Chapter

Surgical Treatment of Velopharyngeal Insufficiency

Nguyen Pham and Isabella Rodoni

Abstract

Velopharyngeal insufficiency (VPI) is a condition where the soft palate and posterior oropharynx fail to close adequately, leading to complications such as abnormal speech, nasal regurgitation and nasal emission. Although there exist many approaches to treating VPI depending on the shape and severity of the insufficiency, this chapter describes the three most frequently used and well-researched techniques: the Furlow Palatoplasty (double-opposing Z-palatoplasty), the creation and placement of a pharyngeal flap, and a sphincter pharyngoplasty. This chapter contains an introduction to VPI causes and treatment, a description of patient assessment methods, step-by-step instructions for the different operative procedures, and the recovery process.

Keywords: cleft surgery, craniofacial, cleft palate, velopharyngeal, pharyngeal flap, furlow palatoplasty, VPI

1. Introduction

The velopharyngeal sphincter separates the nasopharynx from the oropharynx and is located where the soft palate meets the posterior oropharyngeal wall. When functioning properly, the velopharyngeal sphincter closes and opens to allow appropriate air flow for normal speech, eating, and breathing. The sphincter closes to stop airflow up to the nasal cavity for consonant pronunciation and to prevent nasal regurgitation. It opens to produce certain nasal vocalizations and for normal breathing. Velopharyngeal Insufficiency (VPI) occurs when the sphincter cannot close completely and can cause hypernasality, nasal emissions, nasal regurgitation of food and liquid and communication difficulties.

VPI is usually caused by a complete or submucous cleft palate. An estimated 5–30% of patients continue to have VPI post-cleft palate repair [1]. Temporary VPI can also occur following adenoidectomy. Children with velocardiofacial syndrome (DiGeorge Syndrome) can suffer from VPI without a cleft palate. Lastly, traumatic brain injury or neurological disorders can cause VPI due to muscle weakness or difficulty coordinating palatal muscles. Depending on the anatomy of the velopharyngeal gap, there are different surgical approaches to treatment. Possibilities for surgery include Furlow Double Opposing Z-Palatoplasty, sphincter pharyngoplasty, posterior pharyngeal wall injection, or pharyngeal flap pharyngoplasty. These approaches vary based on availability of flap tissue-source, individual closure pattern, and severity of VPI. A surgeon needs to be able to distinguish between each technique's risks and benefits before operating; VPI is expressed differently in every patient, therefore surgical approaches will benefit each patient differently. Correcting VPI can help a patient to gain the ability to effectively communicate, as well as their confidence in doing so by minimizing emissions and improving intelligibility [2, 3].

2. Speech and sphincter assessment

Children with cleft palate are at high risk of developing VPI and should be routinely assessed by a speech pathologist experienced in the management of VPI. Most cases of VPI in the cleft population resolve with speech therapy, however, there remains a significant number of patients who require surgical intervention.

Before surgical evaluation, a patient with suspected VPI should be evaluated by a speech pathologist. The speech pathologist may measure hypernasality, hyponasality, nasal emission, and articulation in addition to glottal stop, pharyngeal fricatives, or pharyngeal stop. At our institution, a combined examination is performed with nasal endoscopy and speech assessment. During this procedure, an otolaryngologist places the tip of a fiberoptic laryngoscope in the nasopharynx directly above the velopharyngeal sphincter. This allows for direct visualization of the movement of the sphincter. With the sphincter under visualization, the speech pathologist then leads the patient through speech assessments. The nose should be anesthetized with topical lidocaine to improve comfort. Children aged six and above are usually able to tolerate this procedure easily. Younger children can often

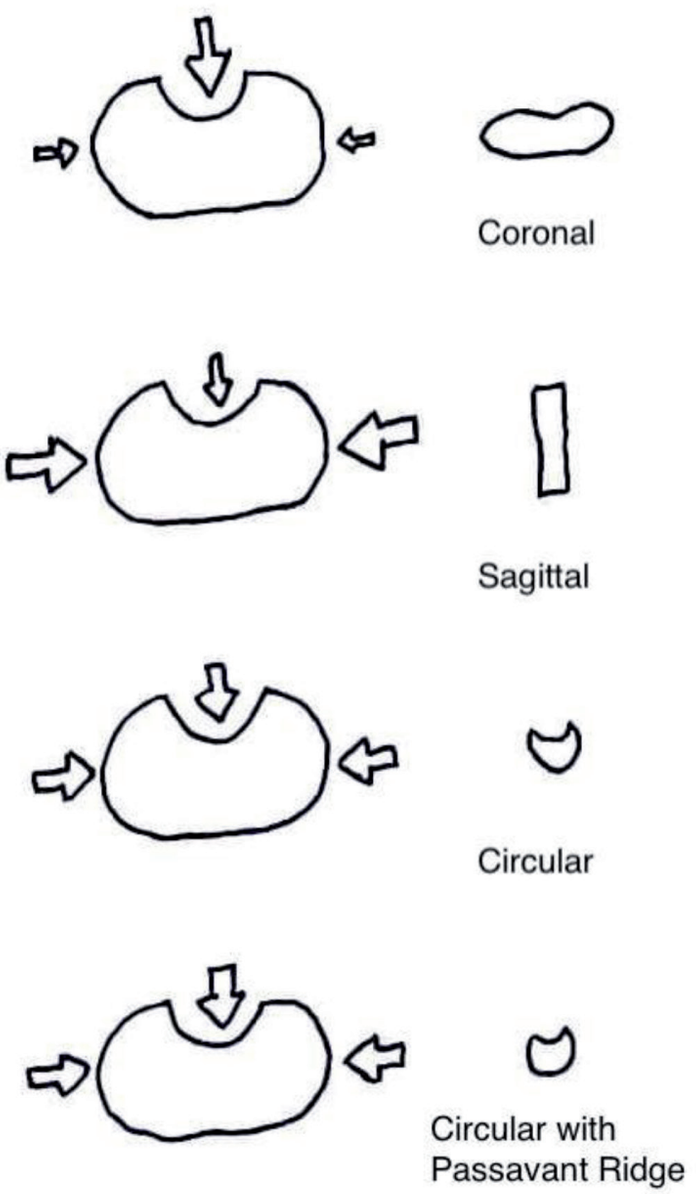

Figure 1.
Velopharynx directional movements of closure patterns.

complete the assessment, but appropriate expectations should be made clear to the parents. Occasionally, assessments may be delayed until the child can successfully cooperate with the exam.

There are four basic closure patterns that the gap is likely to follow: coronal, the most common, in which the movement of the velum closes the velopharyngeal port with little medial motion of the lateral pharyngeal walls; sagittal, the least common, where medial movement of the lateral pharyngeal walls cause closure with minimal velum movement; circular, where both velum and pharyngeal wall movement contribute to velopharyngeal port closure; and circular with the Passavant ridge, which is similar to the circular pattern but with the addition of anterior movement of the posterior pharyngeal wall. A sagittal closure is most common in patients with persistent VPI post-cleft palate repair. Closure pattern is important in determining which surgery will best address the pharyngeal wall motion and control airflow through the port (**Figure 1**).

Magnetic Resonance Imaging (MRI) is also useful in VPI evaluation. While MRIs are noninvasive and may be easier to perform on small children, they do not provide images detailing velopharyngeal motion during speech. Lastly, nasometry measures acoustic activity in the patient's nasal cavity, allowing comparison between the patient's nasalance and normal speech. Nasometry is conducted using a headset with microphones placed in front of the nose and the mouth, separated by a metal plate. Nasometry contributes an objective measure of a patient's nasal acoustic energy to the speech pathologists subjective observations.

3. Assessment of aerodigestive tract anatomy

Prior to the surgical treatment of VPI, an overall assessment of the patient's airway and vasculature must be made. Patients with velocardial syndrome frequently have medialized carotid arteries and assessment via CT angiography is essential in preventing operative complications.

Another preoperative consideration is breathing obstruction. Placement of pharyngeal flaps will obstruct nasal breathing to a degree and may worsen existing breathing difficulties. In cases where the patient already experiences obstruction, a sphincter pharyngoplasty may be better since postoperative breathing obstruction is less than in a posterior pharyngeal flap placement.

Adenoidectomy is often necessary before pharyngoplasty or pharyngeal flap. This is because removal of the adenoids facilitates in raising the pharyngeal flap and in optimizing the pharynx for attachment of the flaps during sphincter pharyngoplasty. If there is tonsillar hypertrophy, tonsillectomy is needed prior to pharyngeal surgery to reduce the risk of developing postoperative sleep apnea. If sphincter pharyngoplasty is planned, the otolaryngologist must take care to preserve the posterior tonsillar pillars so that they can be used for pharyngoplasty flaps.

4. Operative procedures

If the patient presents with sagittal or circular closure is present, a superiorly based pharyngeal flap is recommended. If the closure pattern is coronal relatively small to intermediate in size, a sphincter pharyngoplasty will restore port function. The Furlow palatoplasty is chosen if the closure pattern is coronal with a small gap. In this case, the surgeon may feel that VPI will be addressed with the soft palate lengthening achieved by this technique. A detailed description of each surgical approach can be found below [4].

4.1 Furlow palatoplasty (double opposing Z-palatoplasty)

Furlow double opposing z-palatoplasty is a technique to repair cleft palate. The procedure lengthens the soft palate and is called a "Z-plasty" because of the Z shaped scar that remains. A Dingman retractor is first placed and the palate injected with epinephrine. For a submucous cleft, the procedure begins with dividing the soft palate anteriorly along the midline to approximately 3 mm posterior to the hard palate junction (**Figure 2**).

For an incomplete soft palate cleft, the incision first traverses along the free margin of the soft palate in an axial plane. Next, the tips and medial edges of the uvula are trimmed. A posteriorly based myomucosal flap is incised and elevated on the left side, and an anteriorly based myomucosal flap is then elevated on the right to create a Z-shaped incision. The left-sided muscle and oral mucosa are raised from the nasal mucosa by separating the muscle from the hard palate. On the right, only the mucosa and the submucosa are raised, leaving muscle on the nasal mucosa. The nasal side midline is also divided once both palatal flaps are raised [5] (**Figure 3**).

Incisions are made on the newly formed nasal flaps in a mirror image to the oral flaps. The right-sided nasal myomucosal flap must be rotated posteriorly, and the left-sided mucosal flaps anteriorly. The nasal side is closed first using 4–0 absorbable sutures starting at the apices of the flaps, then at their horizontal midlines, then finishing on the anterior and posterior flap edges (**Figure 4**).

Once the nasal flaps are secured, the oral flaps are transposed and closed using 4–0 absorbable sutures except at the midline, where durable 4–0 PDS sutures can reinforce the soft tissues together. Lastly, the uvula must be closed with a horizontal mattress suture (**Figure 5**) [6].

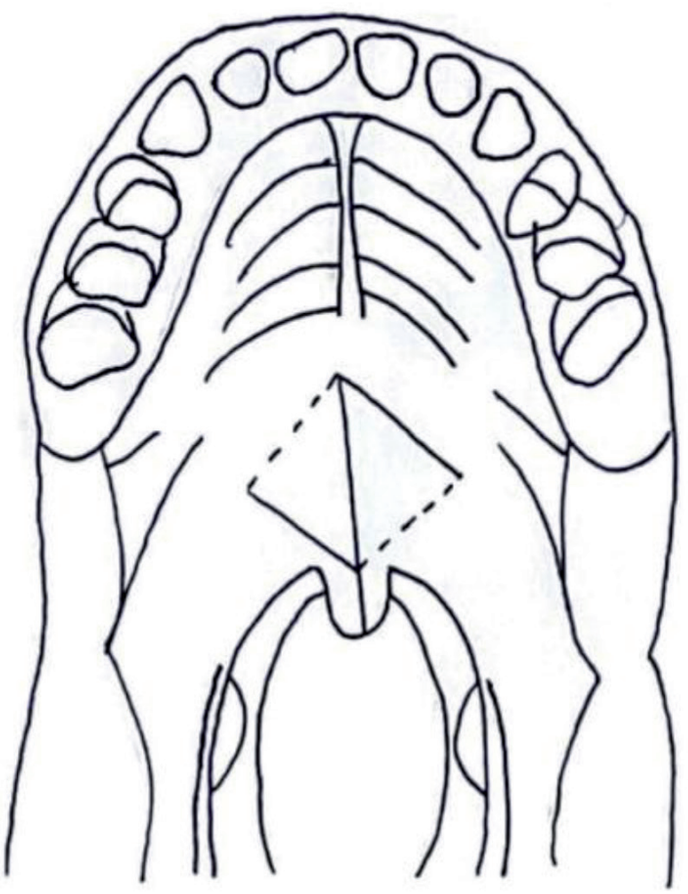

Figure 2.
Incision lines for Furlow Z-plasty, with dotted lines representing nasal incisions and the solid lines representing oral incisions. The lateral incisions are taken towards the hook of the hamulus.

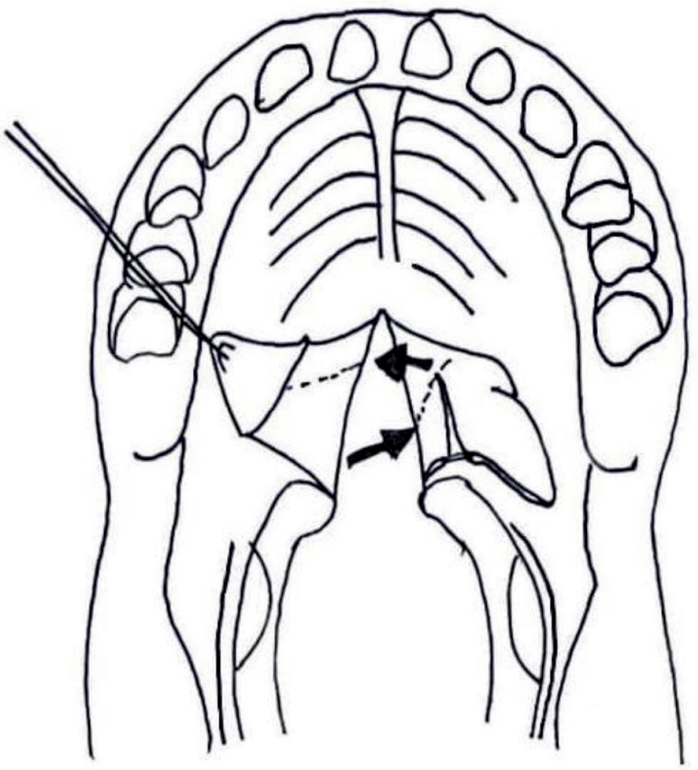

Figure 3.
Raised oral flaps reveal nasal incision lines, which mirror the shape and angle of their opposing oral flaps. Arrows indicate where the nasal tissue will lay between the incised nasal flaps.

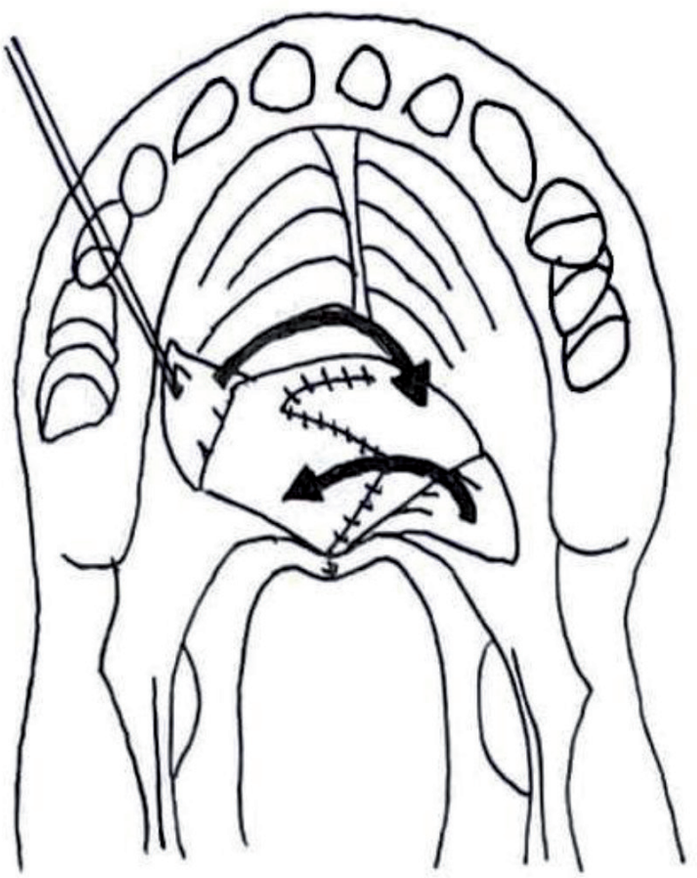

Figure 4.
Secured nasal flaps. Arrows indicate where oral flaps will lay.

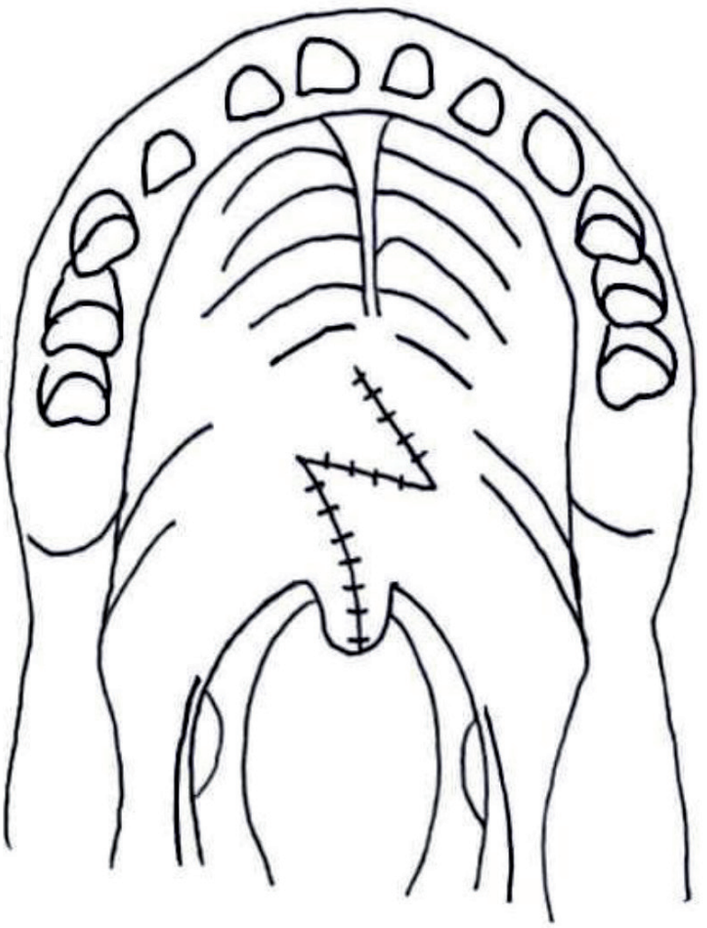

Figure 5.
Suture pattern for final closure of the Furlow Z-plasty.

4.2 Pharyngeal flap

The Pharyngeal flap is the most common secondary surgical procedure used to treat VPI. It involves attaching tissue from the posterior pharyngeal wall to the soft palate creating a partial obstruction of the nasal and oral cavities save for two small laeral ports. The surgery works most effectively on patients with sagittal or circular closure patterns because these patterns retain sufficient lateral wall movement. First, the soft palate is incised along the oral midline from the uvula to the soft-hard palate junction (**Figure 6**).

A "book flap" incision is also made on the posterior pharyngeal wall to the prevertebral fascia. This fascial layer is easily identified by its white appearance and relative lack of vascularity. A submucosal pharyngeal flap is elevated superiorly while the two mucosal flaps are lifted laterally. The free inferior edge of the submucosal flap is then sutured to the posterior nasal edge of the soft palate (**Figure 7**).

The book flap incision is closed by simple approximation of the pharyngeal mucosa. The two oral soft palate flaps are sutured to the base of the pharyngeal submucosal flap and to each other to hide the pharyngeal flap (**Figures 8** and **9**).

VPI closures may be conducted via a superiorly based pharyngeal flap [7].

4.3 Sphincter pharyngoplasty

Sphincter pharyngoplasty is best suited for patients with poor posterior pharyngeal movement and small velopharyngeal ports. The surgery narrows the nasal orifice, limiting nasal airflow during speech. In contrast to pharyngeal flaps, pharyngoplasty narrows the central nasal orifice without creating velopharyngeal ports [8].

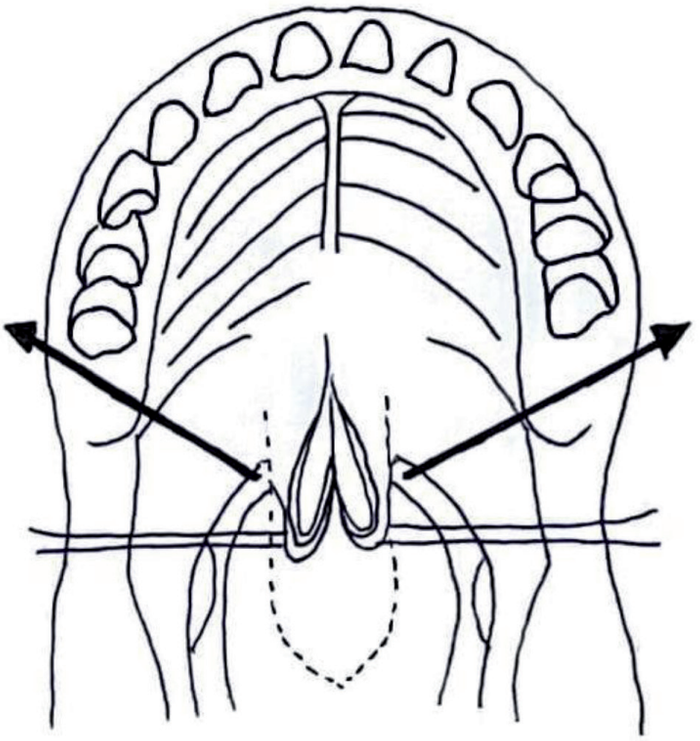

Figure 6.
Midline incision divides soft palate to posterior nasal spine. Arrows indicate the direction that the incised uvula will be lifted in preparation for the next step.

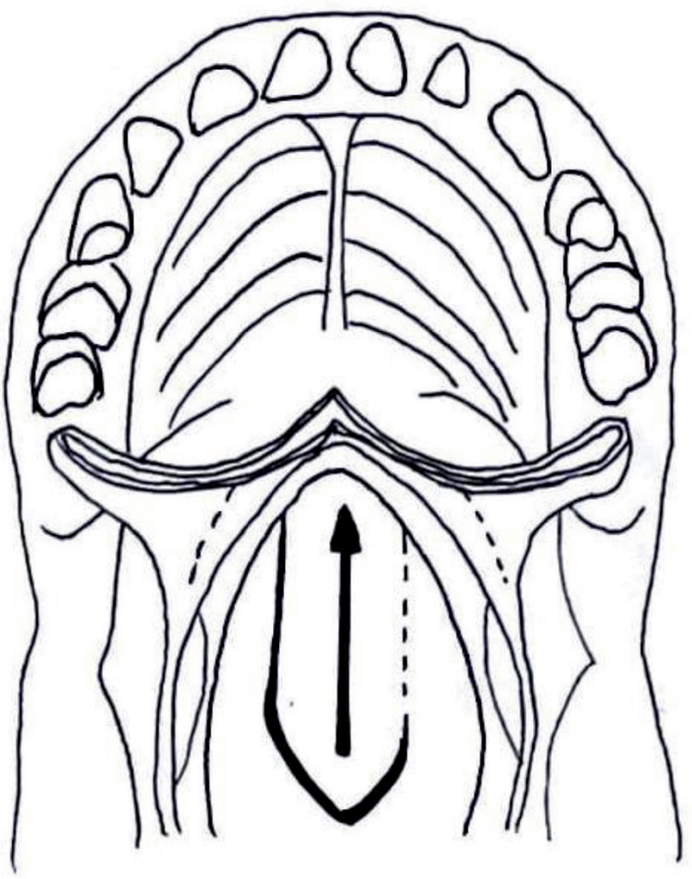

Figure 7.
Book flap incision along the dotted line on the posterior pharyngeal wall that will line lateral ports with mucous membrane. Arrow indicates where the book flap will be raised and secured.

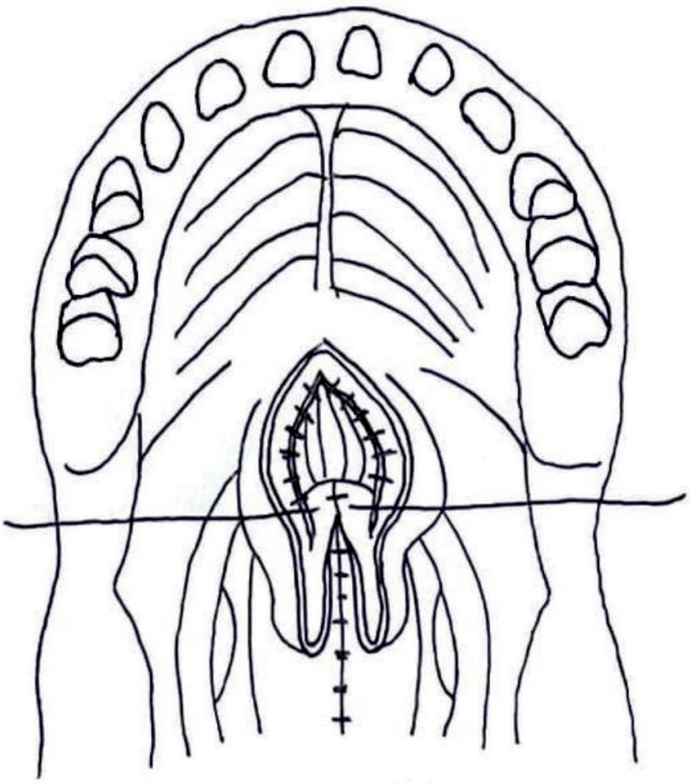

Figure 8.
Two soft palate flaps used to cover raw tissue of pharyngeal flap are sutured to pharyngeal flap base.

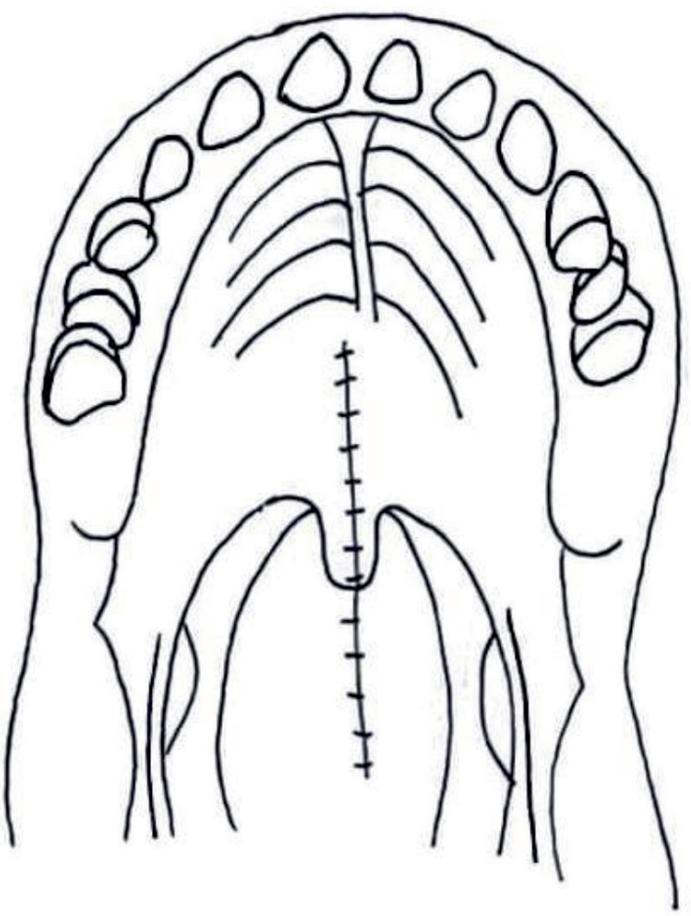

Figure 9.
Closure pattern following pharyngeal flap placement.

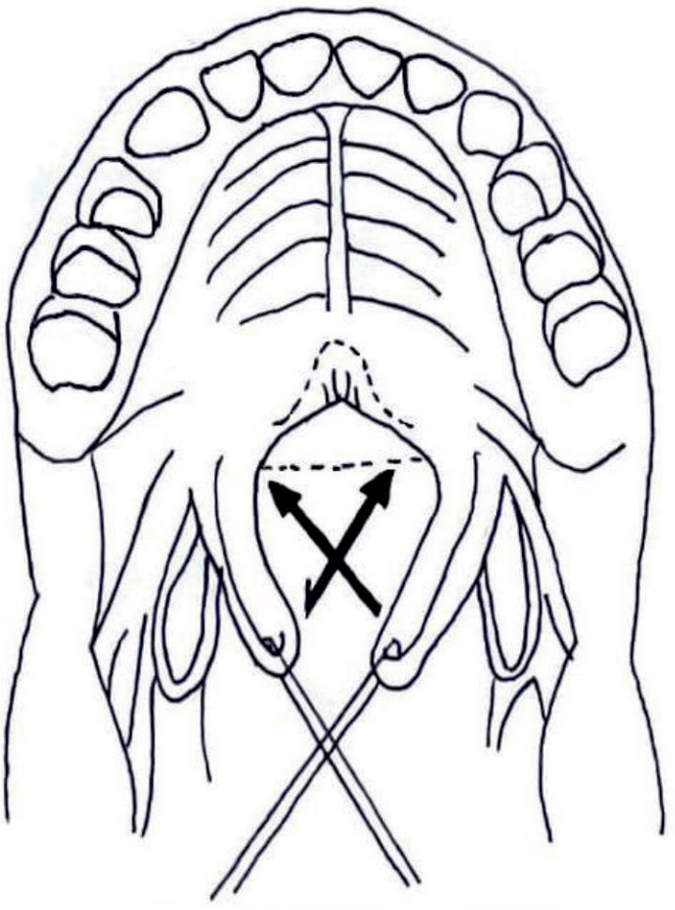

Figure 10.
Raising of both tonsillar pillar flaps. Arrows indicate that the flaps will be laid in a criss-cross fashion.

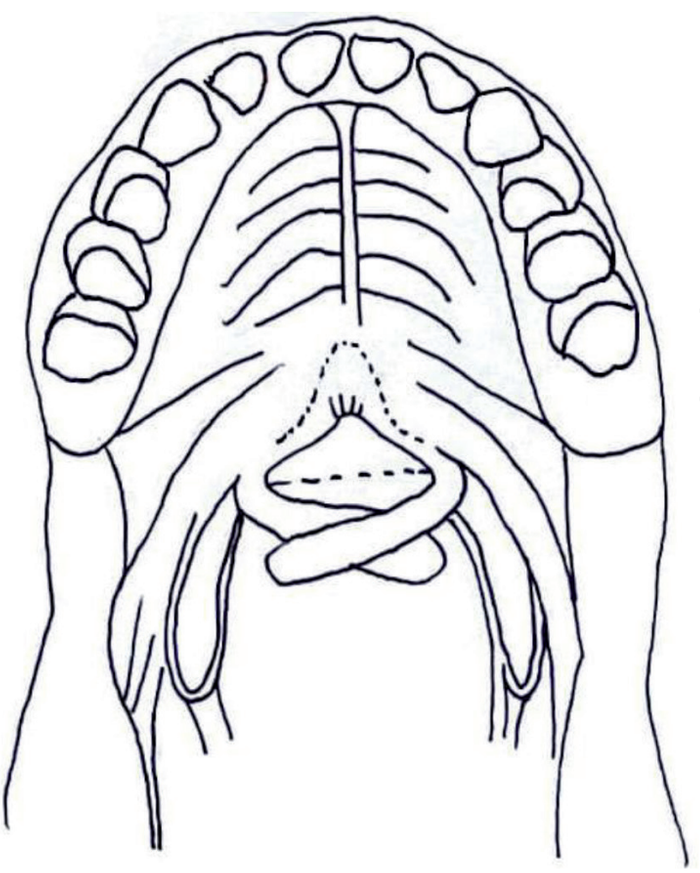

Figure 11.
Ready position of the palatopharyngeal flaps to be sutured to the posterior pharyngeal wall.

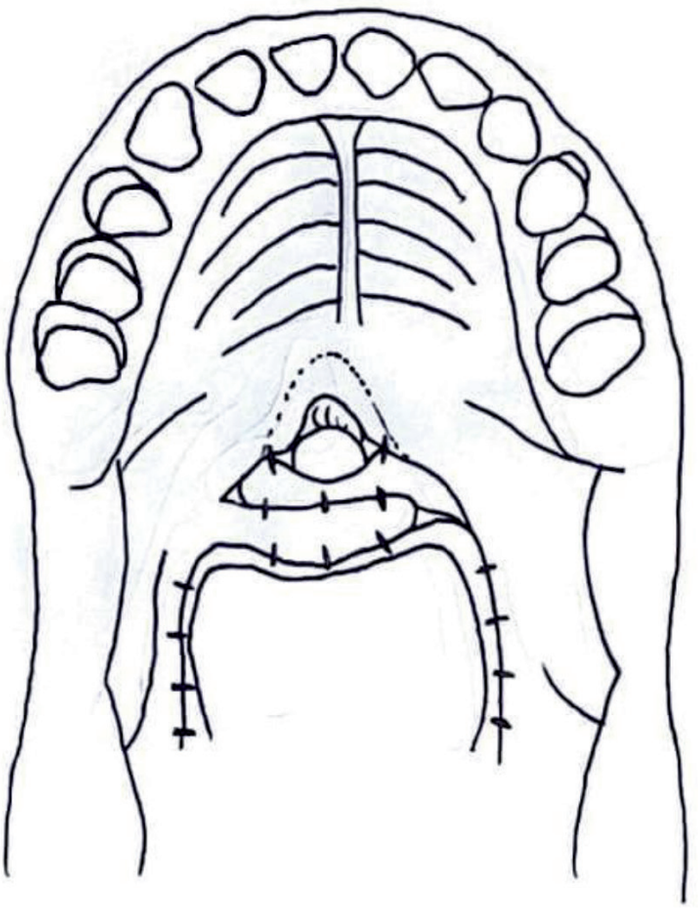

Figure 12.
Completed sphincter pharyngoplasty.

The procedure begins with a rubber catheter that is inserted into the nose and sutured to the uvula to expose the posterior pharyngeal wall. Next, after raising the myomucosal flaps, the posterior pharyngeal wall is incised transversely (**Figure 10**).

The cut should extend from the posterior limb of one of the lateral flaps to the other. Donor sites are closed with 4–0 polyglactin sutures then the catheter is removed before closing. The left flap's superior mucosa is sutured to the posterior pharyngeal wall's superior incision. Then the left flap's caudal mucosa is sutured to the right flap's superior mucosa, causing the flaps to overlap. The right flap's causal mucosa is sutured to the pharyngeal wall's posterior mucosa (**Figure 11**).

The lateral flaps are sutured together in position to secure the new sphincter. The ideal diameter of the resulting port should be one centimeter (**Figure 12**).

5. Recovery

The procedure time for Furlow double opposing Z-palatoplasty is approximately 1.5 hours. Post-operative time spent in the hospitalis most likely one day. For a few days, pain will be minimal to moderate and can be managed with oral medications. The patient should eat only soft foods for 5–7 days after the operation. The palatal wound takes 3–4 weeks to heal, and restraints may be needed to keep the patient from disrupting the incision area [1]. Complications from this procedure include flap breakdown or shrinkage. Additionally, the patient may develop obstructive sleep apnea or nasal congestion. Although the surgery improves speech, speech therapy is recommended to correct post-operatively learnt errors. With surgery and

therapy, the speech normalization rate is approximately 60–70%. Refractory cases may require pharyngeal flaps or pharyngoplasty.

For secondary surgeries like pharyngeal flap and sphincter palatoplasty, patients are monitored overnight and may begin a soft or liquid diet that same day. The patient should sleep with their head elevated for two weeks postoperatively. Any required speech therapy may resume after their three week follow-up. A post-surgery velopharyngeal inspection will occur 3 and 12 months after surgery.

6. Conclusion

Choice of surgical approach to treat VPI depends on the patient's individual anatomy as well as severity. Therefore, evaluation prior to surgery is important in a surgeon's decision of what approach they will use. Due to possible complications and risks involving important arteries, airway obstruction, and future speech ability, a surgeon should carefully consider the procedures above and their respective risks and benefits before operating. Each possible surgery (the Furlow Double Opposing Z-Palatoplasty, sphincter pharyngoplasty, posterior pharyngeal wall injection, and a pharyngeal flap pharyngoplasty) has its own set of conditions under which the patient will experience maximum results in correcting hypernasality, nasal emissions, nasal regurgitation of food and liquid and communication difficulties. The assessment and procedure descriptions above should be sufficient information for a surgeon to choose what approach is best, as well as provide adequate background information on VPI.

Author details

Nguyen Pham[1,2*] and Isabella Rodoni[3]

1 University of California Irvine School of Medicine, Irvine, CA, United States

2 Children's Hospital of Orange County, Orange, CA, United States

3 Cornell University, Ithaca, NY, United States

*Address all correspondence to: nspham@gmail.com

References

[1] T.A. Emara, M.D., A.S Quriba, M.D., "Posterior Pharyngeal Flap for Velopharyngeal Insufficiency Patients: A New Technique for Flap Inset," *The Laryngoscope,* 122:2 pg.260-65, (2012).

[2] A. Evans, T. Driscoll, B. Ackermann, "Prevalence of velopharyngeal insufficiency in woodwind and brass students," *Occupational Medicine*, 61:480-482, (2011).

[3] P.K. Patel, M.D., "Surgical Treatment of Velopharyngeal Dysfunction," *eMedicine*, (2018).

[4] K. Nagy, G. Swennen, "Oral Mucosal Z-Plasty in Combination with Intravelar Veloplasty," *Plastic and Reconstructive Surgery Global Open,* 3:7, (2015).

[5] E. Gunther, J.R. Wisser, M.A. Cohen, and A. S. Brown, "Palatoplasty: Furlow's Double Reversing Z-Plasty versus Intravelar Veloplasty," *The Cleft Palate-Craniofacial Journal: Official Publication of the American Cleft Palate-Craniofacial Association,* 35:6 pg.546-49, (1998).

[6] C. Havstam, A. Lohmander, et al., "Evaluation of VPI-Assessment with Videofluoroscopy and Nasoendoscopy," *British Journal of Plastic Surgery,* 58:7 pg. 922-31, (2005).

[7] S.M. Nam, "Surgical Treatment of Velopharyngeal Insufficiency," *Archives of Craniofacial Surgery,* 19:3 pg.163-67, (2018).

[8] N. Raol, C.J. Hartnick, "Sphincter Pharyngoplasty," *Surgery for Pediatric Velopharyngeal Insufficiency,* 76:58-66, (2015).