Section V. Resonance and Phonation

SAMUEL G. FLETCHER, Ph.D. (CHAIRMAN)

Despite an ever widening scope of topics in cleft palate research, progress in rehabilitation is still largely defined by the extent to which speech disorders exist, may be prevented, or are eradicated (Bauer, 1972; Randal, 1974; Kraus, VanDemark, and Tharp, 1975; Wilder and Baken, 1975).

In the speech section of the previous state-of-the-art review (Spriestersbach et al., 1973) major attention was given to three broad aspects of speech research: 1) disturbances in anatomical and physiological aspects of speaking; 2) assessment of special speech characteristics and disorders attributable to maxillofacial anomaly; and 3) therapeutic processes and procedures for speech habilitation. A number of issues identified in the earlier review remain unresolved. For example, information is still unavailable concerning a variety of essential components of velopharyngeal (V-P) movement in speakers with V-P insufficiency. These include a description of the distribution of forces impinging upon the velopharyngeal valve during normal and impaired speaking, physiologic patterns of altered velar function as a consequence of adenoidectomy and other forms of surgical intervention, and modifications in sound transmission occurring in response to partial-to-complete obstruction of the nasal passageways and associated disturbances in V-P valving.

Three major concerns appear in the forefront of speech resonance and phonation research during the 1972–1976 period: (a) incidence and characteristics of deficiencies in palatopharyngeal structure without overt cleft, (b) development and use of instrumentation and procedures to increase diagnostic and management precision, and (c) systematic evaluation of speech treatment restults. The importance of multistructural dynamic impairment has also been mentioned frequently but has received little direct attention.

Dr. Fletcher is Professor of Biocommunication, Dentistry and Rehabilitation Medicine, Chairman, Biocommunication Department, University of Alabama in Birmingham, P.O. Box 187, University Station, Birmingham, Alabama 35294.

Palatopharyngeal Disturbance Without Overt Cleft

Identification of palatopharyngeal disturbance in the absence of overt cleft serves to highlight a variety of disorders with potentially common speech symptomatology. Calnan (1976) recently re-presented his system for classifying such disturbances. Minami and associates (1975) proposed an expanded etiological classification system in which nearly fifty types of disability known to affect palatopharyngeal structure and function are itemized. They also reviewed observations from 188 patients and attempted to differentiate etiological indices, certain speech characteristics, and appropriate surgical management as a function of disability type. Such information provides an excellent foundation for definitive documentation of speech signs, disorders, and incidence of impairment among patients with the heterogeneous disabilities.

Several papers have appeared recently that provide information about aspects of palatopharyngeal function that have been given little prior attention. Gibb and Stewart (1975) described a patient with "hysterical" hypernasality following simple tonsil dissection. Adenoidectomy was not performed. They suggested that the possibility of emotional reactions should be considered when organic impairment cannot be firmly established.

Messengill, Pickerel and Robinson (1973) observed that some patients with submucosal cleft palate (SMCP) do not

have hypernasal speech. However, in their opinion, patients of this type are few in number. The low incidence claim was recently challenged by Porterfield, Mohler, and Sandel (1976) who reported that 18 of 97 patients they identified with SMCP had normal speech.

An electronic instrument which uses the principle of translumination to detect muscular discontinuity in submucous cleft palate has been described by Pawlawski (1975). The data reported demonstrated an ability to distinguish such persons from those with normal palatal structure.

Hypernasality is typically identified as a consequence of developmental or disease trauma to velopharyngeal structures. Recent advances in facial surgery to correct retroposition of the maxilla have provided an additional opportunity to learn more about the relationships between palatopharyngeal morphology and nasality. Schwartz and Gruner (1976) identified perceptable alterations in nasal resonance as a function of surgically changing the position of the maxilla and attached soft palate. Maxillary advancement was associated with a slight to moderate increase in perceived nasality in 27 of 31 (87%) patients studied with repaired palatal clefts. A small, but identifiable, increase in perceived nasality was detected in two (22%) of 9 patients with no overt palatal clefts. There appeared to be little correspondence between the extent of maxillary advance and the degree of change in nasality. Using Schwartz and Gruner's data, a correlation coefficient was calcualted to examine the strength of this association. The resultant value ($r = .18$) was low and nonsignificant. A variety of explanations could be advanced to account for the intersubject differences in speech degradation following maxillary advancement. For example, differences in degree of velopharyngeal competency could have been unmasked by the changes in structural morphology. Conversely, variation in the strategies used to adapt to the surgically restructured morphology may have been an important factor in the degree of speech degradation found. The potential for gaining new information concerning speech adaptation through study of such patients appears promising.

Vocal Tract Functions Related to Cleft Palate

The introduction of new instrumentation brings opportunity to re-evaluate current concepts about structural deficiencies and speech performance as well as to increase the precision of observations being made. In a review of radiographic techniques used to study velopharyngeal function, Skolnick (1975) called particular attention to the three-dimensional, sphincteric valving characteristics of the V-P portal. Drawing upon evidence from a series of frontal-, lateral- and basal-view studies, he and his associates made videofluroscopic observations which provide unique insight into specific dynamics of V-P action. A system for classifying the spectrum of sphincteric patterns from the basal view orientation supports this thesis. A problem of basal view x-ray is the "sphinx" position used to visualize the soft tissue activities. Shelton and Trier (1976) pointed out that this abnormal posture can influence both the anatomical relationships of the palatopharyngeal structures at rest and the subsequent motion patterns as the person speaks. They also note that the use of radiopaque media to define soft tissue boundaries has been shown to change speech patterns in certain subjects.

Visualization of sphincteric action of palatopharyngeal valving similar to that of basal-view videofluoroscopy may be obtained by oral and nasal endoscopy or fiberoscopy without the risk of radiation. Willis and Stutz (1972) and Zwitman, Sonderman, and Ward (1974) have presented systems for classifying the V-P valving patterns from oral endoscopy. Piggot and Makepiece (1975) and Matsuya, Miyazaki, and Yamaoka (1974) have described V-P functions from nasal endoscopic and fiberoptic viewpoints respectively.

The obvious disadvantage of oral endoscopy is that the instrument lies on or above the tongue during examination. This restricts the phonetic repertoire for speech observations essentially to low vowels and labial consonants. Nevertheless, as shown

by Zwitman, Gyepes and Ward (1976) the observations which can be made show good agreement with those from basal view fluoroscopy.

While nasal endoscopy and fiberoscopy yield data on V-P function without the phonetic restrictions of oral endoscopy, possible changes in physiology from the discomfort incident to insertion of the instrument through the nasal cavities has not been investigated.

A serious problem of all endoscopic and fiberoptic systems for visualizing sphincteric actions of palatopharyngeal valving is quantification. Present lens systems used in endoscopy have progressive distortion from the center of the image (Schwartz, 1975), and none of the instrumental approaches now available enable specification of the cephalocaudal level at which V-P function is being monitored. Use of multi-element ultrasound tranducers (Skolnick, McCall, and Barnes, 1973) may assist in identifying the region of maximum motion and thus help resolve questions concerning the cephalocaudaul level of movements being scrutinized.

The main source of speech degradation associated with palatal clefts is recognized to be from residual disturbances in palatopharyngeal valving. Despite excellent surgery, the incidence of speech impairment has remained in the range of 25% (Morris, 1973). The nature of these remaining disorders is not well understood. Saxman (1972) has suggested that aerodynamic and acoustic disturbances resulting from defective oral-nasal coupling may precipitate secondary reactions in other speech structures. He noted that assessment of such consequences will require multistructural observations for adequate documentation. Ericsson (1973) speculated that compensatory articulation patterns acquired prior to achieving velopharyngeal competence may interfere with later adaptations in V-P function. Unexplored is the possibility that certain intricate coordinations of the laryngeal, oral, and palatopharyngeal structures essential to fine control of nasal resonance have not been acquired. Such considerations have led to expanding cleft palate research to structures of the vocal tract other than those of the velopharyngeal area.

From pneumographic studies Troncyzńska (1972) reported that cleft palate speakers as a group have a greater frequency of breaths during speech than their normal counterparts, and the rate difference tends to become more exaggerated with speech habilitation. Similar observations with respect to control of the airstream were summarized by Warren (1975) in his recent review of aerodynamic changes related to palatopharyngeal incompetency.

Changes in laryngeal function have also been observed in speakers with palatopharyngeal anomalies. McWilliams, Lavorato, and Bluestone (1973) reexamined 27 patients approximately five years after abnormalities of the vocal cords had been identified. They found that 70 per cent of the subjects still demonstrated vocal cord abnormalities and that 53 per cent of those speakers showed the same condition as found previously. All subjects in this latter group had vocal nodules. They also noted that hoarse voice quality persisted in eight subjects although the vocal folds no longer appeared abnormal.

Other evidence of differences in laryngeal function in the presence of nasalization and of assimilated nasality in utterances of normal speakers has been provided by Hamlet (1973). She used combined ultrasonic and acoustic techniques to measure the open quotient of the vocal fold vibratory cycle and peak-to-peak amplitude of the sound waves. From these data she observed that, at equal levels of sound intensity, the open quotient of nasalized vowels was comparable to that of non-nasalized vowels produced during loud phonation. With the degree of mouth opening controlled, the difference between the two modes of speaking was increased. Her conclusion was that "glottal tightness" evidenced by the reduced open quotient could contribute to hoarseness, harshness and vocal nodules secondary to hypernasality.

An aspect of laryngeal physiology that appears likely to characterize differences between cleft palate and noncleft palate

speakers is voice onset time (VOT). Zlatin and Koenigsknecht (1975) and Kent (1976) summarized a series of studies which demonstrate a clear maturational relationship in the pattern of VOT. Kent (1976) indicated that in the first words spoken by children VOT is unimodal. That is, no difference is evident in the timing of voice onset whether the consonant uttered is voiced or voiceless. Shortly thereafter, the VOT values become bimodal, and the overlap between voiced and voiceless consonant ceases. After about eight years of age, VOT is stabilized and remains in the adult pattern. Interactions between changes in laryngeal function associated with palatal clefts and voice onset time have not as yet been reported. Presumably, the series of adaptations in vocal tract functions incident to surgical and developmental changes in and around the oral and pharyngeal cavities would exert a parallel influence on fine motor control of the larynx and consequently have a concomittant significant effect on the maturation of VOT.

The foregoing discussion suggests that laryngeal physiology is likely to become a vital consideration in future treatment, planning, and management for cleft palate speakers.

The morphology and physiology of structures in the oral cavity are also intimately associated with proficiency of speech in those with palatal clefts. The position of the tongue within the oral cavity and the extent of mouth opening have a direct influence on the degree of nasal resonance, as shown in studies reviewed by Lubker (1975). For example, to counteract the increased acoustic impedance during the utterance of vowels such as /i/ and /u/ with high tongue and close jaw positions, the soft palate is raised higher and achieves tighter contact. Electromyographic evidence cited by Lubker suggests additionally that subtle but systematic differences may exist in velopharyngeal valving during production of the consonants although such variations has not been demonstrated as yet by other observational procedures. New technologies such as point parameterization of tongue and palate positions (Kent, Carney and Severeid, 1974), microbeam x-ray (Kiritani, Itoh, and Fujimura, 1975) and palatometry (Fletcher, McCutcheon, and Wolf, 1975) provide ways of specifying structural positions, motions, and contact patterns and may be expected to pave the way toward exploring interstructural relationships in greater depth than has hitherto been done.

Configuration and patency of the nasal airways has received surprisingly little attention as an influence in the patterns of speech production associated with palatal anomaly. It seems likely that the lack of correspondence between deficiency of velopharyngeal valving and many of the attributes of speech disturbance may be related to great variation in anatomical configuration and acoustical transmission properties of the nasal tracts as suggested in 1956 by Counihan.

Ultimately, the listener responds to multiple sources of signal disturbance by a single judgment of perceived "nasality." Degree of velopharyngeal closure represents only one of a number of potentially altered vocal tract properties. Saxman (1972) has emphasized that inadequacies of V-P valving account for only about 25 per cent of the total variance in speech proficiency of cleft palate speakers. The recognition of multiple vocal tract disturbances has brought a resurgence of interest in acoustical measurements (Ericsson, Fant, and deSerpa-Leitao, 1973) which may reflect more encompassing assessment of speech production and thereby achieve closer congruence between perceptual observations and instrumental measurements. For example, a recent study by Fletcher (1976) has shown that a ratio of sound emitted from the nasal and oral cavities within a specific resonance frequency range agrees closely with judgments of perceived nasality. Lindqvist and Sundberg (1972) demonstrated that, when the frontal and nasal sinuses are included as shunting cavities in a twin tube model of the vocal tract, the resonance response curve peaks in the range of 400–600 Hz. This frequency range corresponds with that identified emperically by Fletcher as the region where

oral and nasal signals of speakers with varying degrees of nasality contrast maximally.

Another approach to analysis of nasal and oral signals has been described by Stevens, Kilikow and Willimain (1975). Small, vibration sensitive accelerometers were attached on the neck near the larynx and at the external surface of the nose. The neck-attached sensor was used for later pitch extraction while the one on the nose served to detect the presence of acoustic coupling between the nasal and oropharyngeal cavities. Computer aided displays were used to contrast nasal and nonnasal speech sounds and to indicate nasalization. Correlations between such measures and listener judgments of nasality have not yet been determined.

Modification of Nasal Resonance

An implicit assumption of speech intervention is that speech handicapped persons have residual potential for improvement. The degree of such potential and the stability of changes anticipated are further presumed to be influenced by a variety of factors, many of which may not be controllable. As indicated by the review to this point, such factors include the extent of deviation from a "normal" vocal tract, unused physical ability to "compensate" for deviations or deficiencies inspeech structures, the accuracy with which impairments in structure and function are identified, and the strength of deviant speech production patterns. They also include the person's motivation for changing his speech and the precision of sensing and timing reinforcement of improvements attained (Fletcher, 1973).

A common approach to treatment of speech disabilities related to palatal clefts has been through use of muscle exercises. Such routines have been directed toward gaining voluntary control of muscular functions and increasing the strength, bulk and flexibility of the palate. For example, Massengill and Quinn (1974) described a patient diagnosed as having developed velopharyngeal inadequacy and associated hypernasality incident to regression of adenoidal tissue. They claimed that following a six-month period of sucking exercises, performed ten minutes per day, velopharyngeal insufficiency was overcome.

As noted in a brief review by Powers and Starr (1974), the validity of the association between muscle exercises and speech has been increasingly challenged. To test the hypothesized relationship, they conduced a carefully structured experiment. Four subjects were chosen who had residual nasality following original cleft palate surgery and appeared to have the potential for V-P closure as indicated by oral manometry tests. Cephalometric films demonstrated such closure was not accomplished during sustained utterance of the vowel /i/. The experimental treatment program consisted of blowing, sucking, swallowing, and gagging exercises performed two to four times each day, five days per week, for six weeks. Post-treatment evaluations immediately after completion of the program and six weeks later included V-P gap measurements and ratings of nasality. The mean V-P gap was .75 mm larger immediately after the program and 0.14 mm larger six weeks after the program's conclusion. Mean nasality on a nine-point scale decreased 0.13 between the pretest and immediate post-test and 0.06 between the pretest and final post-test. None of these differences was signıficant. Thus, the creditability of the notion that voluntary muscle exercises *per se* improve V-P closure or decrease nasality is seriously challenged by the results of this study.

The capability of a clinician to sense small decrements in nasality and provide reinforcement at the most propituous moment has also been challenged (Fletcher, 1973). Spriestersbach et al. (1973) stated bluntly that "Velopharyngeal incompetence does not appear to be a problem that can be solved by [speech] therapy".

There is reason to believe that much of the failure in bringing about systematic reduction in excessive nasal resonance may be related to the perceptual difficulties facing clinicians in this task rather than the inability of a speaker to modify patterns of nasality. To increase the accuracy of detecting improvements in velopharyngeal

valving, instrumental procedures have been increasingly sought. Several investigators have shown results. In the prior state-of-the-art review a number of instruments were described which could be used to help in assessing speech functions and determining more precisely the nature and magnitude of disturbances perceived by the speech pathologist. During the 1972–1976 period, increased attention has been given to use of instrumental feedback to assist in modification of disordered speech production patterns.

Shelton et al. (1975) used videopanendoscopic feedback to assist three normal speakers in their efforts to gain voluntary control of palatopharyngeal closure. The speakers were instructed to observe the actions of closure displayed on the video monitor during fixation of the larynx and during gagging then attempt to simulate the action consciously. All three subjects were able to do this.

The capability of modifying defective velopharyngeal closure on the basis of visual feedback has also been claimed by Miyazaki and his associates (1975). They reported that patients with velopharyngeal inadequacy had been benefitted through use of a fiberoptic instrument connected to a video monitor to visualize the movements of their palates. Formal documentation of change in V-P valving and associated effects on speech was not provided.

The importance of habitual speaking patterns as well as accurate feedback has been shown by Fletcher, Sooudi and Frost (1974). In a combined prosthesis-acoustic study, they compared changes in the ratio of nasal and oral sound in the speech of four types of subjects: thirteen speakers with residual hypernasality after primary cleft palate surgery, twelve with hypernasality following surgery for carcinoma of palatal structures, four with hypernasality incident to congenital palatal insufficiency without overt clefts, and three with unrepaired cleft palates with associated hypernasality. Changes in "nasalance" were measured using TONAR 11 prior to and following revisions of speech prostheses. Of particular interest was evidence of regression in nasalance from the level attained through prosthetic obturation. In many speakers with prolonged velopharyngeal incompetence, a mild increase in the level of nasalance was observed during the initial period of adaptation to the prosthesis. This was typically followed by a spontaneous reversal and nasalance was again reduced toward a more normal level. In two speakers, one with congenital palatal insufficiency and one with hypernasality after original surgery for cleft palate, nasalance regressed to virtually preprosthesis level. In contrast, little or no nasalance regression was observed among the speakers with surgically acquired palatal defects who had once had normal speech. The interpretation of these findings was that the ingrained feedback references of speakers with congenital V-P insufficiency or with insufficiency spanning many years precipitated motor behavior that circumvented the prosthetic obturation of the velopharyngeal portal. In most instances, these "compensatory" behaviors apparently gradually eroded and nasalance was reduced. That the two speakers with complete nasalance regression had the physiological capability for normal speech was demonstrated by rapid reduction in nasalance when instrumental feedback and nasalance shaping procedures were instituted. Stability of the reductions achieved and further general improvement in the speech proficiency have since been verified in annual rechecks.

A study of Shprintzen, McCall, and Skolnick (1975) suggests that the ability of subjects to attain palatopharyngeal closure in non-speech acts may be generalized to speech using relatively simple instrumental feedback. This viewpoint contrasts sharply with the assertion by Moll (1965) that differences in velopharyngeal actions during blowing and speaking "caste considerable doubt on the validity of using . . . blowing activities to develop velopharyngeal closure for speech." In support of their viewpoint, Shprintzen, McCall, and Skolnick described three patients with residual hypernasality after primary palatal repair and one after secondary pharyngeal flap surgery. All had had varying amounts of speech therapy without successful re-

duction in their nasality. Multiview fluoroscopic techniques revealed that V-P closure was achieved during blowing and whistling but not speech. A device called a "scape scope" was used to provide feedback concerning velopharyngeal action during treatment. Using such feedback the speaker with the recent pharyngeal flap and two of the other three subjects were reported to gain normal velopharyngeal function in conversational speech. Retention of the function was verified in a post-treatment evaluation one year later.

A displacement transducer designed for monitoring palatal movements was described by Moller, Path, Werth, and Christensen (1973). By means of a spring tip sensor in contact with the oral surface of the soft palate, velar elevation was monitored. The degree of elevation was then detected and indicated to the speaker on an oscilloscope screen. Benefits of this device were evaluated in a single-subject experiment with a 12-year-old boy whose speech was intelligible but moderately hypernasal. Lateral still x-rays demonstrated a two to three mm V-P gap during utterances of /u/ and /s/. Following 14 sessions of treatment using this instrument to provide feedback concerning velar movement during production of an isolated /u/ vowel, radiographic measurements of velar elevation demonstrated an increase of about 2.5 mm during the period of study. The velopharyngeal gap, however, remained constant indicating that factors other than that measured were responsible for persistance of the gap. Perceptual judgments of hypernasality during utterance of the /u/ remained unchanged during the study.

Tudor and Selley (1974) have claimed "encouraging results" from use of a contact sensing transducer against the oral surface of the soft palate. The sensor was positioned so that elevation of the palate interrupted a small current. The speakers were notified when contact ceased by means of circuitry which switched off a light. Subjects were encouarged to gain awareness of the "feel" of the contact, no-contact states indicated by the instrument then to use the resulting sensation in home practice sessions. Unfortunately, only informal evaluations of changes in speech were reported.

Finally, several articles have appeared which summarize current practices in management of patients with palatopharyngeal insufficiency and associated speech disorders. These serve to increase general awareness and understanding of the new knowledge acquired concerning structure, function, and speech proficiency. Examples of such articles which have appeared during the 1972-to-1976 time period are articles by Morris (1975) addressed to otolaryngologists and Mason (1973) to pediatricians on postadenoidectomy hypernasality and by Randall (1974) and Wilder and Baken (1975) to physicians and dentists respectively on problems and management of "cleft palate speech."

References

BAUER, H., [Characteristics and phoniatric treatment of speech disorders caused by cleft palate with special reference to present day knowledge], *Folia Phoniat., 24,* 387–399, 1972. [Ger.]

CALNAN, J., Surgery for Speech. In *Recent Advances in Plastic Surgery.* Edinburgh: Churchhill Livingston (pub), p. 39–57, 1976.

COUNIHAN, D. T., *A Clinical Study of the Speech Efficiency and Structural Adequacy of Operated Adolescent and Adult Cleft Palate Patients,* Unpub. Ph. D. Diss., Univ. Mich., Ann Arbor, p. 204–208, 1956.

ERICSSON, G., FANT, G., and DESERPA-LEITAO, A., Medical applications. A. acoustical and perceptual evaluation of speech training in postoperative cleft palate patients, *STL-QPSR,* p. 25–28, 1973.

FLETCHER, S. G., Perceptual skills in clinical management of nasality, *Folia Phoniat., 25,* 137–145, 1973.

FLETCHER, S. G., "Nasalance" vs. listener judgments of nasality, *Cleft Pal. J., 13,* 31–41, 1976.

FLETCHER, S. G., MCCUTCHEON, M. J., and WOLF, M. B., Dynamic palatometry, *J. Speech Hear. Res., 18,* 812–819, 1975.

FLETCHER, S. G., SOOUDI, I., and FROST, S. D., Quantitative and graphic analysis of prosthetic treatment for "nasalance" in speech, *J. Prosth. Dent., 32,* 284–291, 1974.

GIBB, A. G., and STEWART, I. A., Hypernasality following tonsil dissection-hysterical aetiology, *J. Laryngol. Otol., 89,* 779–781, 1975.

HAMLET, S. L., Vocal compensation: An ultrasonic study of vocal fold vibration in normal and nasal vowels, *Cleft Pal. J., 10,* 267–285, 1973.

KENT, R. D., Anatomical and neuromuscular maturation of the speech mechanism: Evidence from acoustic studies, *J. Speech Hear. Res., 19,* 421–457, 1976.

KENT, R. D., CARNEY, P. J., and SEVEREID, L. R., Velar movement and timing: Evaluation of a model for binary control, *J. Speech Hear. Res., 17,* 470–496,

1974.

KIRITANI, S., ITOH, K., and FUJIMURA, O., Tongue-pellet tracking by a computer-controlled x-ray microbeam system, *J. Acoust. Soc. Am., 57,* 1516–1520, 1975.

KRAUS, C. J., VANDEMARK, D., and THARP, R., Palatoplasty: A comparative study, *Tr. Am. Acad. Opth. Otol., 80,* 551–559, 1975.

LINDQVIST, J., and SUNDBERG, J., Acoustic properties of the nasal tract, *STL-QPSR,* p. 13–17, 1972.

LUBKER, J. F., Normal velopharyngeal function in speech, *Clin. Plast. Surg., 2,* 249–259, 1975.

MASON, R. M., Preventing speech disorders following adenoidectomy by preoperative examination, *Clin. Pediatrics, 12,* 405–414, 1973.

MASSENGILL, R., and QUINN, G., Adenoidal atrophy, velopharyngeal incompetence and sucking exercises: A two year follow-up case report, *Cleft Pal. J., 11,* 196–199, 1974.

MASSENGILL, R., JR., PICKRELL, K., and ROBINSON, M., Results of pushback operations in treatment of submucous cleft palate, *Plast. Reconstr. Surg., 51,* 432–435, 1973.

MATSUYA, T., MIYAZAKI, T., and YAMAOKA, M., Fiberscopic examination of velopharyngeal closure in normal individuals, *Cleft Pal. J., 11,* 286–291, 1974.

MCWILLIAMS, B. J., LAVORATO, A. S., and BLUESTONE, C. D., Vocal cord abnormalities in children with velopharyngeal valving problems, *Laryngoscope, 83,* 1745–1753, 1973.

MINAMI, R. T., KAPLAN, E. N., WU, G., and JOBE, R. P. Velopharyngeal incompetence without overt cleft palate, *Plast. Reconstr. Surg., 55,* 573–587, 1975.

MIYAZAKI, T., MATSUYA, T., and YAMAOKA, M., Fiberscopic methods for assessment of velopharyngeal closure during various activities, *Cleft Pal. J., 12,* 107–114, 1975.

MOLL, K. L., A cinefluorographic study of velopharyngeal function in normals during various activities, *Cleft Pal. J., 2,* 112–122, 1965.

MOLLER, K. T., PATH, M., WERTH, L. J., and CHRISTIANSEN, R. L., The modification of velar movement, *J. Speech Hear. Dis., 38,* 323–334, 1973.

MORRIS, H. L., Velopharyngeal competency and primary cleft palate surgery, 1960–1971: A critical review, *Cleft Pal. J., 10,* 62–71, 1973.

MORRIS, H. L., The speech pathologist looks at the tonsils and the adenoids, *Ann. Otol., Rhinol., Laryngol., 84,* 63–66, 1975.

PAWLOWSKI, Z. [Electropalatography: Experimental and clinical studies], *Otolaryng. Pol., 29,* 265–273, 1975. [Pol.]

PIGOTT, R. W., and MAKEPIECE, A. P. W., The technique of recording nasal pharyngoscopy, *Brit. J. Plast. Surg., 28,* 26–33, 1975.

PORTERFIELD, H. W., MOHLER, L. R., and SANDEL, A., Submucous cleft palate, *Plast. Reconstr. Surg., 58,* 60–65, 1976.

POWERS, G. L., and STARR, C. D., The effects of muscle exercises on velopharyngeal gap and nasality, *Cleft Pal. J., 11,* 28–35, 1974.

RANDALL, P., Velopharyngeal incompetence, *Texas Med., 70,* 69–75, 1974.

SAXMAN, J. H., A call for new directions in cleft palate research, *Cleft Pal. J., 9,* 284–279, 1972.

SCHWARTZ, C., and GRUNER, E., Logopaedic findings following advancement of the maxilla, *J. max.-fac. Surg., 4,* 40–55, 1976.

SCHWARTZ, M. F., Developing a direct, objective measure of velopharyngeal inadequacy, *Clin. Plast. Surg., 2,* 305–308, 1975.

SHELTON, R. L., and TRIER, W. C., Issues involved in the evaluation of velopharyngeal closure, *Cleft Pal. J., 13,* 127–137, 1976.

SHELTON, R. L., PAESANI, A., MCCLELLAND, K. D., and BRADFIELD, S. S., Panendoscopic feedback in the study of voluntary velopharyngeal movements, *J. Speech Hear. Dis., 40,* 232–244, 1975.

SHPRINTZEN, R. J., MCCALL, G. N., and SKOLNICK, M. L., A new therapeutic technique for the treatment of velopharyngeal incompetence, *J. Speech Hear. Dis., 40,* 69–83, 1975.

SKOLNICK, M. L., Velopharyngeal function in cleft palate, *Clin. Plast. Surg., 2,* 285–297, 1975.

SKOLNICK, M. L., MCCALL, G. N., and BARNES, M., The sphincteric mechanism of velopharyngeal closure, *Cleft Pal. J., 10,* 286–305, 1973.

SPRIESTERSBACH, D. C., DICKSON, D. R., FRASER, F. C., HOROWITZ, S. L., MCWILLIAMS, B. J., PARADISE, J. L., and RANDALL, P., Clinical research in cleft lip and cleft palate: The state of the art, *Cleft Pal. J., 10,* 113–165, 1973.

STEVENS, K. N., KALIKOW, D. N., and WILLEMAIN, T. R., A miniature accelerometer for detecting glottal waveforms and nasalization, *J. Speech Hear. Res., 18,* 594–599, 1975.

TRONCZYŃSKA, J., Electrorhinopneumography as an objective method of assessment of velopharyngeal insufficiency in cleft-palate patients, *Folia Phoniat., 24,* 371–380, 1972.

TUDOR, C., and SELLEY, W. G., A palatal training appliance and a visual aid for use in the treatment of hypernasal speech, A preliminary report, *Br. J. Disord. Commun., 9,* 117–122, 1974.

WARREN, D. W., The determination of velopharyngeal incompetence by aerodynamic and acoustical techniques, *Clin. Plast. Surg., 2,* 299–304, 1975.

WILDER, C. N., and BAKEN, R. J., Speech habilitation in cleft palate, *New York J. Dent., 45,* 183–189, 1975.

WILLIS, C., and STUTZ, M., The clinical use of the Taub oral panendoscope in the observation of velopharyngeal function, *J. Speech Hear. Dis., 37,* 495–502, 1972.

ZLATIN, M. A., and KOENIGSKNECHT, R. A., Development of the voicing contrast: Perception of stop consonants, *J. Speech Hear. Res., 18,* 541–553, 1975.

ZWITMAN, D. H., SONDERMAN, J. C., and WARD, P. H., Variations in velopharyngeal closure assessed by endoscopy, *J. Speech Hear. Dis., 39,* 366–372, 1974.

ZWITMAN, D. H., GYEPES, M. T., and WARD, P. H., Assessment of velar and lateral wall movement by oral telescope and radiographic examination in patients with velopharyngeal inadequacy and in normal subjects, *J. Speech Hear. Dis., 41,* 381–389, 1976.