sides. He elevated the mucoperiosteal flap to release it from the palatal bone and sutured it together in

the midline. This method was modified by Dorrance, Veau, Wardill, and Kilner and later by Bardach Y in 1967.¹⁹ In the 1990s, the Bardach technique was used as a default for wider clefts, and the straight line/von Langenbeck technique was used for narrower clefts at the discretion of the individual surgeon.¹¹

Delayed hard palate closure or two-step palatoplasty technique was suggested in 1944 by Schwegendiek H. His idea was based on the early closure of the soft palate at about 7-8 months of age for good speech development, and he postponed the closure of the hard palate until 12-15 years of age to avoid disturbing maxillary growth.²⁰ But a single-stage cleft palate repair is used in 97% of the centers, Furlow DOZ (34.8%), two flap techniques (30.3%), and traveler pyeloplasty (20.4%) were the most commonly used single-stage techniques.²⁵ In 1978, Furlow L presented his ingenious technique- double opposing Z-plasty in the soft palate for palatal lengthening at the Annual Meeting of Plastic Reconstructive Surgeons. His key consideration is to add palatal length by Z plasty with complete freeing of levator muscle from the posterior edge of the hard palate and without a straight midline scar in the soft palate, which could lead to palatal shortening. Randall and Don LaRossa

immediately used this technique, using the von Langenbeck procedure, to achieve a tension-free closure in the hard palate.¹⁹ In Mongolia, the National Center for Maternal and Child Health, where we conducted this study, is the only center that provides a nationwide cleft service. Until 1995, the treatment protocol delayed primary cleft palate repair at five years of age, which led to a widening of palatal defects and increasing rates of formation of a postsurgical oronasal fistula. This complication forced us to modify established techniques for improved post-palatoplasty outcomes.²² Complete velopharyngeal closure is one of the best indexes of palatoplasty. Among the patients in this study, VPI incidence after primary palatoplasty was 39.7% compared with the results (4.9-86%) in international papers⁷⁻¹⁰ In the study of Dong, et al. VPI incidence was 36.4% total, and they reported that the Furlow palatoplasty showed better results (10.5% inadequate) on velopharyngeal competence compared with the two-flap technique (27.5% inadequate) after primary palatoplasty.²³ Also, Yu, et al. observed that the Furlow palatoplasty showed excellent velopharyngeal adequacy results with 98%, but in the von Langenbeck group, only 70% of the patients had adequate velopharyngeal function.²⁴ In our study, incomplete velopharyngeal closure occurred in 10.6% of Furlow palatoplasty and 51.9% for the two-flap technique after primary palatoplasty. The present outcomes of velopharyngeal function are better for the Furlow palatoplasty. This may be because this technique lengthened the soft palate, overlapped the divergent palatal muscles, and straight midline scar in the soft palate can be avoided by reducing postoperative shortening in the anteroposterior direction.

Speech-correcting surgery can be performed at any age of patients, and the most commonly used procedures are the pharyngeal flap and repair of the soft palate using the Furlow DOZ technique.^{25,26} Among secondary palatal procedures, the pharyngeal flap was the most commonly used. However, it has a higher rate of morbidity than other procedures and has some problems such as nasal obstruction, obstructive sleep apnea (OSA), and hyponasality. Liao, et al. reported that the incidence of OSA following pharyngeal flap surgery was 90% in adults and 93% in children.²⁷ The average age of patients at redo DOZ was 10.7±4.5, ranging from 5 to 21 years in the study of Hsu, et al. and all of them performed secondary speech surgery by the Furlow redo DOZ and showed the success result as 92.3% of

the ratio as 1.0 postoperatively.⁶ Our study's mean age was 94 ± 37.6 months (approximately seven years). The most commonly used technique is redone Furlow DOZ (75.9%) for secondary speech surgery, compared with an international survey created to evaluate trends in cleft treatment, which was shown as a result of a minimal age for VPI surgery of 4.1 years. The pharyngeal flap was employed by 34%.²⁸ Postoperative NPS scales were improved in 97.0% of the Furlow DOZ group and 84.4% in the PF group; OSA was not noted in our study.

Our study has some limitations. The main limitation is that we only assessed velopharyngeal insufficiency based on the position of pre and postoperative anatomical structures but did not assess perceptual speech evaluation. In the future, we will expand our study with speech pathologists and include perceptual speech evaluation.

Conclusions

It is concluded from this study that the Furlow double opposing Z-plasty and Mongolian palatoplasty were superior for maintaining velopharyngeal function after primary palatoplasty. For the correction of VPI, the secondary Furlow DOZ and a superior-based pharyngeal flap showed good speech results after surgery.

Conflict of interest

The authors state no conflict of interest.

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