An Outcome Evaluation of Sphincter Pharyngoplasty for the Management of Velopharyngeal Insufficiency

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Sphincter pharyngoplasty is frequently used for the management of children with velopharyngeal insufficiency. The purpose of this study was to evaluate outcome and revision rates of sphincter pharyngoplasty at the authors' institution. Two hundred fifty patients underwent sphincter pharyngoplasty for velopharyngeal insufficiency between January of 1987 and March of 2001. There were 117 female patients and 133 male patients, with a mean age at primary sphincter pharyngoplasty of 7.6 years (range, 1 to 45 years). Diagnoses included velopharyngeal insufficiency alone ($n = 63$), velopharyngeal insufficiency associated with cleft palate ($n = 127$), velocardiofacial syndrome ($n = 32$), submucous cleft ($n = 15$), and other ($n = 13$). Pharyngoplasty revision was defined as any secondary surgical revision of the sphincter as determined by clinical evaluation and objective speech assessment. The pharyngoplasty revision rate was found to be 12.8 percent ($n = 32$). A favorable outcome was demonstrated in 30 of these patients (93.8 percent) after pharyngoplasty revision. Two patients, one with a diagnosis of a submucous cleft and velocardiofacial syndrome and the other with a cleft palate, required a second revision because of persistent velopharyngeal insufficiency. The revision rate was highest in those patients with velocardiofacial syndrome (21.8 percent) and lowest in patients with velopharyngeal insufficiency alone (6.3 percent). Patients who required revision had significantly higher preoperative oral sentence nasometry (55.2 percent versus 46.1 percent; $p < 0.01$) and larger velopharyngeal areas (23.7 mm^2 versus 18.9 mm^2). There was no significant difference in age or sex for those patients who required a revision compared with those who did not require revision. Mean follow-up was 2.4 years (range, 4 months to 13.6 years). Sphincter pharyngoplasty is an effective procedure for the treatment of velopharyngeal insufficiency using revision rate as the standard of success. It had an 87 percent primary success rate that increased to 99 percent after a single revision. Patients with velocardiofacial syndrome, more severe preoperative hypernasal resonance, and larger velopharyngeal areas were more likely to require pharyngoplasty revision. (*Plast. Reconstr. Surg.* 112: 1755, 2003.)

Velopharyngeal insufficiency results from a structural or functional defect at the level of the nasopharynx in which there is an inability to accomplish adequate velopharyngeal closure. Surgical management of velopharyngeal insufficiency has undergone many modifications since first introduced by Passavant in 1862.[1] The rationale behind any surgical intervention is to diminish airflow through the nose during speech by reducing the area of the nasopharynx.

Sphincter pharyngoplasty is usually performed for the correction of velopharyngeal insufficiency. The procedure results in a soft-tissue "diaphragm," narrowing the nasopharynx and enabling velopharyngeal closure.[2,3] The sphincter pharyngoplasty is easily modified, which enhances the success rate of this procedure.[2,4] A successful outcome is often determined by perceptual analysis and quantified by a detailed objective instrumental evaluation. However, it is also important to evaluate the incidence of surgical revision, as this reflects success of the surgical technique, patient selection, and flexibility of the surgical procedure. The purpose of this review was to examine the revision rates for sphincter pharyngoplasty in

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the treatment of children with velopharyngeal insufficiency. Clinical variables and speech data were analyzed to determine risk factors that may increase the likelihood of failure and subsequent revision.

Patients and Methods

Demographics

The records of all patients who underwent sphincter pharyngoplasty for velopharyngeal insufficiency between January of 1987 and March of 2001 were reviewed. All patients were evaluated by a multidisciplinary team that included speech pathologists, audiologists, geneticists, nutritionists, dental specialists, and craniofacial surgeons. Craniofacial clinic databases, medical charts, and office notes were used for review. Each patient was characterized with regard to diagnosis, preoperative assessment, surgical intervention, postoperative care, speech analyses, secondary procedures (and their revision), and outcome.

Two hundred fifty consecutive patients underwent sphincter pharyngoplasty for velopharyngeal insufficiency and were included in this review. There were 117 female patients and 133 male patients, with a mean age at primary sphincter pharyngoplasty of 7.6 years (range, 1 to 45 years). The underlying diagnoses based on category were velopharyngeal insufficiency alone ($n = 63$), velopharyngeal insufficiency associated with cleft palate ($n = 127$), velocardiofacial syndrome ($n = 32$), submucous cleft ($n = 15$), and other ($n = 13$). Forty percent of the patients with velopharyngeal insufficiency alone ($n = 25$) had undergone previous documented tonsillectomy and adenoidectomy. Mean follow-up was 2.4 years (range, 4 months to 13.6 years).

Analysis of Velopharyngeal Function

All patients underwent screening of velopharyngeal function that included perceptual speech evaluation, clinical screening of velopharyngeal closure, and oral examination. The perceptual ratings of speech were determined during live speech samples, which included single words, sentences, and conversational speech. For this investigation, resonance was categorized as (1) hypernasal, (2) hyponasal, (3) mixed, or (3) normal. Screening for velopharyngeal closure was performed with devices sensitive to nasal airflow. Patients determined to have hypernasal or hyponasal resonance, or nasal air escape, were evaluated further using instrumentation and imaging. Imaging studies included lateral phonation radiographs to determine the ratio of nasopharyngeal depth to velar length, the height of attempted velopharyngeal contact relative to the first cervical spine, and any other occult craniofacial signs. Select patients underwent multiview videofluoroscopic and flexible nasendoscopy.

Pressure flow measures were obtained using the Perci-SARS (MicroTronics Corp., Chapel Hill, N.C.) during the repeated production of high-pressure oral consonants in repeated words and/or blowing tasks (for young children not capable of repeating words). Velopharyngeal orifice area (in millimeters squared) was calculated using these measurements. *Nasometry* was performed using a Kay Elemetrics 6200 Nasometer (Kay Elemetrics Corp., Lincoln Park, N.J.). Nasalance scores were collected during the production of oral and nasal loaded speech samples. See Table I[5–7] for published normal data.

Nasoendoscopy was performed using a Pentax FNL 2.4-mm flexible endoscope. The endoscope was positioned just above the velopharyngeal port and patients were asked to repeat

TABLE I

Objective Speech Data in Patients Who Required Revision ($n = 32$)

	Presphincter	Postsphincter	Postrevision	Normal
Aerodynamic				
Velopharyngeal area, mm²	23.7 ± 19.5	23.7 ± 22	4.17 ± 3.88	<5 mm*
Radiography				
Depth-to-length ratio	0.99 ± 0.25	N/A	N/A	0.70 ± 0.88†
Nasometry				
Nasalance	55.2 ± 17.5	40.7 ± 16.8	27.1 ± 16.4	15.6 ± 5‡

* Riski, J. E., Serafin, D., Riefkohl, R., Georgiade, G. S., and Georgiade, N. G. A rationale for modifying the site of insertion of the Orticochea pharyngoplasty. *Plast. Reconstr. Surg.* 73: 882, 1984.

† Hynes, W. Observations on pharyngoplasty. *Br. J. Plast. Surg.* 20: 244, 1967.

‡ Schoenborn, K. Ueber einer neue Methode fuer Staphylorrhaphie. *Verh. Detsh. Ges. Chir.* 4: 235, 1875.

high-pressure and low-pressure oral and nasal loaded speech samples in words and connected speech to assess velopharyngeal function. Velar elevation, lateral wall movement, closure patterns, and overall velopharyngeal function during various speech tasks were assessed. *Lateral radiographs* were used to measure velar length and depth of nasopharynx. These were calculated to determine the ratio of nasopharyngeal depth to velar length. A depth/length ratio greater than 0.80 was termed "unfavorable."

Velopharyngeal insufficiency was defined by (1) a perceptual rating of hypernasal or hyponasality, (2) an observed velopharyngeal gap during an oral loaded speech task via nasendoscopy, (3) a nasalance score greater than 30 percent for an oral loaded speech sample determined by nasometry measurements, and/or (4) a velopharyngeal orifice area greater than 5 mm^2 during pressure-flow studies.

Surgical Procedure

Pharyngoplasty revision was defined as any secondary surgical modification of the sphincter pharyngoplasty. The need for revision was determined by clinical examination, perceptual speech evaluation, and objective instrumental assessment.

Sphincter pharyngoplasty was performed in patients with velopharyngeal insufficiency associated with limited lateral wall movements and/or large velopharyngeal gaps. Bilateral superiorly based palatopharyngeus myomucosal flaps were elevated off the posterior aspects of the posterior tonsillar pillars. These flaps were based caudally to the level of the proposed height of the velum using the first cervical vertebrae as the landmark.[8,9] A transverse incision was then made through the posterior constrictor at this level. The left and right flaps were then attached to the superior and inferior mucosa of the posterior pharyngeal incision, respectively. The newly created sphincter was secured by suturing the lateral flaps to one another with a degree of overlap subjectively determined by results of the preoperative testing, and the donor sites were closed. A nasal trumpet was placed across the sphincter for airway control and removed on postoperative day 1. The children were kept on a soft diet until their first postoperative visit at 3 weeks.

Revision of the sphincter was performed easily by either readvancing or partially removing the original flaps, based on the diagnosis. A simple wedge incision in the posterior pharyngeal wall was performed at the level of the sphincter for those patients with limited hypernasality or hyponasality.

Statistical Analysis

Crude statistical analysis for revision rates stratified by diagnosis was carried out using a 5 $\times$ 2 contingency chi-square test with $p < 0.05$. Prepharyngoplasty and postpharyngoplasty speech data were analyzed using t testing, with significance at $p < 0.05$ for comparisons between those patients who required revision and those who did not require a revision. A multivariate logistic regression model was performed using the maximum likelihood estimation method to identify potential risk factors such as age, sex, and diagnosis (independent variables) for patients who required revision (dependent variable). Nasalance, pressure flow, and velopharyngeal dimensions (determined by cephalometric analysis) were also compared for the two groups. The sample was stratified by clinical diagnosis and comparisons were made. For additional statistical analysis, the cohort was then divided into patients with a cleft palate and those patients without a cleft palate.

RESULTS

Outcome

Success of the primary sphincter pharyngoplasty, defined as improvement by perceptual speech evaluation and analysis foregoing the need for a surgical revision, was demonstrated in 87 percent of patients (218 of 250). A successful outcome was seen in 99 percent (248 of 250) after a single pharyngoplasty revision. The pharyngoplasty required revision in 32 patients (12.8 percent). Twenty-five patients in this group (78 percent) showed evidence of persistent velopharyngeal insufficiency and required a tightening procedure or elevation of the sphincter in the nasopharynx. Seven patients (22 percent) with hyponasal speech, symptoms of nasal airway obstruction, and compromise of the nasopharyngeal opening on endoscopy required expansion of the sphincter. The average time interval to revision was 10.4 months (range, 3 to 36 months). After the initial revision, improvement in velopharyngeal competence was documented in 30 of 32 patients (94 percent). Two patients with a diagnosis of a submucous cleft and velocardio-

facial syndrome with a cleft palate required a tertiary pharyngoplasty because of persistent velopharyngeal insufficiency.

No statistically significant difference was seen in the average age at initial sphincter pharyngoplasty in patients who required a revision (6.8 ± 4.48 years) compared with those who did not require revision (7.4 ± 4.4 years). Sex did not appear to have any significant effect on revision rates either (Table II). Multivariate analysis confirmed that age at the time of the operation and sex were not significantly associated with the need for a revision.

Diagnosis

The initial diagnosis appeared to affect the revision rate; however, no significant differences were found (Table III). The revision rate was highest in those patients with velocardiofacial syndrome (21.9 percent) and lowest in patients with velopharyngeal insufficiency alone (6.3 percent). When further stratified by cleft palate versus no cleft palate, patients with a cleft palate had a slightly higher revision rate (15 percent) than those patients without a cleft palate (10 percent); however, the difference was not significant (Table IV).

Speech Analysis

Preoperative nasometry scores were significantly higher in those patients who eventually required a pharyngoplasty revision (55.2 percent versus 46.1 percent), with a value of $p = 0.01$ (Table V). No significant differences in the preoperative pressure flow measurements or radiographic measurements for the two groups were found. However, the patients who required revision of the pharyngoplasty were more likely to have larger velopharyngeal areas (23.7 mm^2 versus 18.9 mm^2). As expected, postpharyngoplasty measurements (nasalance, velopharyngeal area, and oral pressure) were significantly higher in those patients who did not demonstrate velopharyngeal competence and subsequently required pharyngoplasty revision.

Longitudinal data are presented in Table I for those patients who underwent pharyngoplasty revision ($n = 32$). All measurements improved and appeared to approach normal after pharyngoplasty revision.

TABLE II

Analysis of Pharyngoplasty Reoperation by Age and Sex

	Success ($n = 218$)	Failure ($n = 32$)	p
Age (mean ± SD)	7.4 ± 4.40	6.8 ± 4.48	0.473
Sex (male/female)	117/101	15/17	0.570

TABLE III

Revision Rate Stratified by Initial Diagnosis

Diagnosis	No.	Age at SP (y)	Revision Rate* (%)	Indications (hypernasal/ hyponasal)
VCF syndrome	32	6.7 ± 4.0	7/32 (21.9)	6/1
Cleft palate	127	7.3 ± 5.8	19/127 (15)	16/3
Submucous cleft	15	6.3 ± 2.8	1/15 (6.7)	1/0
VPI without cleft	63	8.4 ± 3.9	4/63 (6.3)	2/2
Other	13	11.2 ± 5.9	1/13 (7.7)	0/1
Overall	250	7.6 ± 5.1	32 (12.8)	25/7

SP, sphincter pharyngoplasty; VCF, velocardiofacial; VPI, velopharyngeal insuffiency.

* Revision rates were not significantly different.

TABLE IV

Reoperation Rate: Cleft Palate versus No Cleft Palate

	No.	Revision Rate (%)	Indications (hypernasal/ hyponasal)
Cleft palate	134	20/134 (15)	17/3
No cleft palate	116	12/116 (10)	8/4
p		0.134	

Discussion

Effective management of children with velopharyngeal insufficiency involves surgical narrowing of the nasopharynx. Passavant described the original procedure for managing velopharyngeal insufficiency as surgical adhesion of the posterior soft palate to the posterior pharyngeal wall.[1] This was followed closely by the introduction of posterior pharyngeal flaps to augment the pharyngeal wall.[10] Numerous modifications of this technique were engineered over the years, settling with the superiorly based flap still popular today.[11,12] The sphincter pharyngoplasty, originally described by Hynes in 1950, was a two-stage procedure intended as an operation for the failed cleft palate.[13] It was designed to narrow the nasopharyngeal isthmus with lateral pharyngeal myomucosal flaps sutured across the posterior pharyngeal wall. After some modification, it now represents a frequently used method for correcting velopharyngeal insufficiency after palatal repair. The observed postoperative sphincteringappears to be passive, caused by contraction of the superior constrictor pharyngeus muscle.[14]

Numerous modifications have been made to this procedure since originally described, in an