Pharyngeal Flap Outcomes in Nonsyndromic Children with Repaired Cleft Palate and Velopharyngeal Insufficiency

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Background: Velopharyngeal insufficiency occurs in 5 to 20 percent of children following repair of a cleft palate. The pharyngeal flap is the traditional secondary procedure for correcting velopharyngeal insufficiency; however, because of perceived complications, alternative techniques have become popular. The authors' purpose was to assess a single surgeon's long-term experience with a tailored superiorly based pharyngeal flap to correct velopharyngeal insufficiency in nonsyndromic patients with a repaired cleft palate.
Methods: The authors reviewed the records of all children who underwent a pharyngeal flap performed by the senior author (J.B.M.) between 1981 and 2008. The authors evaluated age of repair, perceptual speech outcome, need for a secondary operation, and complications. Success was defined as normal or borderline sufficient velopharyngeal function. Failure was defined as borderline insufficiency or severe velopharyngeal insufficiency with recommendation for another procedure.
Results: The authors identified 104 nonsyndromic patients who required a pharyngeal flap following cleft palate repair. The mean age at pharyngeal flap surgery was 8.6 ± 4.9 years. Postoperative speech results were available for 79 patients. Operative success with normal or borderline sufficient velopharyngeal function was achieved in 77 patients (97 percent). Obstructive sleep apnea was documented in two patients.
Conclusion: The tailored superiorly based pharyngeal flap is highly successful in correcting velopharyngeal insufficiency, with a low risk of complication, in nonsyndromic patients with repaired cleft palate. (*Plast. Reconstr. Surg.* 125: 290, 2010.)

Speech to a pediatric plastic surgeon should be like vision to an ophthalmologist. Normal velopharyngeal closure, the goal of palatoplasty, depends on dynamic apposition of the velum and lateral and posterior pharyngeal walls. The velopharyngeal sphincter opens to allow nasal respiration and transmission of acoustic energy into the nasal cavities for nasal consonant production (*n*, *m*, and *ng* in English). The sphincter closes to prevent nasal airflow and acoustic energy into the nasal cavities during oral sound production and to prevent food and liquid from entering the nose during swallowing.[1,2]

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If the velopharyngeal sphincter is incompetent, speech is characterized by hypernasal resonance, possible audible nasal emission, and decreased intraoral pressure for pressure consonants.[2,3] These audible hallmarks of an incompetent velopharyngeal sphincter (known as velopharyngeal insufficiency) are found in 5 to 20 percent of patients following repair of a cleft palate.[4–12]

Secondary operations to correct velopharyngeal insufficiency include pharyngeal flap, sphincter pharyngoplasty, double-opposing Z-palatoplasty, and palatal muscle retropositioning. The superiorly based pharyngeal flap, with width tailored to lateral pharyngeal wall motion, is considered to be the

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standard treatment, with reported long-term success rates of 78 to 98 percent.[13–23] The goal of the pharyngeal flap procedure is to enable velopharyngeal closure for speech without causing obstruction of the upper airway. This is a delicate balance, as a pharyngeal flap that is too wide can lead to nasopharyngeal obstruction and sleep apnea; this complication has been reported to occur in up to 20 percent of patients.[17,20,24–28] Another untoward effect of a pharyngeal flap is hyponasality in 5 to 27 percent of patients.[15–17,20,22,24] On the other end of the spectrum, a pharyngeal flap that is too narrow may fail to correct velopharyngeal insufficiency.[19] For these reasons, sphincter pharyngoplasty, double-opposing Z-palatoplasty, and palatal muscle retropositioning have increased in popularity.

Our purpose was to audit a single surgeon's long experience using a tailored superiorly based pharyngeal flap as a secondary operation to correct velopharyngeal insufficiency in nonsyndromic children with a repaired cleft palate. The outcome measures were perceptual speech results and complications.

PATIENTS AND METHODS

Patient Population

After approval by the Institutional Review Board of the Committee on Clinical Investigation, we identified and reviewed the charts of all patients who had a palatoplasty and were subsequently diagnosed with velopharyngeal insufficiency and treated with a pharyngeal flap under the supervision of the senior author (J.B.M.) at Children's Hospital Boston between 1981 and 2008 ($n = 72$). Children who had primary palatoplasty executed by another surgeon or at another institution were also included ($n = 32$). Exclusion criteria were submucous cleft palate, identified syndrome/association, and Robin sequence. Data collected included birth date, sex, hearing loss, cleft palate type, age at pharyngeal flap surgery, preoperative and postoperative speech assessment, videofluoroscopic results, postoperative complications, history of tonsillectomy or adenoidectomy or both, recommendation for another corrective procedure, and interval to most recent follow-up evaluation.

A speech pathologist, specializing in cleft palate, completed a preoperative perceptual speech assessment on each patient using the Pittsburgh Weighted Values for Speech Symptoms Associated with Velopharyngeal Incompetence instrument.[29] Deviant compensatory articulation patterns associated with velopharyngeal insufficiency (e.g., glottal stops, pharyngeal fricatives, and laryngeal fricatives) were identified and a therapeutic plan outlined to eliminate these patterns and to establish normal oral placement for consonant production.

Speech assessment was based on three structurally correctable variables: resonance (normal, hyponasal, mixed hyponasal/hypernasal, mildly hypernasal, moderately hypernasal, or severely hypernasal), intraoral pressure (normal or decreased), and nasal emission (normal, visible, audible, or turbulent). Overall velopharyngeal competence was graded as follows: (1) normal (normal or mildly hyponasal resonance, absence of visible nasal emission by mirror examination, and normal intraoral pressure); (2) borderline sufficiency (inconsistent mildly hypernasal, visible or inconsistent audible nasal emission, normal intraoral pressure, and no personal or social problems); (3) borderline insufficiency (consistent mildly hypernasal resonance, audible or turbulent nasal emission or inconsistent decreased intraoral pressure, and a personal or social problem); and (4) insufficiency (moderate or severe hypernasal resonance, audible or turbulent nasal emission, and decreased intraoral pressure).

All patients underwent preoperative multiview videofluoroscopy. Patients usually must be 4 to 5 years of age or older to participate in videofluoroscopy.[9,23,30,31] The plastic surgeon and speech pathologist reviewed the studies together before final consideration for a pharyngeal flap. The lateral pharyngeal wall motion (estimated percentage of velopharyngeal sphincter closure by medial movement of the lateral walls), symmetry of lateral wall motion, palatal length (very short, short, normal, or long), velopharyngeal gap size (pinhole, small, moderate, or gross), and defect pattern (coronal, sagittal, or circular) were considered in planning flap width (narrow, medium, wide, very wide, or subobstructing).[14,22,32] An otorhinolaryngologist evaluated the tonsils preoperatively; tonsillectomy was performed at least 8 weeks before the pharyngeal flap if tonsils were enlarged (2+ or greater). Thirty-seven of 104 children (36 percent) had a tonsillectomy and 10 (10 percent) also had an adenoidectomy.

Operative Technique

The technique was modified from methods described previously.[18,22,33–35] The velum was split in the midline from the uvula to approximately halfway to the hard palatal junction. Trapezoid-shaped nasal mucosal flaps were incised and sep-

arated from the oral mucosa of the velum. A superiorly based flap (narrow, medium, wide, very wide, or subobstructing)[14,22,32] was elevated off the buccopharyngeal fascia to above the level of the soft palate. Flap dimension was determined by lateral pharyngeal wall motion and was relative to the size of the pharynx. The differences between a "medium," "wide," and "very wide" flap requires judgment and experience. For example, if the lateral pharyngeal wall motion was 50 percent, a wide pharyngeal flap was designed such that it was 50 percent of the width of the pharynx; an additional 10 percent width was added to each side to account for contraction of the flap and pharynx. The distal end of the pharyngeal flap was apposed to the raw nasal surface of the mid soft palate and secured with three horizontal mattress sutures. The pharyngeal donor site was closed by medial advancement of the lateral mucosal walls, which were sutured to the fascia superiorly to avoid narrowing the base of the flap and apposed inferiorly. Then, 12- or 14-French red rubber catheters were placed through the nose and lateral portals. The catheters facilitated nasal lining closure at the base of the flap; they were not used for "lateral port control."[18] The nasal mucosal flaps were sutured to the base of the pharyngeal flap and then apposed to line the raw surface. The velum was repaired. The nasopharyngeal catheters in the lateral portals were removed at the completion of the procedure.

Outcome Assessment

All patients were followed annually in our interdisciplinary cleft palate clinic, including examination by the surgeon. The speech pathologist who performed the preoperative perceptual speech assessment reexamined the patient and repeated the Pittsburgh Weighted Values for Speech Symptoms Associated with Velopharyngeal Incompetence instrument[29] at least 3 to 6 months after the pharyngeal flap. Normal or borderline sufficiency was categorized as a success and borderline insufficiency or severe insufficiency was categorized as a failure. Hyponasal resonance, obstructive sleep apnea, and need for a revisionary operation (e.g., postoperative tonsillectomy, adenoidectomy, flap division, or dilation of pharyngeal ports) were recorded. Polysomnography was conducted if a child evidenced symptoms suggestive of obstructive sleep apnea.

Statistical Analyses

Patient characteristics and descriptive statistics were summarized. Continuous data were expressed as mean ± SD. We compared proportions of preoperative and postoperative speech characteristics using Fisher's exact test. We used the Wilcoxon signed rank test to compare preoperative and postoperative Pittsburgh Weighted Values scores.[29] All calculated p values were two-tailed and considered significant for values of $p < 0.05$. Statistical analyses were performed using Stata version 8 (StataCorp, College Station, Texas).

RESULTS

We reviewed 104 nonsyndromic patients with repaired cleft palate for whom a pharyngeal flap was necessary for velopharyngeal insufficiency. Patient characteristics are listed in Table 1. Most children had a short palate with a small circular velopharyngeal closure defect (Figs. 1 through 3). The average lateral pharyngeal wall motion toward the midline was 58 ± 24 percent (range, 10 to 95 percent). Pharyngeal flap width was "tailored" based on these assessments (Figs. 4 and 5).

Postoperative speech results were available for 79 of 104 patients (76 percent). There was significant improvement in overall velopharyngeal function, nasal emission, resonance, intraoral pressure, and articulation errors ($p < 0.001$) (Table 2). We also found a significant improvement in the Pittsburgh Weighted Values score ($p < 0.001$) (Fig. 6). Velopharyngeal function was normal or borderline sufficient in 77 of 79 patients (97 percent). Two patients had persistent velo-

Table 1. Patient Characteristics

	Value (%)
No. of patients	104
Age at pharyngeal flap surgery (yr)	
Mean ± SD	8.4 ± 4.6
Range	4.7–26.9
Male-to-female ratio	64:40 (62:38)
Hearing loss	14 (13)
Veau cleft palate type	
I	11 (11)
II	7 (7)
III	54 (52)
IV	32 (31)
Tonsillectomy	37 (36)
Before pharyngeal flap surgery	37 (100)
After pharyngeal flap surgery	0 (0)
Adenoidectomy	10 (10)
Before pharyngeal flap surgery	10 (100)
After pharyngeal flap surgery	0 (0)
Completed postoperative speech evaluation to date	79 (76)
Interval to most recent follow-up after pharyngeal flap surgery (yr)	3.9 ± 3.6*

*Mean ± SD.

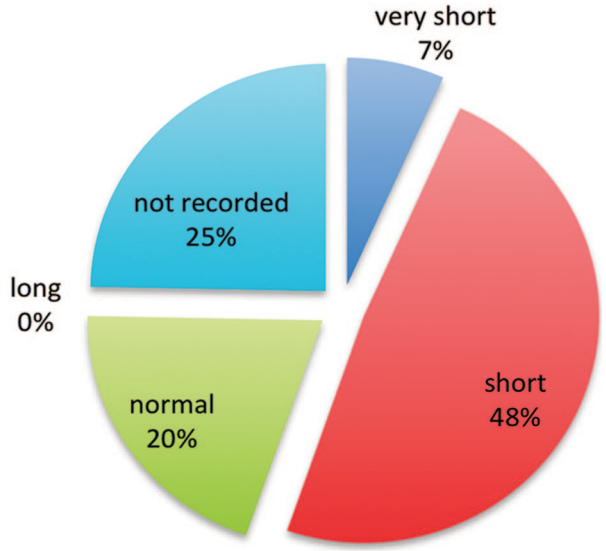

Fig. 1. Pie chart demonstrating videofluoroscopic findings. The percentage of patients by estimated palatal length categories is shown.

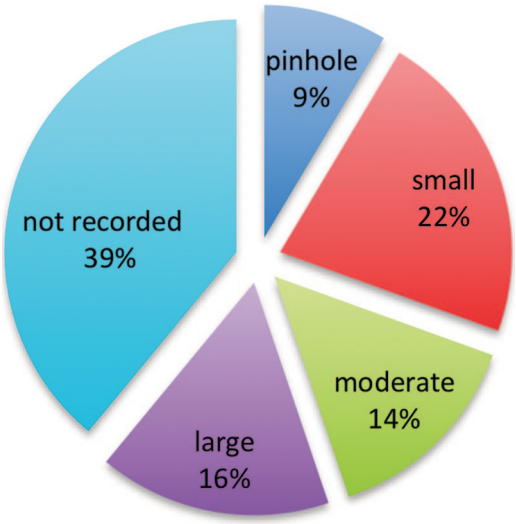

Fig. 3. Pie chart demonstrating videofluoroscopic findings. The percentage of patients by categories of velopharyngeal active gap size is shown.

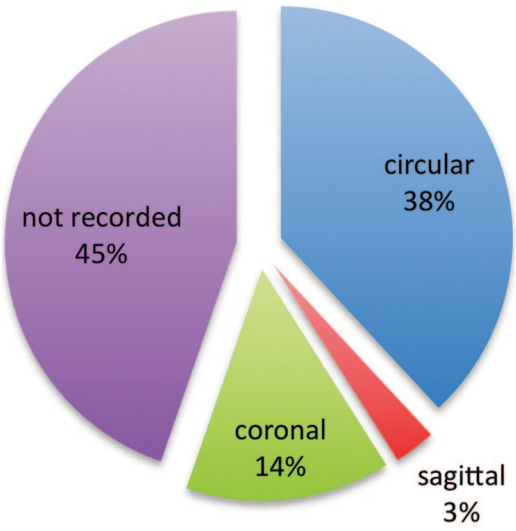

Fig. 2. Pie chart demonstrating videofluoroscopic findings. The percentage of patients by categories of velopharyngeal closure patterns is shown.

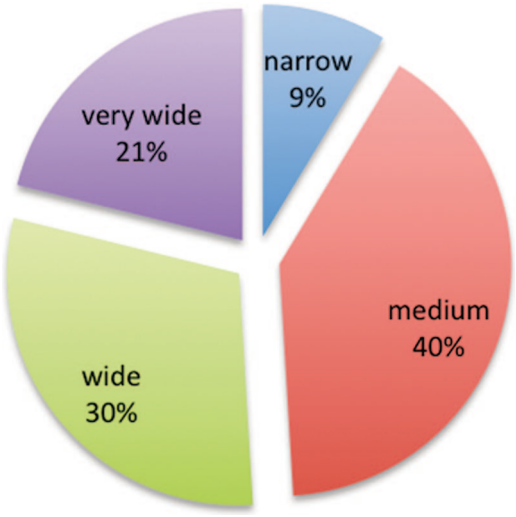

Fig. 4. Pie chart demonstrating tailored pharyngeal flap width. The percentage of flaps by width categories is shown.

pharyngeal insufficiency. One was a Spanish-speaking boy who had a repaired Veau type IV cleft palate and 10 percent lateral pharyngeal wall motion and a very wide flap. Another boy with a Veau type III cleft palate and 40 percent lateral pharyngeal wall motion had persistent velopharyngeal insufficiency following a wide flap. To date, neither patient has elected to undergo pharyngeal flap revision.

Nine patients underwent polysomnography; sleep apnea was diagnosed in two patients. These two patients had wide and medium pharyngeal flaps for 80 and 90 percent lateral pharyngeal wall motion, respectively. One child had a tonsillectomy before the pharyngeal flap; the other did not have tonsillar hypertrophy. Both patients chose continuous positive airway pressure ventilation during sleep rather than division of the pharyngeal flap. None of the pharyngeal flaps dehisced. The were no cases of postoperative bleeding.

DISCUSSION

A favorable outcome for correction of velopharyngeal insufficiency requires careful plan-

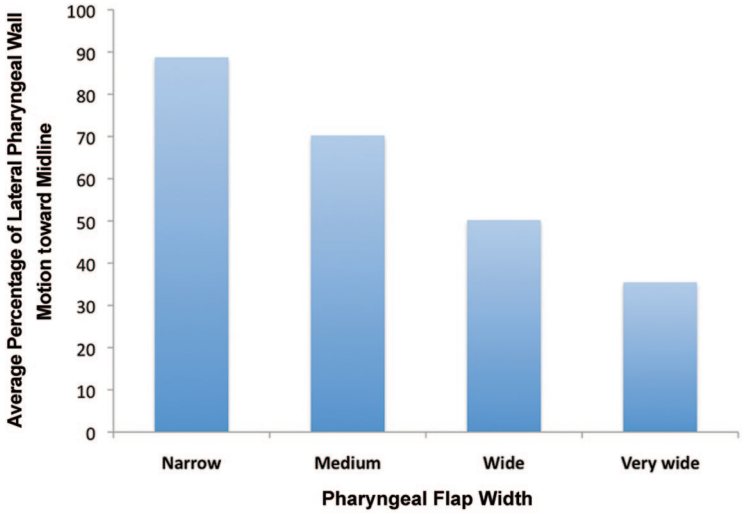

Fig. 5. Average lateral pharyngeal wall motion toward the midline by pharyngeal flap width categories.

Table 2. Results of Perceptual Speech Evaluation

	Preoperative (n = 104) (%)	Postoperative (n = 79) (%)	p*
Age at speech evaluation (yr)	7.3 ± 4.4†	11.4 ± 4.8†	
Overall velopharyngeal function			<0.001
Normal	0 (0)	67 (85)	
Borderline sufficiency	0 (0)	10 (13)	
Borderline insufficiency	19 (18)	0 (0)	
Insufficiency	85 (82)	2 (2)	
Nasal emission			<0.001
Normal	0 (0)	27 (35)	
Visible	47 (49)	48 (62)	
Audible/turbulent	48 (51)	3 (4)	
Not recorded	9	1	
Resonance			<0.001
Normal	2 (2)	60 (76)	
Hyponasal	0 (0)	9 (11)	
Mixed hyponasal/hypernasal	7 (7)	2 (3)	
Mildly hypernasal	14 (14)	7 (9)	
Moderately hypernasal	44 (45)	1 (1)	
Severely hypernasal	29 (30)	0	
Not recorded	7	0	
Intraoral pressure			<0.001
Normal	15 (16)	77 (97)	
Reduced	80 (84)	2 (3)	
Not recorded	9	0	
Articulation errors			<0.001
Normal	37 (39)	64 (82)	
Errors	58 (61)	14 (18)	
Not recorded	9	1	

*The p values were calculated using Fisher's exact test.
†Mean ± SD.

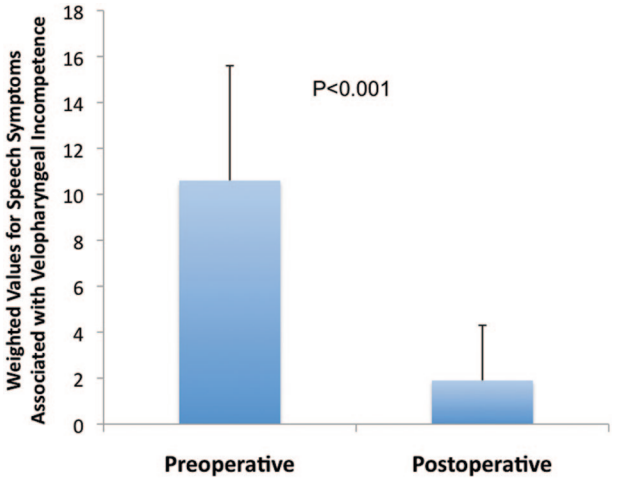

Fig. 6. Comparison of average preoperative and postoperative Pittsburgh Weighted Values for Speech Symptoms Associated with Velopharyngeal Incompetence scores (McWilliams BJ, Philips BJ. *Audio Seminars in Speech Pathology: Velopharyngeal Incompetence*. Philadelphia: Saunders; 1979) using the Wilcoxon signed rank test. Pharyngeal flap surgery resulted in a significant improvement in speech ($p < 0.001$).

ning, including a close working relationship between the speech pathologist and plastic surgeon in an interdisciplinary cleft palate center. They should review together the relevant patient information and preoperative studies before consideration of a pharyngeal flap. This study confirmed that a tailored superiorly based pharyngeal flap is highly effective in correcting velopharyngeal insufficiency following palatoplasty in nonsyndromic patients. Furthermore, we noted few complications, including sleep apnea. Our pharyngeal

flap success rate (97 percent) is comparable to other reviews of 78 to 98 percent.[13,15–23]

Preoperative videofluoroscopy is important for determining the extent of lateral pharyngeal wall movement. Closure of the lateral velopharyngeal portals following pharyngeal flap surgery is dependent solely on this medial movement of the lateral pharyngeal walls.[14,19,22] Thus, pharyngeal flap width is tailored to lateral wall motion and must be balanced between that required to eliminate hypernasality without overcorrection to the point of hyponasality.[15,32] Patients with excellent lateral wall motion should have narrower flaps so that nasal airflow is not obstructed, whereas those with poor to absent lateral wall motion may require a subobstructing flap.[22] A medium or wide flap was used in the majority of patients (70 percent), which is comparable to other reviews.[17,20] Our tailored flap resulted in successful correction of velopharyngeal insufficiency in a breadth of velopharyngeal port closure patterns, with variable lateral pharyngeal wall motion, gap size, and palate length.

Despite careful planning and execution, complications can occur. Critics often note that a pharyngeal flap can cause hyponasal speech or sleep apnea. Indeed, in the immediate postoperative period, many children will have some degree of nasal obstruction; they should have continuous monitoring of oxygen saturation and cardiac status for 1 to 2 days in the hospital. Although minor obstruction, hyponasal speech, and snoring are common soon after pharyngeal flap surgery, the frequency is low 2 to 3 months postoperatively.[17,25,26,36,37]

Hyponasal speech indicates some degree of obstruction; this finding was documented in 8.7 percent of our patients. Others investigators report hyponasality in 3 to 27 percent of patients following pharyngeal flap surgery.[15,16,18–20,22,24] Hyponasal speech is not normal but it is far more intelligible than hypernasal speech.[22] Minor obstruction leading to hyponasal speech is unlikely to have major physiologic effects. Severe obstructive sleep apnea has been reported in 0 to 20 percent of patients following pharyngeal flap surgery; potential sequelae are pulmonary hypertension and right ventricular hypertrophy.[17,20,24,26–28,32,38,39] Similar to our findings, surgeons experienced with constructing a tailored pharyngeal flap have documented a low incidence (0 to 3.3 percent) of sleep apnea.[9,17,24,28,32,38]

Predictors of obstructive sleep apnea include syndromic patients, Robin sequence, structural narrowing of the upper airway, and enlarged tonsils.[17,28,40] Tonsils can be a mechanical obstruction to velopharyngeal sphincter closure and a risk factor for developing sleep apnea following pharyngeal flap surgery because of posterior displacement into the oropharynx and potential subsequent hypertrophy.[17,28] Ysunza and colleagues[28] found enlarged tonsils in 13 of 15 patients who developed sleep apnea following pharyngeal flap surgery. They described complete resolution of sleep apnea in 14 patients after tonsillectomy and uvulopalatopharyngoplasty. Assessment of tonsillar and adenoidal size before pharyngeal flap surgery is part of our protocol. If patients were noted to have 2+ tonsillar or adenoidal hypertrophy, tonsillectomy or adenoidectomy or both was performed before the pharyngeal flap. Nevertheless, two children developed obstructive sleep apnea, despite tonsillectomy and adenoidectomy 8 weeks before a wide and medium width pharyngeal flap. Of note, no child with a very wide or subobstructing flap developed sleep apnea. The two patients with sleep apnea elected to use continuous positive airway pressure. Severe sleep apnea may require takedown of the pharyngeal flap. Fortunately, the improved speech following pharyngeal flap surgery is often preserved after division.[41]

Persistent velopharyngeal insufficiency is attributable to inadequate flap width and failure of lateral wall movement to close lateral portals.[22] The design of the nasal flaps and coverage of the raw surface of the flap are also critical technical points. An inadequately lined flap will contract and narrow.[22,25] Two patients (2 percent) in our series were recommended for, but did not elect, reoperation because of persistent velopharyngeal insufficiency. Revisionary surgery for velopharyngeal insufficiency has been reported to be necessary in 4 to 12 percent of patients following pharyngeal flap surgery.[20,24,27] If a patient has persistent velopharyngeal insufficiency after pharyngeal flap surgery, we recommend take-down of the flap and waiting for healing of the velum and pharynx. Another videofluoroscopic examination is scheduled in preparation for a secondary pharyngeal flap. In designing this flap, the surgeon must take into account not only the pharyngeal wall motion but also the difficulty in redissection of the nasal flaps and posterior pharynx, and the narrowed pharynx.

Although we found the pharyngeal flap to be highly successful and with few complications, successful correction of velopharyngeal insufficiency has also been reported with other secondary operations. Success seems to depend on proper planning and execution rather than the type of secondary correction.[19] Sphincter pharyngoplasty is a comparable secondary operation, with a reported success rate similar to that of a pharyngeal flap (78

to 90 percent).[32,42–48] Prospective randomized trials comparing a pharyngeal flap to a sphincter have shown that a pharyngeal flap is slightly, although not statistically significantly, more effective than a sphincter pharyngoplasty.[13,32] Once thought to function as a dynamic closure, sphincter pharyngoplasty, like the pharyngeal flap, is a passive tissue obturator.[49] Although pharyngeal flap width can be adjusted, sphincter pharyngoplasty has more flexibility in terms of length, width, position, and degree of overlap of the palatopharyngeal flaps.[47,50] Sphincter pharyngoplasty may be a good option if a "coronal" pattern of velopharyngeal portal closure (good velar movement and poor lateral pharyngeal wall movement) is documented preoperatively. Nevertheless, in agreement with others, we found a pharyngeal flap to be equally successful with this coronal closure pattern.[19] Reported complications of a sphincter pharyngoplasty are higher than for a pharyngeal flap, with revision rates of 12 to 16 percent[43,45,47,50] and hyponasality in up to 22 percent of patients.[43] The rate of obstructive sleep apnea with a sphincter procedure is not different from a pharyngeal flap.[13]

Double-opposing Z-palatoplasty lengthens the palate and repositions sagittally oriented levator veli palatini muscles, and has had reported success rates of 56 to 97 percent in correcting velopharyngeal insufficiency. This procedure is usually considered for patients with less severe velopharyngeal insufficiency and a small, active pharyngeal gap.[24,51,52] Radical muscular retropositioning has also been recommended for treatment of sagittally oriented muscles.[11,53,54] Double-opposing Z-palatoplasty or muscular retropositioning is less likely to cause nasal airway obstruction.[24,52,55,56]

Study Limitations

This retrospective review could be criticized because complete and accurate medical records were available in only three-fourths of the children. Another possible weakness is that speech outcomes were obtained from qualitative descriptions by more than one speech pathologist, and interrater reliability was not evaluated. Although the speech pathologists in our interdisciplinary clinic specialize in cleft abnormality, they may vary in their description of resonance, nasal emission, and intraoral pressure. Polysomnography was not routinely conducted on all children after pharyngeal flap surgery, but only on those who presented with obstructive symptoms. Even with close follow-up assessment, children with minor sleep apnea may have gone unrecognized.

CONCLUSIONS

We audited a series of 104 nonsyndromic patients with repaired cleft palate who exhibited velopharyngeal insufficiency. Our results confirm that a tailored superiorly based pharyngeal flap, performed by an experienced surgeon, successfully corrects velopharyngeal insufficiency (97 percent), with a low incidence of obstructive sleep apnea (2.5 percent).

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REFERENCES

1. Marsh JL. The evaluation and management of velopharyngeal dysfunction. *Clin Plast Surg.* 2004;31:261–269.
2. Smith B, Guyette TW. Evaluation of cleft palate speech. *Clin Plast Surg.* 2004;31:251–260.
3. Shprintzen RJ, Golding-Kushner KJ. Evaluation of velopharyngeal insufficiency. *Otolaryngol Clin North Am.* 1989;22:519–536.
4. Bearn D, Mildinhall S, Murphy T, et al. Cleft lip and palate care in the United Kingdom: The Clinical Standards Advisory Group (CSAG) Study. Part 4: Outcome comparisons, training, and conclusions. *Cleft Palate Craniofac J.* 2001;38:38–43.
5. David DJ, Anderson PJ, Schnitt DE, Nugent MA, Sells R. From birth to maturity: A group of patients who have completed their protocol management. Part II. Isolated cleft palate. *Plast Reconstr Surg.* 2006;117:515–526.
6. Inman DS, Thomas P, Hodgkinson PD, Reid CA. Oro-nasal fistula development and velopharyngeal insufficiency following primary cleft palate surgery: An audit of 148 children born between 1985 and 1997. *Br J Plast Surg.* 2005;58:1051–1054.
7. Kirschner RE, Wang P, Jawad AF, et al. Cleft-palate repair by modified Furlow double-opposing Z-plasty: The Children's Hospital of Philadelphia experience. *Plast Reconstr Surg.* 1999;104:1998–2010; discussion 2011–2014.
8. LaRossa D, Jackson OH, Kirschner RE, et al. The Children's Hospital of Philadelphia modification of the Furlow double-opposing z-palatoplasty: Long-term speech and growth results. *Clin Plast Surg.* 2004;31:243–249.
9. Salyer KE, Sng KW, Sperry EE. Two-flap palatoplasty: 20-year experience and evolution of surgical technique. *Plast Reconstr Surg.* 2006;118:193–204.
10. Schnitt DE, Agir H, David DJ. From birth to maturity: A group of patients who have completed their protocol management. Part I. Unilateral cleft lip and palate. *Plast Reconstr Surg.* 2004;113:805–817.
11. Sommerlad BC. A technique for cleft palate repair. *Plast Reconstr Surg.* 2003;112:1542–1548.
12. Witt PD, Wahlen JC, Marsh JL, Grames LM, Pilgram TK. The effect of surgeon experience on velopharyngeal functional outcome following palatoplasty: Is there a learning curve? *Plast Reconstr Surg.* 1998;102:1375–1384.

13. Abyholm F, D'Antonio L, Davidson Ward SL, et al. Pharyngeal flap and sphincterplasty for velopharyngeal insufficiency have equal outcome at 1 year postoperatively: Results of a randomized trial. *Cleft Palate Craniofac J.* 2005;42:501–511.
14. Argamaso RV, Shprintzen RJ, Strauch B, et al. The role of lateral pharyngeal wall movement in pharyngeal flap surgery. *Plast Reconstr Surg.* 1980;66:214–219.
15. Cable BB, Canady JW, Karnell MP, Karnell LH, Malick DN. Pharyngeal flap surgery: Long-term outcomes at the University of Iowa. *Plast Reconstr Surg.* 2004;113:475–478.
16. Canady JW, Cable BB, Karnell MP, Karnell LH. Pharyngeal flap surgery: Protocols, complications, and outcomes at the University of Iowa. *Otolaryngol Head Neck Surg.* 2003;129:321–326.
17. Chegar BE, Shprintzen RJ, Curtis MS, Tatum SA. Pharyngeal flap and obstructive apnea: Maximizing speech outcome while limiting complications. *Arch Facial Plast Surg.* 2007;9: 252–259.
18. Hogan VM. A clarification of the surgical goals in cleft palate speech and the introduction of the lateral port control (l.p.c.) pharyngeal flap. *Cleft Palate J.* 1973;10:331–345.
19. Lam E, Hundert S, Wilkes GH. Lateral pharyngeal wall and velar movement and tailoring velopharyngeal surgery: Determinants of velopharyngeal incompetence resolution in patients with cleft palate. *Plast Reconstr Surg.* 2007;120:495–505; discussion 506–507.
20. Morris HL, Bardach J, Jones D, Christiansen JL, Gray SD. Clinical results of pharyngeal flap surgery: The Iowa experience. *Plast Reconstr Surg.* 1995;95:652–662.
21. Schmelzeisen R, Hausamen JE, Loebell E, Hacki T. Long-term results following velopharyngoplasty with a cranially based pharyngeal flap. *Plast Reconstr Surg.* 1992;90:774–778.
22. Shprintzen RJ, Lewin ML, Croft CB, et al. A comprehensive study of pharyngeal flap surgery: Tailor made flaps. *Cleft Palate J.* 1979;16:46–55.
23. Sloan GM. Posterior pharyngeal flap and sphincter pharyngoplasty: The state of the art. *Cleft Palate Craniofac J.* 2000; 37:112–122.
24. Dailey SA, Karnell MP, Karnell LH, Canady JW. Comparison of resonance outcomes after pharyngeal flap and Furlow double-opposing z-plasty for surgical management of velopharyngeal incompetence. *Cleft Palate Craniofac J.* 2006;43:38–43.
25. Shprintzen RJ. Pharyngeal flap surgery and the pediatric upper airway. *Int Anesthesiol Clin.* 1988;26:79–88.
26. Sirois M, Caouette-Laberge L, Spier S, Larocque Y, Egerszegi EP. Sleep apnea following a pharyngeal flap: A feared complication. *Plast Reconstr Surg.* 1994;93:943–947.
27. Valnicek SM, Zuker RM, Halpern LM, Roy WL. Perioperative complications of superior pharyngeal flap surgery in children. *Plast Reconstr Surg.* 1994;93:954–958.
28. Ysunza A, Garcia-Velasco M, Garcia-Garcia M, Haro R, Valencia M. Obstructive sleep apnea secondary to surgery for velopharyngeal insufficiency. *Cleft Palate Craniofac J.* 1993; 30:387–390.
29. McWilliams BJ, Philips BJ. *Audio Seminars in Speech Pathology: Velopharyngeal Incompetence.* Philadelphia: Saunders; 1979.
30. Marrinan EM, LaBrie RA, Mulliken JB. Velopharyngeal function in nonsyndromic cleft palate: Relevance of surgical technique, age at repair, and cleft type. *Cleft Palate Craniofac J.* 1998;35:95–100.
31. Garcia Velasco M, Ysunza A, Hernandez X, Marquez C. Diagnosis and treatment of submucous cleft palate: A review of 108 cases. *Cleft Palate J.* 1988;25:171–173.
32. Ysunza A, Pamplona C, Ramirez E, Molina F, Mendoza M, Silva A. Velopharyngeal surgery: A prospective randomized study of pharyngeal flaps and sphincter pharyngoplasties. *Plast Reconstr Surg.* 2002;110:1401–1407.
33. Owsley JQ Jr, Lawson LI, Miller ER, Blackfield HM. Experience with the high attached pharyngeal flap. *Plast Reconstr Surg.* 1966;38:232–242.
34. Schoenborn D. Ueber eine neue Methode der Staphylorskaphie. *Arch F Klin Chir.* 1876;19:528–531.
35. Sanvanero-Rosselli. Divisione palatina e sua aura chirugico alu. *Cong Interne Stomatal.* 1935;36:391–395.
36. Lesavoy MA, Borud LJ, Thorson T, Riegelhuth ME, Berkowitz CD. Upper airway obstruction after pharyngeal flap surgery. *Ann Plast Surg.* 1996;36:26–30; discussion 31–32.
37. Orr WC, Levine NS, Buchanan RT. Effect of cleft palate repair and pharyngeal flap surgery on upper airway obstruction during sleep. *Plast Reconstr Surg.* 1987;80:226–232.
38. Hofer SO, Dhar BK, Robinson PH, Goorhuis-Brouwer SM, Nicolai JP. A 10-year review of perioperative complications in pharyngeal flap surgery. *Plast Reconstr Surg.* 2002;110:1393–1397; discussion 1398–1400.
39. Shprintzen RJ. Pierre Robin, micrognathia, and airway obstruction: The dependency of treatment on accurate diagnosis. *Int Anesthesiol Clin.* 1988;26:64–71.
40. Abramson DL, Marrinan EM, Mulliken JB. Robin sequence: Obstructive sleep apnea following pharyngeal flap. *Cleft Palate Craniofac J.* 1997;34:256–260.
41. Agarwal T, Sloan GM, Zajac D, Uhrich KS, Meadows W, Lewchalermwong JA. Speech benefits of posterior pharyngeal flap are preserved after surgical flap division for obstructive sleep apnea: Experience with division of 12 flaps. *J Craniofac Surg.* 2003;14:630–636.
42. James NK, Twist M, Turner MM, Milward TM. An audit of velopharyngeal incompetence treated by the Orticochea pharyngoplasty. *Br J Plast Surg.* 1996;49:197–201.
43. Losken A, Williams JK, Burstein FD, Malick D, Riski JE. An outcome evaluation of sphincter pharyngoplasty for the management of velopharyngeal insufficiency. *Plast Reconstr Surg.* 2003;112:1755–1761.
44. Orticochea M. The timing and management of dynamic muscular pharyngeal sphincter construction in velopharyngeal incompetence. *Br J Plast Surg.* 1999;52:85–87.
45. Riski JE, Ruff GL, Georgiade GS, Barwick WJ, Edwards PD. Evaluation of the sphincter pharyngoplasty. *Cleft Palate Craniofac J.* 1992;29:254–261.
46. Witt PD, D'Antonio LL, Zimmerman GJ, Marsh JL. Sphincter pharyngoplasty: A preoperative and postoperative analysis of perceptual speech characteristics and endoscopic studies of velopharyngeal function. *Plast Reconstr Surg.* 1994;93: 1154–1168.
47. Witt PD, Marsh JL, Arlis H, Grames LM, Ellis RA, Pilgram TK. Quantification of dynamic velopharyngeal port excursion following sphincter pharyngoplasty. *Plast Reconstr Surg.* 1998; 101:1205–1211.
48. Ysunza A, Pamplona MC, Molina F, Chacón E, Collado M. Velopharyngeal motion after sphincter pharyngoplasty: A videonasopharyngoscopic and electromyographic study. *Plast Reconstr Surg.* 1999;104:905–910.
49. Ysunza A, Pamplona MC. Velopharyngeal function after two different types of pharyngoplasty. *Int J Pediatr Otorhinolaryngol.* 2006;70:1031–1037.
50. Sie KC, Tampakopoulou DA, de Serres LM, Gruss JS, Eblen LE, Yonick T. Sphincter pharyngoplasty: Speech outcome and complications. *Laryngoscope* 1998;108:1211–1217.
51. Furlow LT Jr. Cleft palate repair by double opposing Z-plasty. *Plast Reconstr Surg.* 1986;78:724–738.
52. Sie KC, Tampakopoulou DA, Sorom J, Gruss JS, Eblen LE. Results with Furlow palatoplasty in management of velopharyngeal insufficiency. *Plast Reconstr Surg.* 2001;108:17–25; discussion 26–29.

53. Sommerlad BC. The use of the operating microscope for cleft palate repair and pharyngoplasty. *Plast Reconstr Surg.* 2003;112:1540–1541.
54. Sommerlad BC, Fenn C, Harland K, et al. Submucous cleft palate: A grading system and review of 40 consecutive submucous cleft palate repairs. *Cleft Palate Craniofac J.* 2004;41:114–123.
55. Chen KT, Wu J, Noordhoff SM. Submucous cleft palate. *Chang Gung Med J.* 1994;17:131–137.
56. D'Antonio LL, Eichenberg BJ, Zimmerman GJ, et al. Radiographic and aerodynamic measures of velopharyngeal anatomy and function following Furlow Z-plasty. *Plast Reconstr Surg.* 2000;106:539–549; discussion 550–553.