A Clarification of the Surgical Goals in Cleft Palate Speech and The Introduction of the Lateral Port Control (L.P.C.) Pharyngeal Flap*

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Introduction

The pharyngeal flap operation popularized by Rosenthal in 1924 (*1*), following Schoenborn's first operation in 1876 (*2*) on a 17-year-old female patient, has been widely used as a technique for elimination of velopharyngeal incompetence. The technique of Rosenthal consisted of an inferiorly based pharyngeal flap; Sanvenero-Rosselli (*3*) advocated a superiorly based pharyngeal flap. Many variations of the pharyngeal flap operation have been evolved. We wish to describe observations made during the treatment of 93 patients in order to clarify the goal of surgery in the treatment of cleft palate speech and describe an operative procedure which has yielded unexpectedly good results.

Normal Speech and the Velopharyngeal Sphincter. Normal speech may be broadly defined as speech which is free from any feature which calls attention to itself.‡ If the manner of speaking is attention arresting, a speech defect exists which must be diagnosed.

In the "normal" individual, the velopharyngeal sphincter, an anatomical and functional entity, separates the oropharynx from the nasopharynx, and during continuous speech *closes completely*, effectively sealing off the nasopharynx from the oropharynx so that certain sounds such as "e" or "s" may be articulated normally.§

The sphincter is formed largely by the levator veli palatini muscle and

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‡ Exclusive of dialect and foreign accent influences.

§ There are only three sounds in English which require the sphincter to be open—"m", "n", and "ng".

the superior constrictor muscle of the pharynx. Closure may result from a balanced constriction of these muscles, bringing the posterior pharyngeal wall, the two lateral walls, and the velum together or closure may result from the predominant movement of one muscle or muscle group. For example, posterior upward movement of the velum frequently predominates and closure occurs along the posterior pharyngeal wall with minimal lateral wall participation. In other patients, velar movement may be negligible and closure is effected primarily by the mesial movement of the lateral pharyngeal walls. The presence of contiguous masses such as adenoid tissue, may help to obliterate the opening as also may the presence of a Passavant's ridge or an abnormally forward sloping nasopharyngeal wall. Combinations of these various elements may also occur and produce a "normal" sphincteric effect during speech.

Regardless of the precise mechanism of velopharyngeal closure, the results is always the same in the normal, i.e. the opening or port is virtually obliterated whenever certain sounds are produced during continuous speech. If, on the other hand, the sphincter cannot close adequately or at the proper time, utilizing any or all of the various elements described above, it is no longer competent to perform its role in speech production. Velopharyngeal incompetency or inadequacy is the primary cause of cleft palate speech.

When is a Velopharyngeal Sphincter Incompetent or Inadequate? A velopharyngeal sphincter becomes incompentent or inadequate when after maximum contraction during connected speech, the residual nasopharyngeal orifice or port remains too large for normal speech production. Determining how large the port must be for incompetency to occur has been the object of much investigation. Warren (*4, 5, 6*) analyzing aerodynamic pressure flow patterns of consonant production in normal speech concluded that oropharyngeal air pressure began to diminish rapidly when the velopharyngeal port area exceeded 10 mm^2 and that nasal escape of air was clearly evident at 20 mm^2. Ishiki, Honjow and Morimoto (*7*) utilizing acoustical as well as aerodynamic techniques found a port size of 5 mm in diameter (19.6 mm^2 in area) to be the approximate threshold for the occurrence of hypernasality. Bjork (*8*) utilizing basal radiographic techniques estimated incompetency to occur with a port size approximating 20 mm^2 in area. Thus if the velopharyngeal port is greater than 20 mm^2 in area during connected speech, hypernasality and nasal escape will tend to be present. The 20 mm^2 area thus appears to represent the threshold of velopharyngeal incompetence.

The Effect of Velopharyngeal Incompetency on Speech. When the velopharyngeal sphincter is incompetent, several important events occur in the production of connected or continuous speech which alter the patient's ability to communicate normally. Air, which during most consonant production is normally expelled exclusively through the mouth, passes through the incompetent sphincter and escapes through the nose. Not only does the listener often perceive the abnormal sound of the nasality escaping turbulent air (nasal escape), but there is consequently less air pressure available in the oral cavity to make effective consonant sounds such as "p", "t", or "k". These sounds often become weak or absent.

In addition, an abnormal acoustical phenomenon takes place between the oral and nasal cavity because of the presence of an oversized velopharyngeal port. "Acoustic coupling" occurs between the oro- and nasopharynx, resonances change and the quality of the voice becomes altered. The alteration of the voice quality which occurs because of velopharyngeal incompetency is called, hypernasality.

The *direct* result of velopharyngeal incompetence in speech is to produce hypernasality and nasal escape. The patient knows his speech to be abnormal, and attempts to correct these abnormalities by adopting a variety of *indirect* compensating speech behavior patterns such as poor tongue positioning, pharyngeal fricatives, glottal stops, and nasal grimacing. These indirect or secondary adjustments are maladjustments in that they result in less intelligibility and contribute significantly to the clinical condition we call *cleft palate speech.*

THE GOAL OF SURGERY IN THE TREATMENT OF CLEFT PALATE SPEECH. The goal of surgery in the treatment of cleft palate speech is to restore velopharyngeal sphincter competency. On the basis of the research establishing the port size for velopharyngeal incompetence (*4, 5, 6, 7, 8*), the premise was made that competence would be established when the velopharyngeal port during connected speech fell below 20 mm^2 in area, thus eliminating hypernasality and nasal escape. Any operative procedure or combination of procedures which produces a *competent* sphincter will eliminate the *direct* (i.e. hypernasality and nasal escape) defect in cleft palate speech and will represent the end-point of surgical intervention. Once velopharyngeal competency is restored, does the patient speak normally? Of course not. He is still left with *indirect* or secondary speech maladjustments—pharyngeal fricatives, glottal stops, poor tongue positioning, etc. as mentioned above, which must be eliminated in order for him to achieve normal speech. Thus the goal of surgery is to eliminate the primary or direct defects of cleft palate speech, and thereby to create a functional situation which permits the patient and/or the therapist to eliminate the secondary or indirect defects.

ESTABLISHING THE SUCCESS OF THE SURGERY. Objective techniques of high reliability are available for establishing whether hypernasality and nasal escape have been eliminated by the surgical procedure.

The aerodynamic techniques of Warren can be utilized to determine postoperative port size. An acoustic analysis of normal and hypernasal vowel production can determine the presence or absence of postoperative hypernasal resonance patterns (*9*). Evaluation of pre- and postoperative tapes, utilizing the backward playing of the tapes as suggested by Sherman (*10*) together with scaling procedures can be employed to evaluate

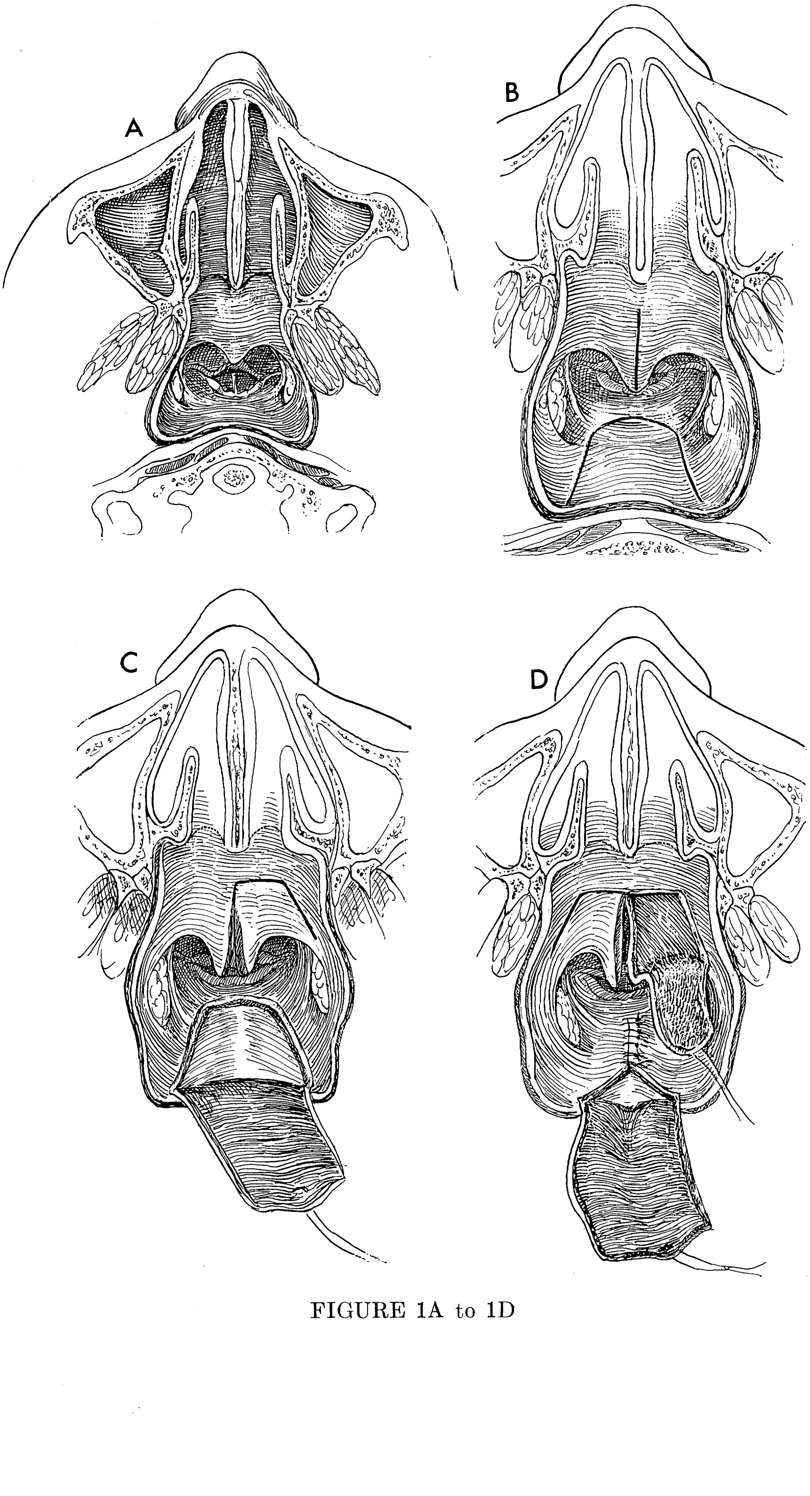

FIGURE 1A to 1D

hypernasality. More elaborate measuring techniques, such as basal cine-radiography are also useful confirmatory adjuncts.

Speech tests which are fairly accurate for measuring the composite abnormality of cleft palate speech are often too broadly constructed to evaluate surgical results, particularly when they include consonant evaluation. They often include measurements of improvement in secondary or *indirect* defects of cleft palate speech which are not the objective of the surgical procedure. Thus, routine *articulation tests and tests of intelligibility* should be viewed cautiously, if not sceptically by the surgeon if used as the sole technique for evaluating the success of an operative procedure.

Selection of an Operative Procedure to Restore Velopharyngeal Competency. In 1965 the surgical treatment for velopharyngeal incompetence at the Institute of Reconstructive Plastic Surgery was the superiorly based lined pharyngeal flap, an evolved model of the original pharyngeal flap of Schoenborn (*2*). In an unpublished study of 20 patients utilizing this operation and evaluating results by objective evaluation of pre- and postoperative speech recordings, we noted that 60% of our patients have had an excellent result, 20% a modest improvement, and 20% to have had no improvement at all. Owsley (*11*) utilizing a superiorly based lined pharyngeal flap reported complete elimination of hypernasality in 48% of his patients with an additional 38% exhibiting minimal residual hypernasality. The success rate was established by subjective judgments of the speech results by three speech pathologists who rated the patients from "tape recorded samples of speech including isolated words and connected conversational speech. A comparison of tape recordings made before and after operation was used to evaluate the result of surgery."

Figure 1(A–I) illustrates the main technical details of the superiorly based lined pharyngeal flap. This procedure was often combined with the Veau-Wardill-Kilner push-back procedure for lengthening the palate. The objective was to crowd as much anatomical material as one could into the

FIGURE 1A represents a cross-section of the skull just above the level of the soft palate and the velopharyngeal isthmus. We are looking from the top of the skull downward toward the floor of the nose and nasopharynx.

FIGURE 1B illustrates schematically the placement of incisions for the standard superiorly based lined pharyngeal flap. A midline incision is placed in the soft palate extending downward toward the hard palate stopping at a distance of three-quarters of a centimeter from the hard palate. The pharyngeal flap is constructed on the posterior pharyngeal wall and based superiorly. It encompasses the entire width of the posterior pharyngeal wall and extends downward into the oropharynx.

FIGURE 1C is a schematic representation showing the midline incision through the soft palate and a beginning incision of the lining flap. This lining flap is constructed from the nasal surface of the soft palate. The pharyngeal flap is shown elevated from its oropharyngeal bed. It is full-thickness including the muscle of the constrictor area and the prevertebral fascia is shown.

FIGURE 1D shows the reflection of one-half of the developed lining flap and also the closure of the oropharyngeal wall. As the wall is pulled together, notice how the pharyngeal flap is slightly narrowed at its base.

region of the velopharyngeal port and to hope that when the swelling disappeared and muscular activity returned, competency would be restored. Figure 1A represents a cross section of the skull. We are looking from the top of the skull downward toward the floor of the nose and the nasopharyngeal port. Figure 1B schematically illustrates the placement of in-

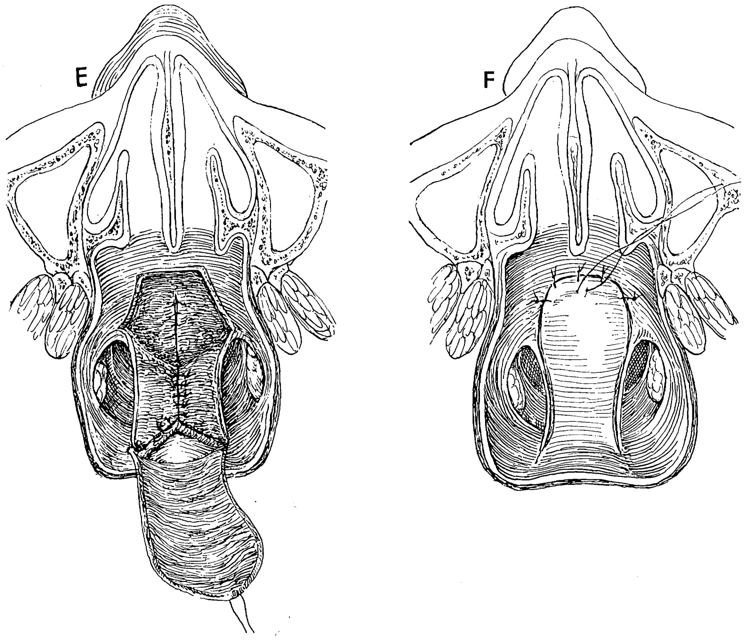

FIGURE 1E shows the midline suturing of the lining flaps. In the actual operation, this procedure is carried out last because the operation proceeds from the oral side of the soft palate but for schematic representation we have illustrated it at this point.

FIGURE 1F shows the superiorly based flap brought over and sutured into the nasal surface of the soft palate. This completes the standard superiorly based lined pharyngeal flap procedure as commonly practiced in this clinic and other clinics.

FIGURE 1G illustrates the movement of the lateral pharyngeal walls medially to approximate the lateral margins of the pharyngeal flap during speech, obliterating the lateral ports in this example.

FIGURE 1H illustrates a pharyngeal flap which may have been constructed on too narrow a base, or was unlined and shrunk postoperatively, and illustrates the resultant wide lateral ports. This is the type of patient who may have spoken well originally due to the swelling of the operative technique and later on velopharyngeal incompetence returned because of the shrinkage of the pharyngeal flap.

FIGURE 1I illustrates the ineffectiveness of the mesial movement of the lateral pharyngeal walls in approximating the lateral margins of the pharyngeal flap when such a flap has shrunk or when such mesial movement is minimal or absent.

FIGURE 1J illustrates the lateral port control operation where the lateral margins of the pharyngeal flap are sutured to the superior portion of the soft palate, laterally to the lateral pharyngeal wall almost completely to the base of the pharyngeal flap. Port size is controlled by a measured catheter with an external diameter of 4 mm and thus positive control is exerted over the size of the port for the first time. This has enabled us to achieve virtually complete success in eliminating hypernasality and nasal escape in the cleft palate patients.

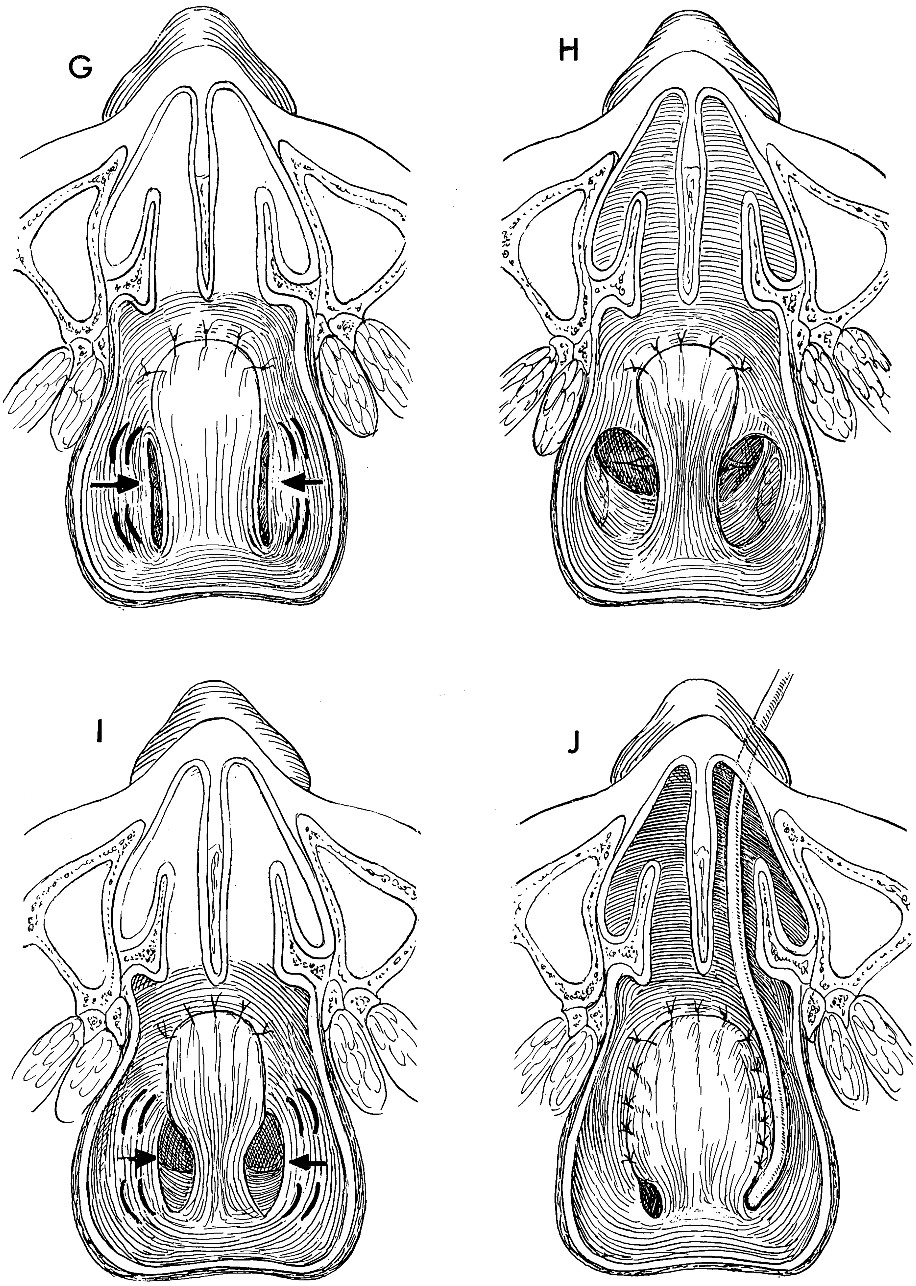

FIGURE 1G to 1J

cisions for the standard superiorly based lined pharyngeal flap. A midline incision is made in the soft palate to a point situated ¾ cm. from the junction of the hard and soft palate. The pharyngeal flap is designed on the posterior pharyngeal wall, based superiorly. It encompasses the entire width of the posterior pharyngeal wall and extends downward into the oro-pharynx. Figure 1C represents the completion of the midline incision through the soft palate, and an outline of the lining flap to be constructed on the nasal surface of the soft palate. The pharyngeal flap is shown elevated from its pharyngeal bed. The flap is full thickness including the muscle of the constrictor area and pharyngeal mucosa, and the prevertebral fascia is shown as the bed of the donor area. Figure 1D shows the reflection of ½ of the developed lining flap and also closure of the defect in the oro-pharyngeal wall. As edges of the defect are approximated and sutured it will be noted the pharyngeal flap is slightly narrowed at its base. Figure 1E illustrates the completed midline approximation of the lining flaps. In the actual operative procedure this step is carried out last because the operation proceeds from the oral side of the soft palate. However, for schematic representation we have illustrated this step at this point. Figure 1F shows the superiorly based flap sutured into the nasal surface of the soft palate. This completes the standard suepriorly based pharyngeal flap procedure. Figure 1G illustrates the mesial movement of the lateral pharyngeal walls as they approximate the lateral margins of the pharyngeal flap during speech, obliterating the lateral ports. The causes of failure in the superiorly based lined pharyngeal flap procedure are illustrated in Figures 1H through 1I. Figure 1H illustrates a pharyngeal flap which may have been constructed on a too narrow base or perhaps was not lined, and subsequently shrunk post-operatively resulting in wide lateral ports. This is the type of patient who may have spoken well immediately following surgery due to postoperative edema; later, however, velopharyngeal incompetence recurred because of the shrinkage of the pharyngeal flap. Figure 1I illustrates the situation when there is ineffective mesial movement of the lateral pharyngeal wall resulting in lack of approximation with the margins of the pharyngeal flap. This can occur when a flap has shrunk or when mesial movement of the pharyngeal walls is minimal or absent. It is thus quite important to evaluate mesial movement of the lateral walls prior to surgery. Figure 1J illustrates our new lateral port control operation in which the lateral margins of the pharyngeal flap are sutured to the nasal surface of the soft palate and to the lateral pharyngeal wall. Positive control is exerted over the size of the lateral port by means of a catheter (usually a ※14 French catheter) of a measured external diameter (usually 4 mm in diameter). This technique has enabled us to achieve virtually compete success in eliminating hypernasality and nasal escape in cleft palate patients.

Operative Technique

General anesthesia, endotracheal intubation and the Dingman mouth gag are used. The soft palate is injected in the midline with a solution of ½% procaine and 1:200,000 adrenalin. The soft palate is opened in its mid-line with two objectives in mind (1) the incision must not reach the hard palate because of the tendency for fistula formation at this area of junction with the soft palate, (2) it must, however, be long enough to provide sufficient space for an adequate insertion of the pharyngeal flap on its nasal surface. 4-0 silk sutures are placed through the wound edges of the oral surface of the soft palate and serve as retractors in order to expose the posterior pharyngeal wall. The full width of the posterior pharyngeal wall is used to construct the pharyngeal flap. It is based superiorly and the base of the pharyngeal flap is 10 to 15 millimeters below or inferior to the eustachian tubes. The handle of the Dingman mouth gag is slightly elevated, if necessary, in order to gain deeper exposure of the oropharyngeal wall and to obtain additional length of the pharyngeal flap, if needed. The posterior pharyngeal wall is injected with the dilute anesthetic local solution. The flap is incised outlining its lateral margins. The flap can be retracted cephalad as the Dingman gag is lifted so that additional length may be obtained and the trap-door flap thus formed including both mucosa and the pharyngeal musculature is then dissected free from the underlying glistening prevertebral fascia. If the flap extends onto the lateral wall of the pharynx there is danger of cutting the ascending pharyngeal artery and indeed if bleeding occurs at this stage of the operation, it is usually from this artery or one of its branches. Careful attention must be given to the elevation of the flap particularly as one approaches its base. The lateral incisions must not be allowed to curve mesially across the base of the flap or the blood supply to the flap may be endangered. A suture of 4-0 chromic cat gut is placed through the tip of the flap and used to retract it upwards in order to expose the donor area. After bleeding is controlled by electrocautery, the pharyngeal donor area is closed with interrupted 4-0 chromic cat gut sutures (Figure 2A). Closure of the posterior pharyngeal wall is considered important for two reasons: (1) it re-establishes the sphincteric action of the pharyngeal wall by reconstituting the superior constrictor muscle and it (2) decreases appreciably the postoperative morbidity of these patients. Lining flaps are then constructed from the nasal surface of the soft palate (Figure 2B). The edge of the nasal mucosa of the soft palate most laterally adjacent to the bed of the elevated lining flap is sutured to the lateral margin of the pharyngeal flap to control the size of the lateral port (Figure 2C). If the port appears to be too large an incision down to the lateral pharyngeal wall in this area will allow the port to be reduced in size. After construction of the port on each side, the remaining margins of the pharyngea flap are sutured to the nasal mucosa of the soft palate. The lining flaps are then brought over and sutured to the raw surface of the

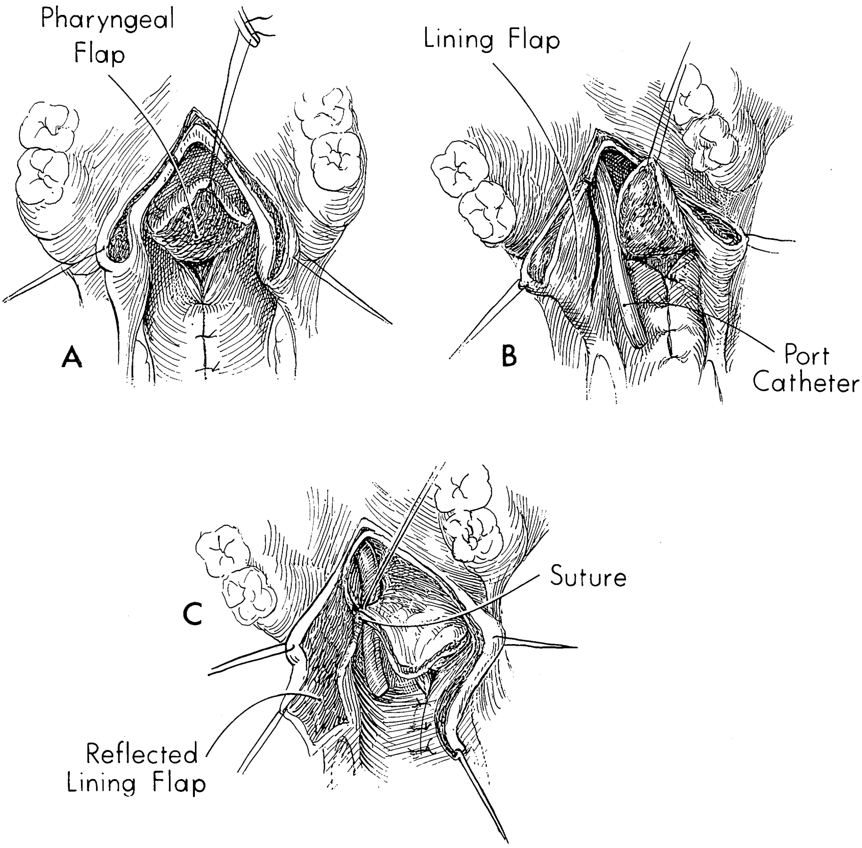

FIGURE 2A. The soft palate has been split; a superiorly based pharyngeal flap encompassing the full width of the posterior pharyngeal wall has been elevated. The pharyngeal wall defect has been closed.

FIGURE 2B. A lining flap has been designed on one side of the elevated nasal surface of the soft palate and is based on the posterior margin of the soft palate. (Note the donor area on the nasal surface of the soft palate when the flap is reflected (2C); the remaining edge of the soft palate mucosa which will be sutured to the lateral margins of the pharyngeal flap; Note the catheter placed in the gutter between the pharyngeal flap and the soft palate which will be used as a guide in constructing the lateral port.

FIGURE 2C. The port has been constructed by the placement of a suture between the mucosal edge of the nasal soft palate and the lateral side of the pharyngeal flap. The pharyngeal flap is now sutured with three additional sutures to the remaining mucosal margin of the soft palate, coming to lie in the bed of the elevated lining flap, raw surface to raw surface. The same procedure is performed on the contralateral side until only the central or apical portion of the pharyngeal flap remains to be sutured to the divided nasal mucosa of the soft palate. The lining flaps are placed over the raw under surface of the pharyngeal flap, sutured to the pharyngeal flap and to each other in the midline. This eliminates the raw surface of the pharyngeal flap, helping to prevent flap contraction which might produce tension on the sutures between the flap and the soft palate, and between the flap and lateral pharyngeal wall.

pharyngeal flap and then sutured to each other in the midline with 4-0 chromic catgut. 4-0 chromic catgut sutures, placed as vertical mattress sutures, alternating with single sutures, reconstruct the uvula and close the oral surface of the palate. It is important to avoid inverting mucosa between the sutures and thus increase the danger of fistula formation.

Postoperative Management

Following completion of the operative procedure, the patient enters the most critical period of his hospitalization. *Attentive postoperative management of the airway is mandatory.* Before removal of the mouth gag the stomach is evacuated with a Levine tube. An "O" silk suture is placed through the tongue in a horizontal mattress fashion. The Dingman mouth gag is then removed. Suction through the nose is carefully performed immediately following surgery *by the surgeon* to eliminate the danger of residual clots slipping through the ports, but any subsequent nasal suction is interdicted. The patient must be breathing well on his own before extubation takes place. However, extubation must occur before the patient is wide awake, or gagging on the endotracheal tube may increase venous pressure and initiate pharyngeal bleeding. Cleft palate patients often have a large tongue and the surgical narrowing of the pharynx may precipitate an airway problem. The possibility of productive vomiting having been dimished by evacuation of the stomach, the posterior pharyngeal area must be kept dry of all secretions so that coughing which might stimulate bleeding can be kept at a minimum. The patient is placed on his side in the recovery room and nursing personnel instructed to frequently suction the medial aspect of the dependent cheek, but not to place the tube deep into the pharyngeal area. If the 4 mm diameter polyvinyl tubes used to control port size are left in the nose following surgery, they may be trimmed at the level of the nostril and sutured into the membraneous septum. Generally such tubes are used during the procedure to establish the size of the port and once this has been established their primary function is over. They do not generally provide a good nasal airway because they become easily obstructed. The patient is placed in a steam room with O_2 by vaporizer and carefully watched. Postoperative agitation may be controlled by intravenous *Valium.®* It is important to diminish the incidence of pharyngeal bleeding by maintaining a quiet, anxiety-free patient for at least 24 hours. The tongue suture is generally removed when the patient is awake. The hospital stay averages about four postoperative days. The patient is kept on clear fluids for three days and a soft diet thereafter for two weeks. Antibiotic coverage has generally consisted in the administration of penicillin for a period of one week. The importance of a trained anesthesiologist and a team alert to potential airway problems cannot be overemphasized. Although tracheostomy has not been required in any of our patients, we would not hesitate to utilize this technique if indicated. Only one patient required a transfusion and he was subsequently shown to have had a bleeding dyscrasia. To reiterate: the postoperative period is the most critical period of the patient's hospital stay. Problems have usually disappeared by 24 hours, but a cautious watchfulness is necessary for an additional day or two.

Technical Details

Initially, two catheters of 4 mm diameter were used as guides during surgery and the lateral port areas were sutured tightly around them. This produced a total port size of about 25 mm^2 in area (12.5 mm^2 + 12.5 mm^2), or slightly larger than our threshold value of 20 mm^2. Because of the mesial movement of the lateral pharyngeal walls which occurs during speech in the vast majority of non-paralyzed cleft palate speakers (*9, 10*) we theorized that ports of larger size could be constructed during surgery (with the palate at rest), relying on the mesial movement of the lateral pharyngeal walls to obliterate the residual larger port during active, connected speech. Thus, the ports constructed at surgery in the non-paralyzed velopharyngeally incompetent patient could be larger than our threshold values, emphasized above, provided good mesial movement of the lateral pharyngeal walls had been demonstrated before surgery. Naturally, in the patient with paralysis of the velopharyngeal musculature, the port must be strictly designed to conform to our threshold area of 20 mm^2.

We learned that it is better to have competency with a large resting port than with a small, tight resting port. Postoperative hyponasality which is temporarily present in all of our cases is present for a shorter period of time, the patient can begin to make the normally nasal sounds ("m", "n", "ng") sooner, and there is less danger of permanently obliterating the ports through an unfortuitous scar contracture or misplaced suture. If the ports have been obliterated, it is a simple matter to open them by utilizing a simple "catheter" technique.

The "Catheter" Technique

When hyponasality following surgery persists for longer than one year, usually accompanied by the patient's inability to breathe nasally, surgical enlargement of the obliterated parts is indicated. By inserting catheters intranasally, and visually locating their tips intraorally, we can define the area of the obliterated lateral ports. Incising through these areas allows the catheters to pass into the oropharynx and re-establishes the patency of the lateral ports. Several catgut sutures approximating the penetrated nasal and oral mucosa insure their persistence. Often the catheters are left in for 5 to 7 days to allow epithelization to occur.

Longitudinal Studies

Results of the Lateral Port Control Operation on 93 Consecutive Repaired Cleft Palate Patients. The 93 patients included in this study range in age from 4 to 42 with a mean age of 16 and a standard deviation of 7. Females slightly predominated over males and the patients had an average of 3.2 previous surgical procedures with some having had as many as 12 operations on their palates. Many patients had concomitant problems such as palatal fistulae, previous pharyngeal flap remnants and severe scarring with tissue shortage. The lateral port control procedure has been performed over a period of six years, with the average follow-up being 3.0 years.

Parameters

Three methods have been utilized in analyzing the results of the operative procedures: (1) perceptual, (2) aerodynamic, and (3) acoustic:

(1) *Perceptual.* Samples of continuous speech as well as isolated vowels were tape recorded pre- and postoperatively and evaluated for perceived severity of hypernasality using the method for equal-appearing-intervals as applied by Sherman (*10*) and Spreistersbach (*12*) to the evaluation of hypernasality. In addition, perceptual judgments were made of the presence or absence of nasal emission and hyponasality.

(2) *Aerodynamic.* Using the techniques developed by Warren and his associates measurements of velopharyngeal orifice area were derived by obtaining simultaneous values of intra-oral air pressure, intra-nasal air pressure and trans-nasal air flow and by inserting them into his modification of the hydrokinetic formula

$$A = \frac{V}{.65\sqrt{2\frac{(P1 - P3)}{D}}}\ *$$

Areas were calculated for both vowels and consonants in continuous speech.

Rate of airflow through orifice

(3) *Acoustic.* Using the data concerning the basic acoustic correlates of nasalization described by Dickson (*13*) and Schwartz (*9*), isolated vowels were tape recorded pre- and postoperatively and subjected to sound spectrographic analyses.

* Orifice area = Correction Factor $\sqrt{2\,\frac{\text{orifice differential pressure}}{\text{density of air}}}$

Results, to date, have been obtained for 93 patients and have demonstrated the following findings:

Perceptual judgments of hypernasality revealed its total elimination in 91 (98%) of the cases. Persistent hyponasality (lasting more than six months) was found in three cases. Nasal emission was eliminated in all cases.

The aerodynamic measurements of the 91 successfully treated patients showed an average velopharyngeal patency during speech of 5.8 mm^2. Since the surgically created ports averaged an area of 25 mm^2, the difference in patencies represents the effect of muscle activity adjacent to the ports during speech. Of the postoperative failures, one possessed a velopharyngeal inadequacy of approximately 45 mm^2 (this was apparently the result of a unilateral breakdown of the flap) and the other showed a port size of 36.4 mm^2, probably representing a mistake in surgical judgment of port size at the time of surgery. Using the measurements of transnasal airway resistance developed by Ogura (*14*), the 90 non-hyponasal patients showed that the flap contributed negligibly to an increase in nasal resistance during quiet respiration; the persistently hyponasal patients, of course, demonstrated infinite nasal airway resistances. A minor operative procedure utilizing the catheter technique (see above) was performed on each of the three patients. The procedures re-established the port patencies and successfully eliminated the hyponasal condition in each.

The results of the acoustic analyses revealed a substantial increase in the intensity of the first formant and a concomitant reduction in formant bandwidths of the vowels studied and for a majority of the patients. In addition, the presence of extra resonances, often noted preoperatively, was virtually eliminated.

Summary

An attempt is made to redefine cleft palate speech in terms of *direct* and *indirect* causes. The *direct* cause is velopharyngeal incompetence characterized by hypernasality and nasal escape, and the *indirect* causes represent the sum of the patients' maladjustments to the direct cause, e.g. pharyngeal fricatives, glottal stops, poor tongue positioning, deliberate lowering of the voice to mask hypernasality and nasal grimacing.

The elimination of the direct cause is the goal of surgery. An operation is described, the Lateral Port Control (L.P.C.) pharyngeal flap, which has restored competency to the velopharyngeal mechanism in 97% of 93 patients. Its rationale is derived from the investigative work of a dentist, a speech scientist and a radiologist who, utilizing three different scientific disciplines, arrived virtually at the same understanding of the nature of velopharyngeal incompetence in cleft palate speech, providing us with a precise surgical goal in the treatment of this condition.

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