A Selected Review of Palatal Training Procedures

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The modification of velopharyngeal closure deficits is generally achieved through the utilization of some type of surgical or prosthetic management. In addition to these primary techniques, a number of experimental palatal training procedures have been reported in the literature. The experimental procedures differ primarily with respect to: type of treatment, evaluation of treatment change, and subject characteristics. This paper reviews the various palatal training procedures and discusses variables that may deserve consideration in future research.

KEY WORDS: Velopharyngeal closure, palate training, experimental treatments

The velopharyngeal mechanism has been described as a valve whose actions serve to separate the oral and nasal sections of the upper airway (Thompson and Hixon, 1979). During normal speech production, closure of the port enables a speaker to develop sufficient oral air pressure and air flow for the production of various consonant speech sounds. The oral consonants which require the development of air pressure and flow are plosive, fricative, and affricate sound classes (Kent, 1981; Huntington, 1968). In addition, proper action of the valve allows the generation of voice without accompanying hypernasal voice quality. English vowels and semivowels are produced with minimal constriction of the vocal tract; their voicing requirement necessitate adequate valve operation (Minifie, 1973). The above overview of velopharyngeal function is brief and oversimplified but serves to illustrate the importance of the velopharyngeal valve during speech production. Kuehn (1979) has indicated that faulty timing of closure or failure to achieve closure may result in various speech production problems.

Persons with cleft palate often demonstrate problems with velopharyngeal closure (Riski and Millard, 1979; Subtelny, 1968). Spriestersbach et al. (1973) have identified consonant articulation errors, generally involving pressure consonants, nasal air emission, hypernasality and possibly hoarseness as sequalae of velopharyngeal valving deficits. Shelton and his associates (Shelton, Morris and McWilliams, 1973; Shelton, Hahn, and Morris, 1968) suggest that remediation activities be directed to articulatory disorders, if present. The surgeon or prosthodontist has the responsibility of providing a closure mechanism adequate for speech production purposes. Spriestersbach and his group concur with Shelton and others and indicate that modification of velopharyngeal inadequacy through training does not appear to be a tenable goal for persons with closure deficits.

Despite these reservations, speech pathologists appear to employ treatment regimens to improve the actions of the velopharyngeal mechanism (Massengill and Phillips, 1975). Schneider and Sphrintzen (1980) surveyed the attitudes of a group of 1,000 speech pathologists toward a number of different treatment issues related to the management of persons with velopharyngeal inadequacy. A majority of those who responded indicated that they used various activities such as blow-

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ing, sucking, swallowing, and other stimulation to improve velopharyngeal action. Yules (1970) reviewed secondary correction procedures for velopharyngeal inadequacy and stated that training the palatal muscles might prove an effective treatment for some persons. In addition, it has been suggested that muscle training of the palate and/or pharyngeal muscles be included along with surgical and prosthodontic management as a possible treatment (Cole, 1971a).

The utilization of velopharyngeal training is an issue that has not been resolved since authorities appear to disagree. The purpose of this paper is to review investigations which have attempted to improve the adequacy of the velopharyngeal mechanism for speech through various training procedures. In this way, it is hoped that guidelines for clinical management and suggestions for future research will be formulated.

Cole (1979; 1971b) organized palatal training procedures into three categories: *indirect*, *semidirect*, and *direct training methods*. Investigations will be presented under this scheme except where training procedures include combinations of the above methods and will be discussed as such.

Indirect training methods presumably involve activity of the velopharyngeal mechanism but the actual treatment does not focus on the velopharyngeal muscles. Articulation therapy would be an example of indirect treatment since the primary aim is to correct placement of sounds produced in the oral cavity. Semidirect techniques consist of nonspeech activities that require activity of the velopharyngeal muscles. Activities such as blowing and swallowing, would qualify as semidirect techniques. The closure requirements for the semidirect procedures in some cases appear different from that for speech production (Sphrintzen et al., 1974). Direct training would be any form of direct stimulation to the palate and/or pharyngeal muscles such as electrical stimulation. Cole (1971b) has indicated that . . . "direct muscle training techniques seem to increase palatal and pharyngeal muscle activity by teaching the patient to bring under voluntary control an essentially involuntary reflex through the introduction of a variety of sensory stimuli." Dalston (1977) has suggested that the speech literature reflects two different viewpoints concerning muscle training. An alternate position to Coles' is that continued stimulation results in increased sense of position or movement. Readers are referred to a paper by Shelton (1963) for a detailed discussion of the role of therapeutic exercise in movement physiology.

Indirect Training Methods

Shelton and his associates (Chisum et al., 1969; Shelton et al., 1969) studied the influence of articulation training on velopharyngeal closure, pharyngeal wall movement, and tongue posture. The subjects exhibited articulation errors and velopharyngeal inadequacy for speech. Six subjects were in the experimental training group and five served as untreated controls. All subjects were evaluated through articulation testing and lateral cinefluorographic films. The experimental group demonstrated a statistically significant change in articulation skills following a period of training, but there were no differences between groups with respect to the closure variables that were studied cinefluorographically. The results suggested that articulation training did not influence changes in patterns of closure.

The following series of studies required subjects to practice various speech activities while receiving some type of information that served as an index to velopharyngeal activity. This form of practice with accompanying information about performance is a type of biofeedback. Davis and Drichta (1980, p. 288) define biofeedback as:

> . . . the use of instrumentation to provide moment-to-moment information about a specific physiological system that is under control of the nervous system but not clearly or accurately perceived. Biofeedback derives its effectiveness by making ambiguous internal cues explicit, thereby providing accurate information about changes in target responses (i.e., muscle tension) during training so that instrumental control of the response is facilitated. By precisely detecting a physiological event and then converting the resulting electronic signal into auditory, visual, tactile, or kinesthetic feedback, a subject can be made immediately and continuously aware of the level of a physiological event.

Tonar and Tonar II are instruments that were developed in part to detect nasality in person with suspected closure problems

(Fletcher, 1972; Fletcher, 1976). The acoustic signal produced by an individual is separated into oral and nasal channels and a nasal/oral acoustic ratio is automatically computed. Tonar II has a readout display which is known as a tonagram. The readout graphically shows the nasal signal, oral signal and a percentage of nasality. The percentage figure is a ratio computation between the nasal and oral signals $(\frac{N.S.}{O.S.})$. Fletcher has suggested that the instrumentation is not only appropriate for assessment but may also be used in clinical training. In the 1972 paper he also cited two experiments wherein the instrumentation has been used for training purposes.

In the first experiment, two subjects who wore speech appliances practiced while simultaneously receiving performance information via tonagrams. Nasality goal ratios were determined initially and then periodically adjusted across practice sessions. In this manner the subjects could attain intermediate values while gradually reducing nasality over time. The Tonar data showed reductions in the nasal component but complete elimination was not achieved. The second experiment was carried out in the same manner as the first with seven subjects who had repaired palatal clefts and velopharyngeal inadequacy for speech. Dependent variable measures included Tonar, articulation proficiency and word intelligibility. The results did not contain information pertaining to all the measurement variables, but instead stated that subjects did show varying amounts of nasality reduction. Fletcher indicated that only one subject in the group appeared to have the potential for total elimination of nasality with continued practice.

Daly and Johnson (1974) used Tonar in a palate training program with three mentally retarded children. One of the three subjects had a repaired palatal cleft; the other subjects exhibited hypernasality of unknown etiology. Each subject underwent articulatory testing, intelligibility testing, and Tonar before and after completion of the experiment. Results indicated that articulation improved, intelligibility increased and nasality was reduced but not completely eradicated. The authors suggested that the findings were limited but did not negate the employ of Tonar in future training studies. Moreover, they felt that a major feature of the device was the immediacy of feedback to the learner.

An experiment conducted by Roll (1973) attempted to study the utilization of visual feedback in the form of a light display. Two children with repaired clefts and the ability to achieve velopharyngeal closure were subjects. Each was fitted in the nares with a piezo-electric crystal from a contact microphone. The subjects phonated isolated vowels and unwanted nasal vibration was detected with the microphone crystal. A light display, which was activated by the nasal device, provided feedback on each practice trial. The subjects were able to reduce progressively the number of trials produced with nasal vibration. However, retention of vowel production without nasal vibration and generalization across other phonetic units was not determined.

Another instrument developed for assessment and then adapted for training was reported by Ellis and his group (1978). The device measures nasal airflow during speech. Airflow is directed through a nasal mask to a thermistor and finally a nasal anemometer. The signal is recorded and then visually displayed on a graphic chart. The chart shows any unwanted nasal airflow in synchrony with the voicing signal of the recorded item. The authors' paper dealt mainly with the utility of the procedure in assessment and only briefly mentioned its use for training purposes. The training was undertaken with a single subject who was reported to have made "considerable improvement". The lack of detail does not allow an exact interpretation of the actual success demonstrated by a single client.

Following methodological development of a training procedure (Shelton et al., 1975), Shelton et al. (1978) examined the utilization of direct visual feedback training in the form of videopanendoscopy. Two subjects, one of whom had a repaired cleft palate and the other with suspected velopharyngeal insufficiency served as subjects. They practiced isolated vowels, syllables, and syllable repetitions while observing the velopharyngeal port. A speech clinician observed along with the subjects and provided verbal feedback regarding trial to trial performance. Results suggested that improvement did occur but increased closure did not generalize to spontaneous speech. The authors indicated that the findings were promising but the treatment could not be applied clinically for persons with velopharyngeal closure deficits.

A report by Shelton and Ruscello (1979) summarized a number of training procedures. Subjects were heterogenous with respect to articulation proficiency, chronological age, and cause of velopharyngeal inadequacy. Four subjects were administered palate only training in the form of visual feedback while producing speech. Three observed tracings of unwanted nasal airflow that were obtained with pressure flow equipment, another observed the velopharyngeal port by way of videoendoscopy. Three others were given palatal feedback training and, after feedback training, articulation lessons were introduced. Two subjects observed nasal airflow tracings and a single subject participated in both flow monitoring and videoendoscopy training. Only one subject out of both groups showed substantial change after enrollment in the palatal training program. That individual had congenital sensorineural hearing loss without cleft palate and had monitored nasal airflow tracings exclusively. Those subjects also given articulatory lessons showed improvement in articulatory production skills despite the presence of velopharyngeal inadequacy.

Semi-direct Training Methods

While semi-direct activities such as blowing and sucking have been employed for improving velopharyngeal inadequacy (Buck and Harrington, 1949), they have not been evaluated in extensive fashion. In a study by Massengill et al. (1968), thirteen subjects with velopharyngeal dysfunction were divided among one of three training groups. Group A practiced blowing exercise into a manometric or other blowing device; Group B practiced sucking through a straw or into a meter that registered sucking pressure; Group C carried out swallowing practice while monitoring thyroid excursion with their index fingers. Practice sessions were conducted twice a day for 27 consecutive days; speech therapy was also given during the experiment. Comparison of pre and post-cinefluorography showed no differences for groups A and B but group C exhibited a statistically significant change between measurement sessions. That is, smaller velopharyngeal gaps were found for those subjects who received swallow training.

In case report by Massengill and Quinn (1974) an adult male suffered from nasal air leakage when playing woodwind instruments. Lateral view radiographic studies suggested that the patient was achieving touch closure. Films taken at the time of referral and approximately 8 years prior showed a reduction in the patient's adenoidal tissue. The patient practiced sucking exercises through a straw for approximately six months, after which leakage did not occur during musical play. Rechecks were consistent with the initial findings.

Powers and Starr (1974) undertook an investigation of the influence of nonspeech activities on velopharyngeal closure. Four subjects with repaired clefts and velopharyngeal inadequacy for speech were enrolled in an intensive six week training program. Therapeutic activities employed were: blowing, sucking, gagging and swallowing exercises. Results indicated no substantial change in either nasality ratings or velopharyngeal gap measurements following treatment.

Direct Training Methods

Lubit and Larsen (1969) developed an exercise device which was thought to improve movement of the closure mechanism. The device consisted of an oral bite block, inflatable rubber bag, and hand pumping bulb. A patient would be instructed to insert the bite block-rubber bag into the oral cavity and pump the hand bulb until the bag was inflated. The inflated bag acted to displace the palate toward the pharyngeal wall. Practice was carried out daily with distributed practice sessions each day. The authors stated that twenty-eight persons with velopharyngeal inadequacy for speech were receiving treatment with the device; and data was being collected. A single case report showed positive change following treatment on all evaluation variables except nasality.

Electrical stimulation of the soft palate and lateral pharyngeal walls was examined by Yules and Chase (1969). Thirty patients of varying age and inadequacy type were enrolled in the training program. Patients were taught to phonate the vowel /a/ while receiving simultaneous electrical stimulation to the soft palate or lateral pharyngeal walls. Patients also carried out home practice by stimulating the posterior pharyngeal wall with cotton swabs. When cinefluorographic studies showed soft palate elevation and airflow examination revealed decreased nasal airflow, treatment shifted to indirect visual feedback training. The patients wore a unit (speechometer) that contained oral and nasal microphones. Output from the microphones was channeled to a balance meter thus providing a signal of the oral-nasal balance. Subjects practiced speech materials while a speech clinician manipulated the volume controls to alter channel emphasis. The authors indicated that 24 patients reduced measurable nasal airflow and 60% of the 24 eliminated hypernasality.

A replication of the Yules and Chase experiment was carried out in the same laboratory by Weber, Jobe, and Chase (1970); the findings were not in agreement with the initial data. In this investigation 34 patients were given the experimental treatment over a period of 12 months. The investigators concluded that the stimulation methods were not successful in reducing or eliminating nasal airflow and hypernasality.

Tash et al. (1971) evaluated the ability of subjects to produce voluntary movements of the pharyngeal walls with tactile stimulation. Four normal speaking children and two with inadequate velopharyngeal closure for speech participated in the experiment. Two of the normals served as controls; the two other normal speakers along with defective speakers received the experimental treatment. Various training conditions were employed that involved tactile stimulation of the lateral and posterior pharyngeal walls with a cotton swab. Subjects, regardless of closure status, did learn to control pharyngeal wall movement. However, closure for speech was not improved for the defective speakers.

Massengill, Quinn, and Pickrell (1971) reported on an intraoral training device which they called a palatal stimulator, designed to "stimulate movement of the soft palate away from the device." Five subjects who exhibited velopharyngeal gaps ranging from 3 to 13 mm before treatment reduced their gap dimensions to a range of values from 0 to 7 mm. The duration of the treatment was approximately 12 months.

A case report by Moller et al. (1973) described a displacement transducer attached to a patient's molar tooth and contacting the soft palate. The subject with velopharyngeal inadequacy phonated the vowel /u/ and observed elevations of the palate visually displayed via an oscilloscope. While the individual did show increased velar elevation with the transducer in place, pre-and post-training comparisons of velopharyngeal gap and hypernasality did not differ. However, it was determined that configuration of the posterior pharyngeal wall (adonoid atrophy) was most likely responsible for inability to demonstrate decreased gap and nasality judgments.

A similar palatal training device was designed by Tudor and Selley (1974) consisting of an acrylic plate molded to fit the contour of the hard palate. A U-shaped bar extended posteriorly from the plate into the oropharyngeal region and made contact with the soft palate at rest. Elevation of the palate activated an electrical circuit which in turn set off an external monitoring light. The authors used the training device with a variety of patients with closure deficits. Although their criterion measures were not clearly specified, they suggested that cases developed closure with the device but it was not transferred to spontaneous speech. It should be noted that the instrumentation is sensitive to movement of the velum away from the sensor. Information concerning the range of soft palate movement is not available.

Subject reponse to electrical or tactile stimulation during a single session was reported by Peterson (1974). Twenty speakers participated: five had acceptable closure in the presence of repaired clefts; five had velopharyngeal inadequacy for speech; and ten had speech defects but no palatal problems. Subjects underwent cinefluorographic filming prior to the study and during the experimental tasks. The electrical current provided and the force of the tactile stimulation were measured on each trial. The results suggested that electrical stimulation did influence movement for some subjects, although stimulation at levels below pain threshold produced inconsistent movement patterns.

Combinations of Various Training Methods

In some studies it is difficult to make a clear distinction, but those that follow appear to incorporate combinations of methodology.

Speech appliances for velopharyngeal inadequacy presumably involve direct stimulation of the pharyngeal muscles during both speech and nonspeech velopharyngeal gestures. Speech appliances may function as therapeutic devices because resistance is created between an appliance and muscular forces (Mazaheri and Mazaheri, 1973; Mazaheri, 1962). In some cases function improves and the appliance is either removed completely or the pharyngeal section is reduced in size.

An initial report by Blakeley (1960) provided a rationale for the use of speech appliances with cases demonstrating velopharyngeal inadequacy and oral articulation errors. With such cases closure could be achieved to facilitate oral consonant acquisition. Blakeley cited the case of a youngster failing in a program of articulation therapy who began to acquire speech sounds following the fitting of a speech appliance. The youngster developed adequate articulation skills and discarded the speech device approximately three years later. The child was slightly nasal without the appliance but articulation skills were not adversely affected.

In a series of additional reports (Blakeley, 1964; Blakeley, 1969; Blakeley and Porter, 1971) Blakeley discussed the clinical efficacy of speech appliances with various types of velopharyngeal inadequacy. In the first report, patients who failed to achieve velopharyngeal adequacy following initial surgical repair were fitted with appliances and the pharyngeal sections were gradually reduced in size prior to secondary surgery. Three cases were mentioned where appliance reductions were done without any adverse effect upon speech or resonance quality.

Blakeley (1969) further suggested that speech appliances stimulate pharyngeal muscle development. The resulting hypertrophy allows the prosthodontist, in conjunction with the speech pathologist to reduce the size of an appliance or remove it completely. Figures cited from Blakeley's clinical population indicate that 22 children out of approximately 100 no longer required appliances.

The final report by Blakeley and Porter (1971) was a case study of a boy with velopharyngeal inadequacy of an unknown neurological origin. The subject wore an appliance which was periodically reduced in size over a 31 month span and then removed. Speech remained essentially normal, manometric readings were satisfactory, nasal flutter test negative, and nasal air escape was not detected through listening tubes. The evaluation procedures were repeated after one month with the same results.

Weiss (1971) published a clinical report that presented the results of 125 patients who had participated in an obturator reduction program over an eight year period. Twenty-three patients (19%) of the total group did not require continued use of speech appliances. Variables associated with the successful wearers included: cooperation between the patient and his/her parents; early enrollment in the reduction program; adequate palatopharyngeal compensation; speech training simultaneous with appliance insertion; consistent use of the appliance; and careful case selection.

An additional retrospective study further examined variables thought to be indicative of candidates who might require an appliance on a temporary basis (Wong and Weiss 1972), the authors identified 20 patients out of a group of 40 as those who no longer needed speech appliances. Duration of wear among all subjects ranged from 7 months to approximately 7 years with an average of 3 years, 4 months. Variables indicative of the successful group were: age (the younger the patient the better the prognosis); sex (more girls than boys were in the successful group); cooperation (family, parents and patients); and anatomy (successful patients generally had longer veli and greater range of pharyngeal wall movement).

Shelton and his associates (1971a) conducted an investigation to determine whether pharyngeal wall movement increased with patients undergoing appliance reduction. Three subjects with repaired cleft palates wore custom made appliances with removable pharnygeal sections. Measurements of oral and nasal SPL, nasal air pressure, articulation proficiency and cinefluorography were recorded. Smaller pharyngeal sections were gradually substituted. Measures obtained at the termination of the experiment remained unchanged. However a single subject appeared to have developed some degree of pharyngeal wall movement without achieving closure.

In a study by Shelton et al. (1971b), nine persons with open clefts and nine with repaired clefts wore speech appliances and underwent from one to three reductions in the appliances at intervals of approximately four to six weeks. Lateral-view cinefluorographic films did not detect increased pharyngeal wall movement following reduction in the posterior and lateral margins of the pharyngeal section.

A final series of investigations utilized nonspeech training tasks as an intermediate step in attempting to develop velopharyngeal closure for speech. Patients were trained to perform nonspeech movements in isolation or simultaneous with speech. If the movements were realized, transfer to exclusive speech contexts was undertaken.

Research conducted by Miyazaki and his associates (Miyazaki, Matsuya, and Yamaoka, 1975; Matsuya, Yamaoka, Miyazaki, 1979) used the nasal fiberscope in the diagnosis and treatment of persons with velopharyngeal closure deficits. The velopharyngeal port can be viewed directly or shown by way of a video monitor. Nishio et al., (1974) reported that nineteen patients were seen for fiberscopic training. They were first taught to blow and observe their movements with the fiberscope. After closure for blowing had been achieved, training shifted to speech practice activities. Closure generalized to plosive and fricative sound classes in less than one month for all cases.

In an unpublished report the group (Yamaoka et al.) also provided training to 59 patients with velopharyngeal inadequacy for speech. The patients received a combination of closure training and articulation training for a period of approximately 12 months. The closure training included both blowing and articulatory components performed while monitoring velopharyngeal action visually. Of the 59 patients seen, nine developed closure across all speech and nonspeech criterion measures; the remaining patients showed variable patterns of closure on the measures.

Sphrintzen, McCall, and Skolnick (1975) identified four subjects who had inadequate closure for speech but adequate closure during whistling or blowing. The subjects received a treatment which contained an initial step of simultaneous whistling or blowing and speech. The nonspeech activity was then faded in favor of exclusive speech practice; the speech activities progressed from isolated vowel production to conversational speech. Nasal air escape was identified with the use of a scape-scope. The device is inserted into a nares so that unwanted nasal airflow is detected by displacement of a small piston. Of the four subjects receiving treatment, two achieved closure for speech when assessed through videofluoroscopy, nasality ratings, and nasal air emission. An additional subject showed improvement but did not achieve closure on a consistent basis. The remaining subject did not complete the program.

Discussion

Clinical Issues. The reported findings as presented in Table 1 do not support palatal and/or pharyngeal wall training procedures. This is not a startling conclusion, being consistent with earlier reviews (Dalston, 1977; Shelton, Morris, and McWilliams, 1973). In spite of this, velopharyngeal training appears to be employed rather extensively by speech clinicians. Data collected in the Schneider and Sphrintzen (1980) survey show that 80% of 592 respondents used some form of training for the treatment of velopharyngeal inadequacy. Of those utilizing palatal training procedures, 84% used conventional speech therapy, 54% employed nonspeech activities such as blowing and sucking, and 48% used direct palatal stimulation. The training procedures were not mutually exclusive so it was possible to have overlap among the categories. There appears to be a difference between the state of the art and current clinical management practices for velopharyngeal inadequacy (Ringel, 1972).

Research Issues. The studies reported demonstrate a number of limitations that should be considered in designing future investigations. Many of the treatments that were reviewed defy replication because they were not presented in sufficient detail. Since research on palatal training is equivocal, replication is important to verify a treatment effect; particularly when only a limited number of subjects were used. Plutchik (1968) states that, "If different investigators, using different samples of subjects, are able to verify

TABLE 1. SUMMARY OF INVESTIGATIONS THAT HAVE BEEN REVIEWED

Investigator	*Type of Stimulation*	*Number of Subjects*	*Evaluation Measures*	*Outcome*
Indirect Methods				
Shelton et al. (1969) Chisum et al. (1969)	Articulation Therapy	6	Judgements of articulation and lateral view cinefluorography	Articulation improved but closure did not.
Fletcher (1972)	a. Visual monitoring of Tonar signal while producing speech	2	Tonar assessment	Reduction in the nasal component of the speech signal
	b. Visual monitoring of Tonar signal while producing speech	7	Tonar assessment, articulation, and intelligibility testing	
Roll (1973)	Visual monitoring of a light display that indicated the presence or absence of nasal vibration	2	Piezo-electric crystal was used to detect nasal vibration	Both subjects improved their ability to produce isolated vowels without nasal vibration.
Daly and Johnson (1974)	Visual monitoring of Tonar signal while producing speech	3	Tonar assessment, articulation, and intelligibility testing	Reduction in the nasal component of the speech signal
Ellis et al. (1978)	Visual monitoring of nasal airflow tracings displayed via chart recordings during speech	1	Reduction in the measurable amount of nasal airflow	"Considerable improvement" with a single case
Shelton et al. (1978)	Visual observation of the velopharyngeal port via videopanendoscopy during speech	2	Increased movement toward closure of the velopharyngeal part	Movement toward closure increased with practice but did not transfer on an automatic basis.
Shelton and Ruscello (1979)	Visual observation of nasal airflow tracings or the velopharyngeal port via videoendoscopy during speech	7	Increased movement toward closure of the velopharyngeal part or reduction in the measurable amount of nasal airflow	A single subject was able to eliminate unwanted nasal airflow through observation of tracings.
Semi-direct Methods				
Massengill et al. (1968)	Blowing, sucking, and swallowing exercises	13	Lateral view cinefluorography	The group of 5 subjects who received swallow training showed significant reductions in velar gap.
Massengill and Quinn (1974)	Sucking exercise program	1	Patient report	Elimination of nasal airflow during musical play
Powers and Starr (1974)	Blowing, sucking, gagging, and swallowing exercises	4	Perceptual ratings of nasality and velopharyngeal gap measurements.	No change in nasality or velopharyngeal gap following training.
Direct Methods				
Lubit and Larsen (1969)	Direct palatal stimulation with an exercise device	1	Intelligibility ratings of connected speech, articulation, nasality ratings, breath pressure ratios, spectrographic analysis, and lateral cephalometrics	The patient showed positive change in all measurements except nasality.

Yules and Chase (1969)	Electrical and tactile stimulation of the palate, and visual feedback training	30	Nasality ratings, airflow studies, and cinefluorography	Twenty-four patients reduced nasal airflow and 14 of 24 eliminated their hypernasality.
Weber, Jobe, and Chase (1970)	Electrical and tactile stimulation of the palate	34	Nasality ratings, airflow studies, and cinefluorography	The treatment did not appear to influence positively reduction in either nasal airflow or hypernasality.
Tash et al. (1971)	Tactile stimulation directed to the pharyngeal wall	4	Cinefluorographic films, isolated vowel phonation, fundamental frequency and jitter analyses, oral and nasal sound level, and water manometry.	The subjects did produce voluntary movements of the pharyngeal wall but there was no improvement of closure for speech.
Massengill, Quinn, and Pickrell (1971)	Palatal stimulation with an intraoral training device	5	Cinefluorographic measurement of velopharyngeal gap	Velopharyngeal gaps in the patients were eliminated or partially reduced.
Moller et al. (1973)	Palatal stimulation via displacement transducers and visual feedback via oscilloscope tracings of palatal movement	1	Lateral view radiographic data and perceptual judgments of hypernasality	There were no changes in the evaluation measures, but perhaps due to other factors.
Tudor and Selley (1974)	Palatal stimulation and visual feedback of palatal evaluation	24	Actual evaluation measures could not be discerned but radiography was included	Closure was established in practice tasks but did not transfer to spontaneous speech.
Peterson (1974)	Electrical or tactile stimulation of the soft palate	20	Comparison of cinefluorographic measures of speech and blowing with task performance	Direct palate stimulation below pain threshold did not result in consistent palatal elevation.
Combinations				
Blakeley (1960)	Speech appliance	1	Author's evaluation of the patient	Appliance was removed with slight hypernasality but articulation was not altered.
Blakeley (1964)	Speech appliance reduction	3	Author's evaluation of the patients	Effects upon articulation and resonance were negligible with all three patients.
Blakeley (1969)	Speech appliance reduction	Approx. 100	Nasal flutter test and listening tubes	Twenty-two of the patients no longer required speech appliances.
Blakeley and Porter (1971)	Speech appliance reduction	1	Manometry, nasal flutter test, listening tubes, articulation testing, and lateral X-ray	Patient no longer needed obturation.
Weiss (1971)	Speech appliance reduction	125	Judgment of resonance quality	Twenty-three patients discontinued use of their speech appliances
Wong and Weiss (1972)	Speech appliance reduction	40	Judgements of articulation and resonance quality	Twenty patients discarded their appliances permanently.
Shelton et al. (1971a)	Speech appliance reduction	3	Oral and nasal SPL, nasal air pressure, articulation tests, and cinefluorography	Dependent variable measures did not show changes.

a reported finding, confidence in that finding is greatly increased." A number of investigations are excellent examples of training studies which have clearly outlined the treatment that was employed (Shelton et al., 1978; Sphrintzen, McCall, and Skolnick, 1975; Moller et al., 1973).

Another factor is the amount of time invested in a particular treatment. This is especially relevant for those studies that have evaluated the utility of speech appliance reduction. In some studies some patients have worn appliances for extended time intervals and then had them reduced or removed completely (Wong and Weiss, 1972; Weiss, 1971; Blakeley, 1969). It is difficult to establish a treatment effect for a procedure which is administered over a period of years. This is not to deny such results, but the longer the duration of treatment, the more likely for intervening variables to influence the outcome of the experiment (Hubbel, 1981).

An additional methodological problem in a number of studies was the administration of different treatments simultaneously. For example, investigators (Yamaoka et al.; Massengill et al., 1968) have provided palatal training activities in conjunction with articulation therapy to their experimental subjects. Post-training changes in palate dependent variable measures were attributed to the palate training program. The fact that different treatments were administered does not allow one to state with any degree of confidence that one of the treatments was directly responsible for any measured changes. The ambiguity of such experimentation creates problems of internal validity (Campbell and Stanley, 1963) and greatly limits any direct statements regarding treatment effectiveness.

A final point concerns the dependent variable measures that have been used. Experimenters in many cases have used a single measure and then made statements based on that measure exclusively. Shontz (1963) has stated that measurement variables can be organized into direct and remotely controlled categories. A measurement variable under direct control furnishes some index of direct observation. A study technique such as cinefluorography would presumably allow the experimenter direct observation of the phenomenon of interest. Remotely controlled variables give information which is used to for-

TABLE 1. SUMMARY OF INVESTIGATIONS THAT HAVE BEEN REVIEWED—*continued*

Investigator	*Type of Stimulation*	*Number of Subjects*	*Evaluation Measures*	*Outcome*
Shelton et al. (1971b)	Speech appliance reduction	18	Cinefluorographic assessment of posterior pharyngeal wall	No alteration in pharyngeal wall movement was found.
Nishio et al. (1974)	Observation of velopharyngeal port during blowing and speech via a nasal fiberscope	19	Nasal fiberscopic examination (other measures were not specified.)	All subjects developed closure for fricatives and plosives after one month of training.
Yamaoka et al.	Observation of velopharyngeal part during blowing and speech via a nasal fiberscope	59	Nasal fiberscopic examination	Nine patients developed closure across all test contexts.
Sphrintzen, McCall and Skolnick (1975)	Practice of simultaneous blowing or whistling and speech, then speech alone, Instances of nasal airflow were identified with a scape-scope.	4	Videofluoroscopy nasality ratings, and monitoring nasal emission	Two subjects achieved acceptable closure for speech while an additional subject improved but not completely.

mulate inferences about the phenomenon of interest, but rules of correspondence must be established between the phenomenon of interest and the measurement variable. For example, one might obtain nasal airflow data and then make certain inferences concerning the status of velopharyngeal closure for speech.

Since measurement procedures supply different types of information, it seems important that dependent variable measures include perceptual, acoustic, and physiological data. Shelton and Trier (1976) have described velopharyngeal closure for speech as a complex process which requires very systematic study through multiple measurement techniques. This philosophy has not been consistently employed in investigations that evaluated palatals training procedures.

FUTURE RESEARCH. Fletcher et al. (1977) have stated that the potential to change velopharyngeal closure and the stability to change are probably influenced by many variables. Some may not be subject to precise experimental control. The extreme variation in results seen across investigations suggests that palate training may be a treatment procedure for a very limited number of individuals with velopharyngeal inadequacy for speech. Perhaps predictor variables should be utilized in case selection so that treatments are evaluated with persons who may have the potential for change. The work of Sphrintzen, McCall and Skolnick (1975) is an example, where subjects demonstrated the ability to achieve closure during blowing or whistling activities. Since closure requirements for the activities approximated closure during speech, the subjects were selected to receive the experimental treatment.

The concept of palatal training with subjects who show certain limited patterns of closure is similar to the clinical use of stimulability testing (Shelton, Hahn, and Morris, 1968). It should be noted that in either case, there is no guarantee that a closure pattern in one activity will generalize to another. However, the inclusion of such a control measure or some other may serve an important function in future palatal treatment studies.

Finally, recent methodologies presented by Shelton et al. (1978) and Sphrintzen, McCall, and Skolnick (1975) appear to hold promise for the future. Both investigations had treatment regimens which incorporated biofeedback training and thus enabled individuals to obtain ongoing performance information while producing speech. In the case of the Sphrintzen et al. (1975) investigation, patients practiced simultaneous whistling or blowing with speech. The activity was gradually faded to speech exclusively.

The biofeedback techniques reported in the Davis and Drichta paper (1980) support these methods in the modification of various speech disorders.

Conclusion

The utilization of palatal training procedures by the speech pathologist remains an issue that has not been resolved. Present clinical treatments directed to the palatal mechanism do not have empirical support and consequently cannot be successful on a routine basis. At the present time most patients with velopharyngeal inadequacy for speech generally require surgical or dental management to correct the closure problem (Shelton, Hahn, and Morris, 1968).

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