Pharyngeal Flap as a Primary and Secondary Procedure

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Most commonly, pharyngeal flap surgery is employed as a secondary procedure to correct residual palatopharyngeal incompetence subsequent to palatal closure. Less frequently, pharyngeal flap is used in combination with palatoplasty as a primary or initial operation in infants (*6, 9, 11*) or in later age groups for patients with a wide cleft, short palate, or submucous cleft (*2*).

This study of patients in later age groups was undertaken:

1. To compare results of pharyngeal flap surgery employed as a primary and as a secondary procedure;
2. To describe morphological differences as delineated by cephalometric roentgenography;
3. To discuss the differences in treatment from the surgical aspect.

Patients with posterior cleft palate were specifically selected for study because previous research has shown: (a) patients with repaired posterior cleft palate have speech articulation which is inferior to that of other speakers with more extensive clefts involving the lip and palate (*8*); and (b) pharyngeal flap surgery is required more frequently for patients with repaired posterior cleft palate (*1*). In combination, these findings confirm the clinical impression that many patients with posterior cleft palate do not attain acceptable speech after the initial palate repair.

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Procedure

SUBJECTS. The total sample of 20 patients with posterior cleft palate was subdivided. Group A, the primary procedure group, consisted of ten patients who had had no previous surgery for palate closure. Five patients in the group had velar clefts and five had posterior clefts involving the hard palate. Six of these ten patients wore prosthetic speech aids. For purposes of this study, all data were secured without obturation.

Group B, the secondary procedure group, consisted of ten patients who had had at least one procedure for palate closure. Measures of palatopharyngeal openings secured from tracings of cephalometric films taken during /s/ production ranged from 2 mm to 10 mm.

Sample characteristics are reported in Table 1. In overview, the groups were differentiated by operative status, with age averaging 15 years in both groups.

Measures of cephalometric films, speech, intraoral air pressure and nasal airflow were secured slightly before and eight months after surgery to evaluate the efficacy of valving in the palatopharyngeal region and to permit intergroup comparisons for both pre and post-operative conditions. Speech materials included the Templin Darley Articulation Test, intelligibility word lists (7) and a continuous speech sample to provide material for judgement ratings of nasality and nasal emission. The latter ratings were made by two speech pathologists with extensive experience in the cleft palate area.

TABLE 1. Sample characteristics and cephalometric measures for Group A (primary procedure) and Group B (secondary procedure).

group A primary procedure					*group B secondary procedure*				
subj.	*sex*	*age (yrs/mos)*	*palatophar. opening**	*pharyngeal depth (mm) (PTM-phar.)*	*subj.*	*sex*	*age (yrs/mos)*	*palatophar. opening*	*pharyngeal depth (mm) (PTM-phar.)*
1	F	13/2	(6)	13.0	11	F	7/1	2.5 mm	17.0
2	M	43/6	(3)	24.0	12	M	6/7	10.0 mm	23.0
3	F	8/10	(1)	21.0	13	F	6/4	9.0 mm	19.0
4	M	12/8	(4)	15.0	14	M	13/4	10.0 mm	20.0
5	F	12/6	(2)	22.0	15	M	7/1	7.0 mm	21.5
6	M	13/10	(6)	30.0	16	F	6/1	11.0 mm	20.5
7	F	12/11	(3)	26.5	17	M	14/0	2.0 mm	27.0
8	F	12/1	(6)	19.5	18	F	32/2	8.0 mm	23.0
9	F	15/6	(5)	24.5	19	F	26/1	10.5 mm	25.0
10	M	10/7	(5)	26.5	20	F	33/0	7.0 mm	26.0
mean.........		15/6.7	mean......	22.2	mean..........		15/2.1	mean......	22.2
range.........		8/10 to 43/6	SD.........	5.3	range..........		6/1 to 33/0	SD........	3.2

* When velar structures were united, palatopharyngeal opening was measured in mm from tracings of films taken during sustained /s/. When the palate was unrepaired, the antero-posterior extent of cleft was specified by oropharyngeal examination as follows: (1) Bifid uvula; (2) Posterior third of velum; (3) Posterior two thirds of velum; (4) Complete cleft of velum, not involving posterior border of hard palate; (5) Posterior third of hard palate; (6) Posterior two thirds of hard palate.

Recordings of intraoral air pressure and oral-nasal airflow were made during articulation of /p/ and /s/ produced within the context of the vowel /i/. Instrumentation and procedures utilized in data collection and analysis have been described previously (*10*).

Results

PRE-OPERATIVE COMPARISONS. Statistical analysis of preoperative speech measures revealed the two groups did not differ significantly. Articulation error averaged about 24% in both groups; word intelligibility averaged 57% and 60% for Group A and B respectively (Table 2). Averaged ratings of nasality showed both groups were hypernasal with promi-

TABLE 2. Comparisons between Group A and Group B *before* pharyngeal flap surgery.

measurement	*group A primary procedure (N = 10)*	*group B secondary procedure (n = 10)*	*d.f.*	*t*
word intelligibility				
mean	56.70%	59.90%	19.30	−.31
sd	25.36	21.11		
articulation error				
mean	24.90%	23.90%	17.35	.14
sd	19.26	13.06		
nasality rating				
mean	6.20	5.90	19.02	.81
sd	.92	.74		
Nasal emission				
mean	3.90	3.70	19.94	.40
sd	1.10	1.16		
intraoral pressure				
implosion /p/				
mean	4.40 cmH_2O	2.60 cmH_2O	11.55	1.31
sd	4.12	1.41		
articulation /s/				
mean	3.15 cmH_2O	2.20 cmH_2O	17.56	.80
sd	3.09	2.14		
nasal airflow ratio* nasal/total				
implosion /p/				
mean	.35	.44	17.99	−.89
sd	.23	.19		
articulation /s/				
mean	.47	.49	16.82	−.20
sd	.21	.22		

* Group B n = 8.
Nasality was rated on a hypo-to-hypernasal, seven point scale, with a rating of *three* designating normal voice quality. Nasal emission was rated separately on a one to five point scale.

nent nasal emission before surgery. Speakers in the open cleft group, however, tended to be slightly more nasal. Measures of intraoral air pressure and nasal airflow failed to reveal significant differences. In sum, patients with repaired but inadequate palates were no better in speech than patients with unoperated or open posterior clefts of the palate.

Post-Operative Comparisons. After pharyngeal flap surgery both groups showed marked improvement. Statistical comparisons between groups again revealed no differences in speech or speech related parameters (Table 3).

After flap surgery, the open cleft or primary procedure group included: eight patients with normal voice quality, one with slight nasality and one with denasality. In the repaired or secondary procedure group, six patients had normal quality, three slight nasality and one denasality. On the basis of individual ratings slightly better voice quality was attained when the flap was used as a primary procedure. The difference, however, was not statistically significant.

TABLE 3. Comparisons between Group A and Group B *after* pharyngeal flap surgery.

measurement	*group A primary procedure (n = 10)*	*group B secondary procedure (n = 10)*	*d.f.*	*t*
word intelligibility				
mean	73.10%	75.90%	18.56	.41
sd	17.07	13.02		
Articulation Error				
mean	7.40%	10.30%	15.48	.92
sd	4.97	8.71		
Nasality Rating				
mean	2.80	3.40	17.98	−.98
sd	1.14	1.58		
Nasal Emission				
mean	1.20	1.50	16.90	.82
sd	.63	.97		
Intraoral Pressure				
Implosion /p/				
mean	7.35 cmH_2O	7.20 cmH_2O	12.84	.11
sd	1.68	3.97		
Articulation /s/				
mean	6.70 cmH_2O	5.70 cmH_2O	15.86	.76
sd	2.12	3.59		
Nasal Airflow Ratio Nasal/Total				
Implosion /p/				
mean	.02	.15	10.04	2.00
sd	.04	.20		
Articulation /s/				
mean	.04	.07	19.86	.97
sd	.08	.08		

Post-operative articulation error averaged 7% and 10% for Groups A and B respectively. Word intelligibility averaged 73% and 76%. In both groups, intraoral air pressure and nasal airflow during consonant articulation were significantly improved aftery pharyngeal flap, with no difference between groups indicated.

The cephalometric analysis (Figure 1, Table 4) was included to determine whether morphological differences between groups could be identified. Pre-operative measures of velar length revealed the cleft vela were significantly longer (.01 level) than the repaired palates. Respective measures of pharyngeal depth and velar position, however, failed to indicate differences between the groups.

Comparisons of post-operative measures revealed only one difference of statistical significance. Speakers in the primary procedure groups consistently showed broader, more extensive pharyngeal base attachments. Other tendencies in the primary procedure group included: (1) higher angular positions of the flap at rest and during function; (2) pharyngeal base attachments located in a closer relationship to the palatal plane; (3) slightly greater mobility in the flap; and (4) smaller nasopharyngeal areas at rest and during function. In sum, cephalometric analyses revealed very few differences of statistical significance. None were noted relative to speech function.

Surgical Treatment. The common factor in the operation under anal-

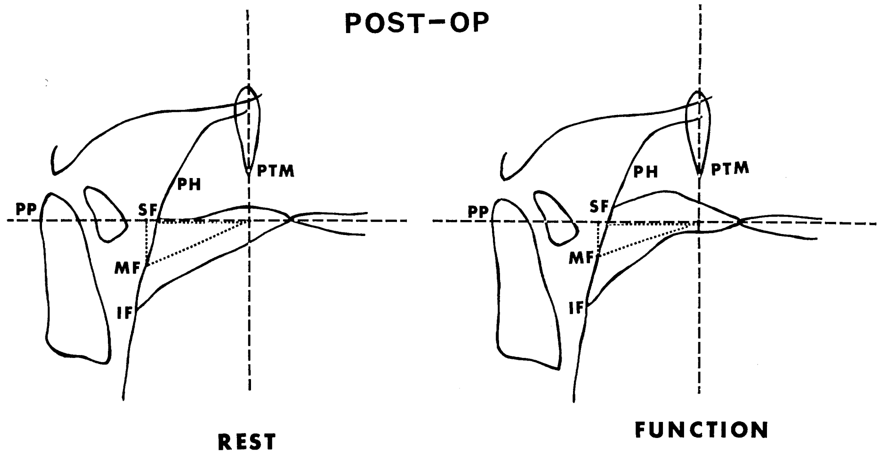

FIGURE 1. Post-operative measurements included: pharyngeal base-superior to inferior point of attachment (SF-IF); base position-midpoint of attachment to palatal plane (MF-PP); angular position of flap—Angle MF-PTM intersect-PP at rest and function. Nasopharyngeal area was defined planimetrically using the pterygomaxillary fissure, the superior posterior contour of the nasopharyngeal space, and the superior surface of the pharyngeal flap at rest and during function. Percent reduction in nasopharyngeal area during function was mathematically derived—

$$\frac{\text{Area at rest} - \text{area in function}}{\text{Area at rest}}.$$

TABLE 4. Comparative cephalometric analysis of Group A and Group B.

measurement	*group A primary procedure*	*group B secondary procedure*	*d.f.*	*t*
pre-operative				
effective velar length (PTM-PP intersect to uvula)				
mean	25.40 mm	19.10 mm	19.71	3.89*
sd	3.41	3.83		
velar position (uvula-PTM intersect-PP)				
rest				
mean	133.70°	125.55°	19.99	1.88
sd	9.81	9.63		
Post-Operative				
flap position (<-midpt. attachment-PTM intersect-PP)				
rest				
mean	150.70°	146.95°	18.51	.85
sd	8.45	11.14		
/u/				
mean	157.70°	149.25°	19.81	1.88
sd	9.55	10.50		
/s/				
mean	161.70°	152.30°	18.89	2.08
sd	8.88	11.23		
site of pharyngeal base attachment (midpt.-PP)				
rest				
mean	13.85 mm	16.50 mm	18.06	.90
sd	5.45	7.52		
/u/				
mean	10.80 mm	14.50 mm	19.51	1.28
sd	5.98	6.96		
/s/				
mean	7.85 mm	12.60 mm	17.79	1.83
sd	4.74	6.71		
vertical extent of flap attachment (superior-infer. pt.)				
rest				
mean	23.80 mm	17.00 mm	19.05	3.87*
sd	3.62	4.22		
/u/				
mean	26.60 mm	20.80 mm	16.01	2.62†
sd	3.60	6.00		
/s/				
mean	27.75 mm	21.15 mm	17.01	3.77*
sd	3.04	4.63		
flap mobility‡				
rest → /u/				
mean	17.90°	13.70°	19.58	.92
sd	9.47	10.89		

TABLE 4. *Continued.*

measurement	*group A primary procedure*	*group B secondary procedure*	*d.f.*	*t*
rest → /s/				
mean	21.50°	16.44°	17.19	.89
sd	10.99	13.60		
nasopharyngeal area				
rest				
mean	386.00 mm²	429.00 mm²	19.72	.61
sd	167.01	148.96		
/u/				
mean	301.00 mm²	362.00 mm²	19.94	.91
sd	153.58	145.74		
/s/				
mean	265.00 mm²	315.00 mm²	18.87	.90
sd	109.47	138.74		
nasopharyngeal area reduction in %				
rest → /u/				
mean	20.16%	16.39%	16.34	.49
sd	20.58	12.72		
rest → /s/				
mean	29.22%	27.13%	17.67	.34
sd	11.10	15.89		

* Significant at .01 level.
† Significant at .05 level.
‡ Before surgery, the midpoint of the soft palate at rest was identified by bisecting a line constructed from the posterior border of the palate to the uvula. By superimposition of pre- and post-operative tracings, this midpoint in the most mobile part of the soft palate could be located to construct a line to the posterior border of the hard palate thus providing for angular measures of flap positioning at rest and function. Degree of flap movement was determined by subtracting position at rest from the position assumed during production of /u/ and /s/.

ysis is the attachment of a flap of tissue from the posterior pharyngeal wall to the soft palate. Several methods of joining a flap of muscle and mucosal tissue, based either inferiorly or superiorly, to the palate are available. In this study, a wide superior based flap of mucosa and muscle tissue was inserted and sutured between two leaves of the split palate. The same technique was used in both primary and secondary procedures. In the opinion of the surgeon, this "sandwich technique" has been perfectly suitable even in the transparent tissue associated with the submucous cleft palate deformity. Only rarely has it been necessary to unite the velar musculature in the midline.

In planning pharyngeal flap surgery, certain morphological and anatomical conditions must be evaluated. In this regard, previous cephalometric analyses can be of inestimable value assisting in the assessment of: the width and depth of the pharynx, cranial base angle, size and location of adenoidal masses, velar length, thickness and mobility, velopharyngeal relationships, nasopharyngeal configuration and size. Other factors, which are important in outlining the proper operative technique, include: action of the lateral and posterior pharyngeal musculature, vascularity of velum, scarring in the velar and hard palate areas, configuration and height of the vault, size and location of tonsillar masses and/or fistulae.

From the surgical viewpoint, the advantages of the superior flap seem to be as follows:

1. Ease of exposure of the entire pharynx (using the Dingman Mouth Gag). A longer flap of tissue can be fashioned, based above, since more available pharyngeal tissue is present.

2. Good firm muscle, fascial and mucosal tissue for suture and attachment to the palate are encountered as contrasted to "mushy" adenoid tissue found at the distal end of an inferior based flap.

3. Normal and compensatory velopharyngeal action is always in a superior direction. This action is generally not restricted by the superior based flap. (Careful closure of the donor site inferior to the attached flap eliminates the tendency toward downward contracture or pull on the flap and velum.)

4. The superior oropharynx narrows cephalad therefore a wide superior based pharyngeal flap along with the compensatory medial action of the lateral pharyngeal walls contributes to maximum efficiency in velopharyngeal valving.

5. No disadvantages have been encountered in burying the pharyngeal mucosa. In fact, removal of this mucosa would only leave attenuated muscle fibers which would not hold a suture satisfactorily.

6. Review by oral inspection, and particularly by cephalometric analysis, further substantiates recommendation for the superior based flap. Experience indicates that scar forming in the area of the donor site closure does not displace the soft palate downward and backward, restricting its movements. For this reason, there appears to be little advantage gained by lining the remainder of the exposed flap or by adding other lateral flaps.

As a Primary Procedure. In this series, when an isolated cleft palate or indeed a complete cleft of the soft and hard palate is surgically closed and a primary pharyngeal flap interposed, a typical Wardill V-Y push-back procedure is generally carried out. This gives ideal relaxation of the tissues and ease of closure of the entire cleft. The temporary retropositioning of the palatal tissue assists in approximation of the pharyngeal flap without tension. The nasal musculature of the split palate is closed first, the pharyngeal flap interposed between the split leaves of the soft palate and held there by 4 to 5 interrupted mattress sutures of 5-0 nylon. Finally the oral mucosal side of the cleft of the palate is closed to complete the primary pharyngeal flap and closure of the cleft of the palate.

Only rarely has it been necessary to "take down" a submucous cleft in the midline and carry out a palatal repair along with the primary pharyngeal flap. One of the advantages of the split palate technique is that it does allow and maintain excellent adherence of the pharyngeal flap tissue to the soft palate and lessen the tendency toward narrowing of the flap.

In older children and adults with open clefts, who have worn prostheses for periods of time, hypertrophy, considerable erythema and increased vascularity of the tissues bordering the prosthesis have been noted. Increased bleeding during operation in spite of infiltration of epinephrine has been encountered in many such prosthetic cases. When this is to be anticipated, removal of the prosthesis two months before operation has been advocated in an attempt to decrease vascularity and the tendency toward excessive operative bleeding.

As a Secondary Procedure. The interposition of excessive scar tissue in the previously operated cleft palate usually brings about lack of mobility and shortness of the soft palate. Other palates closed under considerable tension will generally demonstrate insufficiency in length but, more importantly, thinning out and alternated soft palatal tissues. Despite these statements, the technique, as described, is successful primarily because an unusually long pharyngeal flap can be fashioned, based superiorly, with the "sandwich technique" allowing for a broad attachment to the nasal and oral surfaces of the palate.

Discussion

As previously described, patients who had pharyngeal flap combined with palatoplasty as a primary procedure displayed a tendency toward higher angular positions of the flap at rest and during function, and pharyngeal base attachments located in a closer relationship to the palatal plane. This tendency may be partially explained as follows: The amount of scar tissue contracture following flap operations in the virgin palate tissue is considerably less than that seen in the palate that has been previously surgically repaired. This allows for less contracture toward the midline and greater flexibility of the velum and the flap, following the attachment of the superior based pharyngeal flap.

Although this study is limited to the analysis of 20 patients, in all areas of measurement the results of pharyngeal flap surgery as a primary procedure could not be differentiated from the results obtained when the flap was employed as a secondary procedure. Tentatively, these results indicate that pharyngeal flap as described is equally effective when employed as a primary procedure for correction of posterior cleft palate *within the age group studied.* It appears therefore that pharyngeal flap may well be incorporated in closure of posterior cleft palate for preadolescent and older patients if the adequacy of tissue for simple functional closure is questionable. The question of determining relative adequacy for functional closure is indeed complex involving: peculiarities in the attachment of the soft palate muscles (*5*), marked variation in cleft morphology and in palatopharyngeal relationships. Critical assessment of the form and function of the palate and pharynx is needed before surgery, as recently discussed by Crikelair, Striker and Cosman (*3*).

In the past, cleft palate rehabilitation frequently involved prosthetic fitting. In some instances, speech aids were constructed for wide clefts which were considered inoperable. Most commonly, however, prosthetic treatment was undertaken because previous surgery had failed to meet speech needs.

Within the last decade the clinical situation has changed. Fewer patients are receiving prosthetic treatment. Operative techniques have improved and as a result: a) the incidence of speech success after primary palate closure is much higher than it was formerly; b) wide palatal clefts are rarely considered inoperable; and c) secondary procedures for correction of residual palatopharyngeal defects are more successful than formerly. Because of the latter factors, cleft palate patients now wearing prosthesis are sometimes considered candidates for palatal closure and primary pharyngeal flap surgery. Pertinent questions are introduced by this group of patients. "Should pharyngeal flap surgery be performed to correct palatopharyngeal incompetence in patients who have attained acceptable speech with prosthesis?" "Will surgical repair prove to be advantageous from the viewpoint of speech performance?"

Since additional data were available to seek partial answers to the questions posed, a comparative analysis of speech was undertaken for ten subjects who were wearing prosthesis before pharyngeal flap surgery. Comparison of articulation scores obtained with prosthesis and after surgery showed the percentage of error was: (a) about the same (±3%) in eight subjects; (b) much better (25%) in one subject; and (c) slightly worse (6.6%) in one subject. Word intelligibility was: (a) about the same in four subjects; (b) better (8% to 10%) after surgery in three subjects; and (c) worse (8% to 15%) after surgery in three subjects. Reduction in intelligibility after surgery in two speakers (10% and 15%) is explained by denasality or by surgical over-correction.

Comparative analysis of articulation and intelligibility measures (Figure 2) for the prosthetic and post-operative conditions revealed no differences of statistical significance. The t-values established for measures of intraoral air pressure and nasal airflow ratios also failed to indicate significant differences.

With prosthesis, six speakers had normal voice quality, one had denasality and three slight nasality. After surgery, the distribution of nasality ratings remained approximately the same with a shift toward denasality noted. Six speakers had normal quality, two had denasality and two slight nasality. These figures indicate that under-correction resulting in nasality and over-correction resulting in densality occurred as a result of both prosthetic and surgical treatment. Denasality, however, tended to be more common in the post-operative condition at least as appraised eight

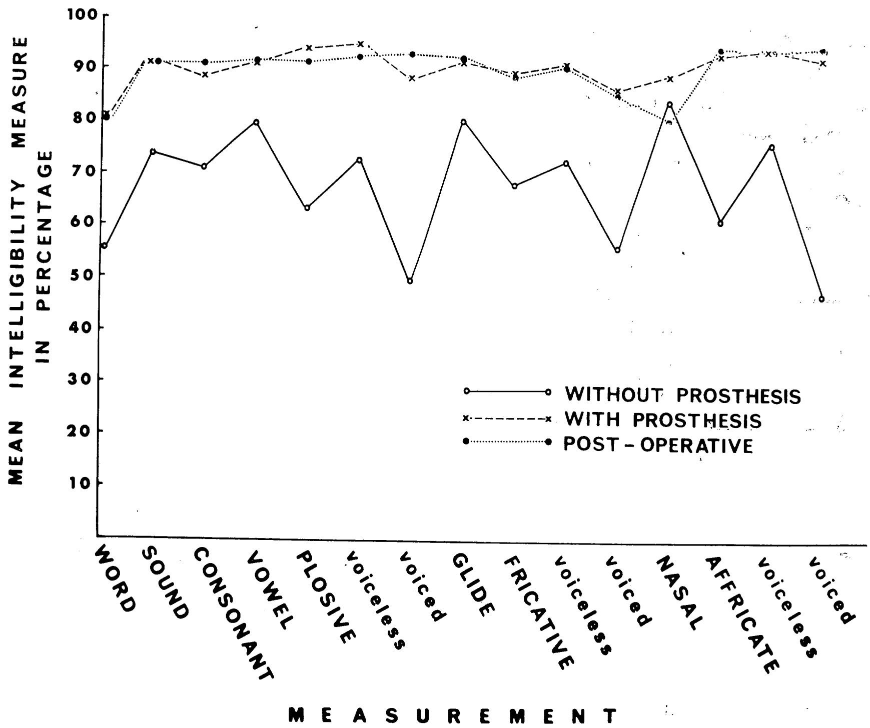

FIGURE 2. Means for intelligibility measures graphed for preoperative status (with and without prosthesis) and after pharyngeal flap surgery. Measures secured with prosthesis and after pharyngeal flap did not differ significantly; however, after surgery, averaged scores for nasal consonant intelligibility were lower (worse) and voiced plosive intelligibility higher (better) than respective measures secured with prosthesis. This is explained by post-operative denasality in two speakers.

months after surgery. This latter observation should be tempered by the fact that continued study over a five year post-operative period has revealed the incidence of denasality decreases as a function of time.

Individual comparisons between ratings with prosthesis and after surgery revealed: (a) seven subjects had exactly the same ratings; (b) one shifted from marked denasality to slight denasality; (c) one from moderate nasality to denasality; and (d) one from slight to moderate nasality. In overview, (a) seven subjects had exactly the same rating; (b) two improved, reducing denasality or nasality; and (c) one became worse with increased nasality. These results compare favorably with those reported by Engstron, Fritzell and Johansen, "... two-thirds of the patients who use obturators maintained or improved their speech proficiency when the prosthetic appliance was replaced with natural tissue" (*4*, p. 430).

Disturbance in the control of nasal resonance has been shown to cause perceptual confusion between nasal consonants and homophonous voiced plosives, i.e., dine-nine; ban-man; etc. This fact is well illustrated by individual intelligibility scores for two subjects speaking with both hypernasality and denasality (Figure 3). To generalize, with hypernasality nasal consonant proficiency is comparatively good and voiced plosive proficiency is poor. With denasality, nasal consonant proficiency is poor and voiced plosive proficiency is good. Although phonetic features of intelligibility loss appear reversed in speech with too much as opposed to not enough nasal resonance, the essential fact repeatedly stressed in speech literature is that speakers must possess the ability to modify resonance in accordance with phonetic demands.

Since most consonants are produced without nasal resonance, with palatopharyngeal closure, or near closure, denasality theoretically would have less effect upon total intelligibility than hypernasality. Present findings support this concept. Word intelligibility was better with denasality (76% and 80%) than with hypernasality (46% and 55%). Although hypernasality had a more detrimental effect upon total intelligibility, present findings show both distortions in resonance have an adverse and measurable effect upon intelligibility.

In sum, it is concluded that speech after pharyngeal flap surgery will be about the same as it was with prosthesis. As a generalization, competent pharyngeal flap surgery did not reduce communication efficiency. A critical analysis of the individual patient and his speech characteristics is mandatory before arriving at a clinical decision. However, little evidence has emerged from this study which is limited to only ten patients to contraindicate pharyngeal flap surgery for patients who have attained acceptable speech with prosthesis.

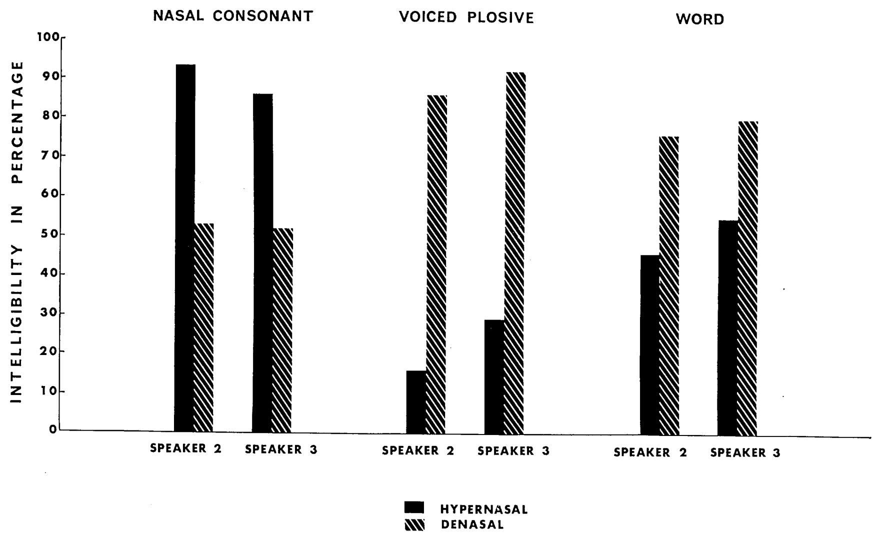

FIGURE 3. Histogram of data for two subjects showing selective effect of hypernasality and denasality upon nasal consonant, voiced plosive and word intelligibility. With hypernasality, both speakers had good nasal consonant intelligibility and poor plosive intelligibility. With denasality, the reverse is indicated. Word intelligibility measures showed poorer scores resulted from hyper rather than hyponasality.

Summary

Post-operative results of pharyngeal flap surgery employed as a primary and as a secondary procedure for twenty posterior cleft palate patients are reported. Statistical comparisons of speech, intra-oral air pressure, nasal airflow and cephalometric measures showed the results of flap surgery as primary and secondary procedures could not be differentiated. The findings suggest pharyngeal flaps, as described, may be indicated in preadolescent and older patients with unoperated posterior clefts when adequacy of velar tissue for functional closure is questionable.

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