Speech and Language Issues in the Cleft Palate Population: The State of the Art

David P. Kuehn, Ph.D.
Karlind T. Moller, Ph.D.

Objective: **State-of-the-art activity demands a look back, a look around, and, importantly, a look into the new millennium. The area of speech and language has been an integral part of cleft palate care from the very beginning. This article reviews the development and progression of our knowledge base over the last several decades in the areas of speech; language; anatomy and physiology of the velopharynx; assessment of velopharyngeal function; and treatment, both behavioral and physical, for velopharyngeal problems.**

Method: **The clear focus is on the cleft palate condition. However, much of what is reviewed applies to persons with other craniofacial disorders and with other underlying causes of velopharyngeal impairment. A major challenge in the next several years is to sort through speech disorders that have a clear anatomic underpinning, and thus are more amenable to physical management, versus those that may be treated successfully using behavioral approaches. Speech professionals must do a better job of finding and applying ways of treating individuals with less severe velopharyngeal impairment, thus avoiding the need for physical management in these persons or ignoring the speech problem altogether.**

Conclusion: **Early and aggressive management for speech and language disorders should be conducted. For most individuals born with cleft conditions, a realistic goal should be normal speech and language usage by the time the child reaches the school-age years.**

KEY WORDS: *cleft lip and palate, language, speech, velopharyngeal impairment*

Dedication

We dedicate this article to H. Harlan Bloomer, Ph.D. (1908–1999), Frederic L. Darley, Ph.D. (1918–1999), Clark D. Starr, Ph.D. (1927–1999), and Willard R. Zemlin, Ph.D. (1929–1998), for their outstanding contributions in developing and sharing wisdom and clinical expertise; expanding our knowledge base through research; and increasing our understanding of the anatomic and physiologic bases of normal speech. We also acknowledge their strong advocacy for the interdisciplinary enterprise. We have been educated, enlightened, and inspired, and we will miss their presence among us.

Management for speech in individuals born with cleft lip and palate and related craniofacial anomalies occurs within three broad categories: surgery, prosthetics, and behavioral therapy. Our goal in this report is to highlight major changes that have occurred in recent years that have an impact on speech and language management for individuals born with such anomalies. We have reviewed the literature, emphasizing the last decade, in the areas of speech and language characteristics, velopharyngeal anatomy and physiology, speech and language diagnostics, and speech treatment in the cleft lip and palate population. Each of these areas will be discussed in the full text version of this report, available for viewing and download from the Cleft Palate-Craniofacial Online Journal (http://cpcj.allenpress.com/cpcjonline/?request=index-html).

Description of Speech Characteristics

Historically, speech characteristics have been an integral part of any description of the sequelae of cleft palate. The structural issues of velopharyngeal function, fluctuating middle ear disease and hearing loss, and dental or occlusal deviations place children with clefts at high risk for speech difficulties. For the most part, children with clefts of the primary palate only, involving the lip and alveolar process, do not demonstrate significant speech problems. In these patients, although there may be labial and dental or occlusal deviations that present hazards to precise articulation, they are often transitory and do not prevent the acquisition of acceptable articulation. Their significance for speech often depends upon the severity

Dr. Kuehn is Professor, University of Illinois at Urbana-Champaign, Champaign, Illinois. Dr. Moller is Professor, University of Minnesota, Minneapolis, Minnesota.

Reprint requests: David P. Kuehn, Ph.D., Department of Speech and Hearing Science, University of Illinois at Urbana-Champaign, 901 S. Sixth Street, Champaign, IL 61820. E-mail: d-kuehn@uiuc.edu.

of the deviation and the existence of a combination of factors including velopharyngeal closure problems. There have been several reviews focusing on dental and occlusal conditions and relationships to speech in persons with or without clefts (Starr, 1979; Peterson-Falzone, 1988; Moller, 1994). Reviews of more general characteristics of speech in individuals with cleft palate have been published more recently (Harding and Grunwell, 1996; Wyatt et al., 1996). The focus of this review will be those structures and valves that function to separate the nasal passage from the oral passage that can prevent acceptable articulation and resonance.

Articulation

Articulation deviations in persons with cleft palate have been recognized and variably described for the better part of this century. Investigations of speech articulation in the 1950s and 1960s focused on description of articulation errors, frequency of errors, type of error, and comparisons with normative data. Clearly, speakers with cleft palate performed less well than speakers without cleft palate at very early ages (Olson, 1965; Bzoch, 1965) and, indeed, as preschool and school-aged children and adults (McWilliams, 1958; Morris, 1962, 1968; Takagi et al., 1965; Moll, 1968). During this time, there was increasing awareness about the heterogeneity of the cleft population and the myriad of structural and learning factors that could affect articulation. There was focus on the relationships among articulation performance and variables such as type of cleft (Spriestersbach et al., 1956; Counihan, 1956; Bzoch, 1956, 1965; Byrne et al., 1961; Spriestersbach et al., 1961), surgical procedures (Spriestersbach and Powers, 1959), and various physiologic and anatomic factors (Starr, 1956; Spriestersbach and Powers, 1959; Subtelny et al., 1961; Van Demark, 1964; Van Demark and Van Demark, 1967; Philips and Harrison, 1969a; 1969b). Based on these studies, it was clear that speakers with cleft palate performed less well than their noncleft palate peers at all ages, although there was considerable variation in speakers with seemingly similar structures and that, indeed, some developed normal articulation. Speech sounds requiring intraoral pressure were mostly affected, nasal consonants and semivowels were least affected, errors increased with increased phonetic complexity, and there was frequent evidence of weak pressure consonant production and audible nasal air emission accompanying pressure consonants. In addition, for some speakers there were unique productions not seen in noncleft speakers. These productions were variously described as glottal or pharyngeal stops and pharyngeal fricatives. Broadly, they were classified as ''gross'' substitution errors (Bzoch, 1971), and the authors talked about them as posterior, compensatory, and maladaptive patterns of articulation. As speech pathologists, the authors considered this pattern to be undesirable because it was inconsistent with normal speech, made it difficult to evaluate adequacy of velopharyngeal closure, and was difficult to modify once habituated (Broen and Moller, 1993). In addition to identifying specific sound errors, group listener judgments/ratings of articulation defectiveness and speech intelligibility during more connected or conversational speech commonly were utilized. Ratings ranged from categorical description (Philips and Bzoch, 1969; Subtelny et al., 1972; McWilliams et al., 1990) to psychological scaling procedures (Hess, 1973; Moller and Starr, 1984). Reliability of listeners' ratings varied but generally have been found to be satisfactory (Van Demark, 1964; Moore and Sommers, 1973; Moller and Starr, 1984; Riski and DeLong, 1984; Van Demark and Hardin, 1986). There is current consensus that multiple-listener judgments are preferred to single-listener judgments even though intralistener reliability has been demonstrated. Clearly, training increases reliability (Fletcher, 1976; Moller and Starr, 1984).

During the 1970s and 1980s speech articulation was systematically described following surgical intervention (Riski, 1979) and change over time (Van Demark et al., 1979; Van Demark and Morris, 1983), and compensatory productions were further delineated (Trost, 1981b). Studies were typically cross-sectional; however, in the last 15 to 20 years, more longitudinal data have been reported (Riski, 1979; Van Demark, 1979; Riski and DeLong, 1984; Broen and Moller, 1993; Neiman and Savage, 1997). Our knowledge about articulation in speakers with cleft palate well into the 1980s was based on the description in persons with sufficient speech development and assessed with available standardized tests and procedures. In general, articulation performance was analyzed at phonetic or taxonomic level (i.e., according to the number or percent of correct versus incorrect productions, types of errors, manner, place and voicing distinctions, consistency of productions [error consistency as well as consistency of correctness], phonetic complexity, and description of the nonstandard or compensatory productions). In this phonetic model, any child, with or without cleft, was assumed to learn or master a set of individual sounds; some sounds that were easier to produce were expected to be learned earlier than other more difficult sounds; and errors were described as omissions, distortions, or substitutions. The compensatory pattern of articulation seen frequently in children with clefts did not seem to fit well within this model.

A state-of-the-art conference report on cleft palate in 1973 (Spriestersbach et al., 1973) called for ''the need for procedures describing the development of articulation skills and accurately identifying their variation in articulation behavior in children with cleft palate.'' An updated state-of-the-art report (Fletcher et al., 1977) suggested we had not progressed significantly in describing variation in articulation behavior but had some new ways of looking at development. The speech and language literature during this time described other models of speech acquisition in children with normal speech structures. These included learning of distinctive features or contrast sounds (Jakobson, 1968; Menyuk, 1968; McReynolds and Huston, 1971), learning a set of phonologic rules (Compton, 1970; Smith, 1973; Ingram, 1974a; 1974b; Dinnsen, 1984;), or learning to suppress natural phonologic processes that act together to simplify speech (Stampe, 1969; Shriberg and Kwiatkowski, 1980). However, as childrens' speech acquisition was followed over time, it became clear that no one system or model explained, in a powerfully predictive way, speech acquisition of normal children. It was clear that children were different and take different paths to eventually master speech articulation. We began to recognize that mastery of the sound system for any particular child was based on individual experiences, speech-producing capabilities, and insights and perceptions into the structure of language. It was important, however, that these models described the productive speech attempts in more detail at earlier ages—not just a listing of errors but patterns of errors that suggested where the child was coming from and, perhaps, the direction in which the child was going.

It was in the early 1980s that articulation description moved from a phonetic orientation to a phonologic orientation. Phonologic implied higher processes of speech, referring to the speaker's knowledge and perception of the sound system and the pattern of errors. Phonetics is a part of phonology, and multiple articulation errors were referred to as sound class problems (Locke, 1983). There was evidence to suggest that normal children with no structural deviations were active and creative in the process of acquiring phonology and that no single order of acquisition existed for all children (Ferguson and Farwell, 1975; Fey and Gandour, 1982). All children initially lack sufficient motor control to produce accurate speech, and their early productions reflect sounds in words they are capable of producing. We came to appreciate that prelinguistic behavior such as babbling may be important as a precursor of early speech and represented a continuum from prelinguistic to early meaningful speech (Lieberman, 1980; Locke, 1983).

These events changed the way the authors viewed children born with cleft palate. Prior to this time, our focus of attention seemed to be on the physical mechanism. There was limited attention to detail on emerging sound production, and we waited to see how speech developed following initial palatal surgery until we could elicit a sufficient speech sample to evaluate. By that time, however, we may have missed important information about childrens' early efforts, what children were attempting to do with the physical mechanism they had, and how they were organizing productive speech efforts to match the more mature adult model. As Menn (1983) suggested, the task that any child faces is to sound like others when communicating with them. Although we recognized that speech is a learned behavior and that factors affecting speech can and will vary from child to child, when children with no physical deviations have speech problems, we assumed they were the products of faulty learning. When clefts were present, we often behaved as though the physical factors were the sole causes of the problems. We began to appreciate that in the presence of a cleft, learning factors, and strategies employed to compensate for the cleft, may play an even more significant role in the acquisition of speech (Moller, 1990). Sound production patterns learned early, desirable or undesirable, may have significant impact on speech performance following primary surgery and the articulation proficiency eventually attained. Trost (1981a) described a range of maladaptive articulation placements utilized by children with cleft palate presumably in an effort to compensate for inadequate velopharyngeal closure mechanism or oral-nasal fistulae. Philips and Harrison (1969) encouraged us to recognize the development of these patterns as early as possible and to intervene when appropriate. Some speakers with cleft palate developed the strategy of compensatory articulation and others did not. We did not always know why.

From the early 1980s to the present time, we have seen increased focus on early vocalizations (babbling) and developing sound productions of children with cleft palate (Dorf and Curtin, 1982; Moller et al., 1984; Philips and Kent, 1984; Grunwell and Russell, 1987; O'Gara and Logemann, 1988, 1994; Chapman, 1991, 1993; Chapman and Hardin, 1992; Broen and Moller, 1993; Lynch et al., 1993; Van Demark et al., 1993; Lohmander-Agerskov et al., 1996). We are currently less content to wait until approximately 2 to 3 years of age for primary palate repair. We recognize that compensatory pharyngeal and glottal patterns might be an early strategy for some but not for others. We know that young children with cleft palate develop prelinguistic and linguistic capabilities at varying ages; some are precocious and earlier palatal repair may be more important for some than others. Warren (1986) suggested that compensatory strategies develop because of the ''need'' to regulate pressures and flows in the vocal tract, even at the expense of undermining speech performance. Kemp-Fincham et al. (1990) argued for primary palate repair, perhaps as early as 4 to 6 months, to avoid maladaptive articulation and delayed meaningful speech. The importance of early and longitudinal description of sound acquisition for children with cleft palate relates to our capability to predict future performance and identify, as early as possible, the need for physical or behavioral intervention (Van Demark, 1979; Broen et al., 1986; Van Demark and Hardin, 1986; Broen and Moller, 1993).

Responses to the early speech utterances of children with cleft palate by parents, peers, and others may also be important in early development and maintenance of compensatory articulation. Studies examining parental and peer preferences (Paynter and Kinard, 1979; Diegel, 1984; Persoon, 1986; Paynter, 1987) suggest rather strongly that the compensatory pattern is perceptually preferred over the pattern of correct placement when there is excessive hypernasality and audible nasal air emission. This suggests that parents and others may be reinforcing a compensatory pattern of articulation and should impel us to educate parents about speech development and appropriate responses to early speech attempts by their children.

We know the infant born with a cleft palate begins the process of learning speech and language early and that it varies from child to child. Each child demonstrates a somewhat different and creative way of attempting to master the sound system based on his or her particular anatomic structure and speech motor control capability (Kemp-Fincham et al., 1990). We recognize the heterogeneic reality of children with cleft palate but have not identified all the factors that contribute to it (Riski, 1995). With more attention to the description of emerging phonologic development, the structural capability of each child can perhaps be determined earlier so appropriate and timely intervention can occur and we can increase the numbers of younger persons with cleft palate who develop acceptable articulation and phonologic skills (Blakeley and Brockman, 1995).

As we move into the next millennium, we need more longitudinal studies that follow up children at early ages and through initial surgical procedures. This should provide opportunities to study timing of surgery factors and sequential events that will help us to identify those factors that better predict eventual speech performance.

Resonance

In addition to articulatory and phonologic aspects, description of the resonance characteristics is usually included for speakers with cleft palate. Indeed, excessive nasality or hypernasality is probably the signature characteristic of persons with cleft palate. In general, we expect persons with clefts involving the primary palate only to have no more resonance problems than speakers without cleft palate. Resonance distortion is, for the most part, the direct effect of coupling of the nasal space with the oral-pharyngeal space during vowel and vocalic productions.

The effects of nasal coupling have been described acoustically (House and Stevens, 1956; Fant, 1960; Dickson, 1962; Warren and Devereaux, 1966) and reviewed by Curtis (1968) and Schwartz (1979). Laboratory experiments in the 1950s and 1960s using electronic speech synthesizers (House and Stevens, 1956; Fant, 1960) demonstrated that increased nasal coupling was directly related to listener judgments of increased severity of nasality. Furthermore, acoustic studies showed that some vowel sounds, specifically the ‘‘low’’ vowels, required a greater amount of nasal coupling to be perceived as nasal. Nasal coupling in the human vocal tract is more difficult to control and derive precise measurements, but physiologic studies of the soft palate elevation associated with various vowels in speakers with normal structures (Moll, 1962) were consistent with acoustic theory predictions. However, the relation between acoustic measures and perceived nasality was far from clear and predictable and varied from speaker to speaker. We came to appreciate that speakers have at their disposal a variety of physiologic compensations that can affect judgments of nasality. Indeed, there have been studies that have investigated oral physiologic maneuvering such as oral port constriction (Dalston and Warren, 1986) and tongue position (Dickson, 1969).

It was written over 50 years ago that the final decision as to whether an individual is nasal is reached through a listener's subjective judgment (Kanter, 1948). Over the years, there have been attempts to develop more ‘‘objective’’ techniques to describe resonance in cleft palate speakers by sensing, detecting, or measuring physiologic or acoustic phenomena thought to be related to what listeners judge to be nasal. These techniques have met with varying degrees of success and will be considered in our discussion of techniques used to evaluate velopharyngeal function. Suffice it to say that at the present time, there is no technique that demonstrates a sufficient relationship to perceived nasality to eliminate the use of perceptual judgments in satisfactory description of speech. The perceptual judgments listeners make about the resonance characteristics will continue to be important and necessary. Instrumental techniques available at this time must still be considered indices of nasality and the final arbiter of nasality lies in the ear of the listener (Kanter, 1948; Moll, 1964).

Perceptual descriptions of resonance in speakers with cleft palate have included judgments of normal versus abnormal; degree or severity utilizing descriptive category judgments such as normal, mild, moderate, and severe; or rating of severity using a variety of psychological scaling procedures such as equal-appearing intervals, direct magnitude estimation, paired comparison, etc. (Subtelny et al., 1972; Moller and Starr, 1984; McWilliams et al., 1990). Clearly, the descriptive category and equal-appearing interval scaling using 5, 7, or 9 points have been employed most frequently. Numbers assigned to descriptive categories or associated with equal-appearing interval scale values have been used to study relationships among nasality and other aspects of speech such as articulation and intelligibility as well as relationships with instrumental assessment of resonance, such as pressures and flows, or physiologic variables such as velopharyngeal opening. Ratings of nasality have also been useful in describing changes in resonance following physical or behavioral intervention. The use of descriptive category judgments, rating of severity, or both will continue to be useful as a means of describing resonance characteristics in speakers with cleft palate.

The extent to which the perception of nasality varies as a function of other aspects of speech has been the focus of several studies over the last 50 years. The studies have shown that nasality is judged to be more severe on high vowels versus low vowels in speakers with clefts (Hess, 1959; Spriestersbach and Powers, 1959), and judgments of severity of nasality vary according to phonetic context (Lintz and Sherman, 1961; Moore and Sommers, 1973) and articulation proficiency (McWilliams, 1954; Van Hattum, 1959). It is generally agreed that articulation defectiveness is related to increased severity of nasality judgments. The relationship of nasality to pitch variation appears to be minimal (Hess, 1959) and unpredictable (Zraick, 1999). Intensity variation also has been shown to have minimal and variable effect on perceived nasality. Starr (1993) concluded that efforts to study intensity effects on nasality are difficult because of other changes that can occur in speech. More recently, Zraick (1999) hypothesized that listeners' perception of nasality is multidimensional involving integrative judgments of nasality, pitch, and loudness. Using a synthesized vowel /i/, the dimensions of pitch, loudness, and nasality were experimentally manipulated and listeners judged the dissimilarity of pairs of stimuli. He found that nasality, pitch, and loudness were correlated with objective measures and that perception of increased nasality was related to increased loudness and an increase or decrease in pitch. Jones and Folkins (1985) found no increase in nasality with increased speaking rate in speakers with cleft palate. Studies investigating the effect of extended speaking time (Webb et al., 1992) and pubertal changes in males (Lang et al., 1992) revealed no clinically significant changes in listener perception of nasality. The effect of voice quality variations on perceived nasality has not been systematically investigated. However, clinical experience suggests that judgments about resonance are difficult to make in the presence of voice-quality deviations. Similar to articulation defectiveness, the presence of voice quality deviations may mask valid judgments of nasality. Indeed, Bzoch (1979) opined that valid judgments about nasality cannot be made because of the multiple articulatory, voice, and speech sampling factors that exist in speakers with clefts. However, McWilliams et al. (1990) believed that judgments of nasality are important clinically and an integral part of the description of speech. Although there has been concern about the reliability of listener judgments (Bradford et al., 1964; Counihan and Cullinan, 1970; Subtelny et al., 1972; Fletcher, 1976) of nasality, especially using isolated vowels, reliability of nasality judgments during connected speech can be increased with training (McWilliams and Philips, 1979; Young, 1969) and use of multiple listener judgments (Moller and Starr, 1984; Starr et al., 1984). It also appears that nasality judgments obtained under different listening conditions such as live, audio, and audiovisual result in similar judgments of nasality, articulation, and intelligibility (Moller and Starr, 1984).

Voice and Other Speech Characteristics

Although there is reported wide variation about the prevalence of voice deviations in persons with cleft palate, they appear to be more frequent than in persons without clefts (D'Antonio et al., 1988; Peterson-Falzone, 1988; Dalston, 1990; McWilliams et al., 1990). The nature of the deviation is most frequently perception of hoarseness, unusual habitual pitch, breathiness, harshness, and reduced loudness. The most common anatomic finding relating to voice deviations is vocal nodules. Although there is no evidence to suggest that the laryngeal or phonatory structures are any different in persons with clefts, the etiology of the voice deviations is best explained by the interaction of velopharyngeal problems and laryngeal compensatory behavior. Acoustic theory would predict that maintenance or increase in speech intensity in the presence of nasal coupling requires increased laryngeal effort (Curtis, 1968; Bernthal and Beukelman, 1977), resulting in vocal abuse and nodule formation.

At this time, there is no evidence to suggest that fundamental frequency or pitch is any different in speakers with cleft palate (Tarlow and Saxman, 1970). Although there is evidence that children with cleft palate speak slower than children without cleft palate, the results may be contaminated by the effects of articulation treatment (Lass and Noll, 1970). The dimension of speech ''naturalness,'' although investigated in disfluent speakers, has not been studied in persons with cleft palate. Interestingly, however, Dalston et al. (1987) reported an unexpectedly low prevalence of stuttering in their population of speakers at risk for velopharyngeal problems.

Future of Description of Speech Characteristics

In the future, we must strive for more a standardized protocol for describing articulation and phonologic, resonance, voice, and other speech parameters. This would yield more consistent reporting in the literature and make comparison of speech findings across centers more meaningful (Dalston et al., 1988; Wyatt et al., 1996; Henningsson and Hutters, 1997; Hirschberg and Van Demark, 1997). This would also enhance evaluation of behavioral and physical intervention and speech outcome resulting in improved decision making and treatment for patients with cleft lip and palate. The expectation of our research and clinical reports should be more standardized descriptions of speech parameters, methods, and procedures that are repeatable and demonstrated reliability of listener judgments.

LANGUAGE

Children with isolated cleft of the primary and secondary palate or cleft of the secondary palate only are most often considered normal children born with a nonnormal sound production mechanism. From a language development standpoint, we expect they will have the normal raw intellectual capacity to learn the complex language system. They, like children born with normal speech structures, will utilize their laryngeal, pharyngeal, oral, and perioral structures to vocalize and make utterances they are capable of producing; they will produce prelinguistic utterances and probably first words, and possibly more, but with an inadequate mechanism. This is most certainly true before the palate is initially repaired and, for some (perhaps 20% to 30%), after palate repair. This, in addition to the high probability of middle ear disease and hearing loss and the dental and occlusal problems that present hazards along the way, puts the child with cleft palate at high risk for speech difficulties. Although the sound production problems we associate with cleft palate are understandable, the rather consistent findings that persons with cleft palate perform less well on language and cognitive measures than their peers without cleft palate has been somewhat perplexing. What is it about the cleft condition that accounts for these differences?

Description of Language

Description of language deficits in children with cleft palate appeared during the 1950s and 1960s (Bzoch, 1956; Spriestersbach et al., 1958; Morris, 1962). It was at that time that standardized language assessment instruments were being developed and normative data established (McCarthy, 1954; Templin, 1957). In general, when young children with cleft palate were compared with children without cleft palate, they were found to be delayed in various language measures such as appearance of first words and two-word phrases (Bzoch, 1956); had shorter mean length of response and structural complexity scores (Spriestersbach et al., 1958; Morris, 1962); demonstrated less verbal output; had fewer words; and performed less well in vocabulary comprehension and usage (Nation, 1970), vocal expression, gestural output, and visual memory tasks (Smith and McWilliams, 1968). Bzoch (1979) listed ‘‘delayed expressive and receptive speech and language development, unaccounted for by concurrent problems of deafness, hearing loss, or mental retardation factors alone,’’ as the second most frequently appearing categorical aspect of 1000 consecutive children with cleft palate seen between 1956 and 1970. Bzoch reported that these children showed consistent delays in expressive, but not receptive, language performance at 12, 18, 24, and 36 months as measured by the Receptive-Expressive Emergence Language Test. However, Philips and Harrison (1969a) found delays in both expressive and receptive skills in children with cleft palate at ages 18 to 72 months.

The 1970s to 1980s was a period of increased interest in, and investigation of, language acquisition. In the speech and language literature, there was proliferation of language assessment instruments and procedures for use to monitor language acquisition with infants and very young children, preschool and school-age children, and adults. This was also a time of increasing recognition that children with cleft lip and palate were a very heterogeneous group. For example, it seemed reasonable that some children with clefts having additional problems, syndromes, or both not previously identified may have affected reported group results of language performance. That continues to be of importance; it appears with further delineation of conditions and syndromes that includes clefting, the occurrence of persons with isolated cleft lip and palate is becoming less frequent. During this time there was increased sensitivity to this issue, and attempts were made to identify and measure specific language parameters of interest and isolate and control relevant variables to more accurately interpret results and generalize findings. There was increased attention to the importance of matched controls, limitations of normative data, and a better appreciation of the myriad of variables that can affect language performance in children with specific disorders such as cleft lip and palate.

Although specific language measures varied and results were mixed, there continued to be the frequent finding that language skills were delayed, or at least less well developed, in very young children with cleft palate (Fox et al., 1978; Estrem and Broen, 1989; Jocelyn et al., 1996), school-age and adolescent children (Faircloth and Faircloth, 1971; Brennan and Cullinan, 1974; Kommers and Sullivan, 1979; McCann et al., 1988; Warr-Leeper et al., 1988), and adults (Pannbacker, 1975; Leeper et al., 1980b). At the present time, most clinicians and researchers will agree about the increased prevalence of language delays in very young children and preschool children and perhaps specific language deficits that may persist in school-age and adolescent children and adults. Review of the literature suggests that a rather consistent finding across age groups has been reduced length of utterance in persons with cleft palate. Chapman and Hardin (1990) reviewed sociocommunicative studies that compared cleft palate children with matched controls that focused on communicative intent and verbal skills in preschoolers (Shames and Rubin, 1979), early gestural communicative intent in 12-month old infants (Long and Dalston, 1982a, 1982b, 1983), and pragmatic language and conversational skills in preschool and school-age children (Warr-Leeper et al., 1988; Chapman et al., 1998). Although the results have been somewhat equivocal, there is at least moderate suggestion that children and adults with cleft palate perform less well in the conversational arena and use language less effectively for communication.

Etiology of Language Differences

The etiology of observed language deficits has been somewhat speculative, and there has been a paucity of data clarifying the precise nature of the deficits. In 1990 McWilliams et al. stated the research describing language differences in children with and without cleft palate was important to know, but there was too little effort to understand the variation observed within the context of other aspects of development. They made a plea for the search for explanations of the language deficits. We need to further identify, isolate, and control, to the extent possible, the multiple factors that can have an impact on language development in all children and the unique ones that directly affect children and adults with cleft lip and palate. At least a partial listing might include early hearing history; early surgeries and hospitalization; psychosocial issues; speech production capability, especially velopharyngeal closure function; and early mother-child communication and interaction. Long hospital stays are indeed a thing of the past; however, the impact of feeding issues and surgical procedures on speech production and readiness to learn for a time surrounding the surgeries may be important (Evans and Renfrew, 1974; Neiman and Savage, 1997).

The cleft lip and palate condition should not affect cognitive development, yet it is well documented that children with cleft palate perform less well than their peers on tests of cognition. Studies have shown that children with cleft palate do less well on verbal cognitive measures than on performance measures (Goodstein, 1961; Lamb et al., 1973; Richman, 1980) and that the cognitive deficits may be secondary to linguistic deficits (Lamb et al., 1973; Richman, 1980; Richman and Eliason, 1982). The relationship between measures of cognition and language is an excellent example of the importance of studying interaction of possible etiologic factors on language performance (Clifford, 1979).

Although the well-known increased frequency of middle ear problems and hearing loss in children with cleft palate seems a tempting etiologic explanation for language and speech delay, no clear relationship has been established. Findings about relationships between otitis media and effusion and later language and between cognitive and academic performance have been equivocal and are likely due to methodologic issues (McWilliams et al., 1990; Roberts et al., 1991; Jocelyn et al., 1996). Although the precise nature and extent of the relationship is unclear, studies of children during the first 3 years suggest that otitis media and fluctuating hearing loss may affect language development (Friel-Patti et al., 1982; Teele et al., 1984; Yoshinaga-Itano and Apuzzo, 1998) and possibly phonologic development as well (Paden et al., 1987). What is clear, however, is that hearing can be depressed without adequate middle ear function (Broen et al., 1996). Documentation of early hearing experience has been largely retrospective and speculative. We need earlier and more frequent hearing information to more accurately determine relationships among hearing function, language, and cognitive and speech development. For example, it would be ideal to identify sufficiently large groups of children, with and without cleft palate, with well-documented very early middle ear and hearing histories, and matched on other relevant variables and assess language performance at appropriate developmental stages.

In a recent study, Broen et al. (1998) investigated early linguistic and cognitive development in matched groups of children with and without cleft palate. The children were followed up at 3-month intervals from 9 to 30 months. Hearing data were obtained at each interval, and ear and hearing history was documented as rigorously as possible. However, no hearing information prior to 9 months was available. Measures included the Mental Scale of the Bayley Scales of Infant Development, Minnesota Child Development Inventory, mean length of utterance and words acquired by 24 months. It was found that although children with cleft palate were within the normal range, they performed significantly less well on the Mental Scale of the Bayley, language subscales on the Minnesota Child Development Inventory, and fewer words were acquired by 24 months. These findings were not surprising and were consistent with previous literature. However, the differences observed in the cognitive development between the two groups were verbal as opposed to nonverbal; that is, they were linguistic in nature. Further, the sources of the observed differences were hearing status at 12 months of age and, interestingly, judgments of velopharyngeal adequacy at 30 months. As Broen et al., suggest, at least tentatively, that if we wish to eliminate the small but consistent differences in language and cognition, we need to treat ear problems aggressively for optimal hearing and provide an adequate velopharyngeal closure mechanism for speech production as early as possible.

There has been little investigation of sociocommunicative competence (Fey, 1986) in children and adults with cleft palate. Chapman and Hardin (1990), as well as McWilliams et al., (1990), make a plea for these investigations. Philips and Harrison (1969a), almost 30 years ago, suggested that early environmental communicative milieu may be important for language development. In the last 10 years, studies have been reported suggesting relationships among maternal-child interaction and language development in children without cleft palate (Conti-Ramsden and Friel-Patti, 1983; Hart and Risley, 1995). Specifically, maternal directiveness was found to have a negative impact on language development, whereas maternal responsiveness had a positive effect. Scheuerle et al. (1992) found that mothers of language-normal children with cleft palate initiated discourse about as often as mothers with language-normal children without clefts. Wassermann et al. (1988) explored maternal interaction and language development in 24-month-old children with speech-related anomalies such as cleft palate, facial anomalies not directly affecting the speech mechanism, and a control group. Although all groups performed within the normal range on measures of language development and cognitive skills, the speech-related anomaly group showed significant language and cognitive delays relative to the control group. Mothers' interaction behavior with these children differed between the control and the other two groups. Ludwigson (1998) investigated the relationship between language performance in 5-year-old children with and without cleft palate and maternal communication and interaction behavior with their children at 30 months of age. She found that increased maternal directiveness was significantly related to poorer language performance on the Clinical Evaluation of Language Fundamentals-Preschool in both groups.

Assessment of Language

What we know about language development and performance is only as good as the assessment tools available. Over the years, a variety of language assessment instruments and procedures have been developed and utilized to measure receptive and expressive skills for children of younger and younger ages. However, we must be cautioned to make sure instruments we are using meet important validity and reliability criteria (McCauley and Swisher, 1984). For children with cleft palate, we should obtain periodic language samples and administer appropriate tests (American Cleft Palate-Craniofacial Association Parameters Document, 1993; Scherer and D'Antonio, 1995). Because of time constraints at clinic visits, this is, perhaps, not frequently done. Consequently, language-screening instruments and parental report about language development have been utilized. Scherer and D'Antonio (1995) found a high correlation between information obtained from parents using the MacArthur Communicative Developmental Inventory for Toddlers and more complete language assessment by a speech-language pathologist. At the minimum, it appears that acquisition of the first 50 words (Estrem and Broen, 1989) and mean length in number of words of a 50-word response sample (Shriner and Sherman, 1967) are useful early-language measures. The desirability of identifying language deficits as early as possible have led to the development of procedures for observation of behaviors believed to be related to future language skills such as gestural communication intent (Long and Dalston, 1982b), and play measures (Scherer and D'Antonio, 1997). These may help identify children at risk for language problems, especially when there is limited speech production.

Treatment of Language

Once a language concern or delay has been identified and documented, some type of intervention is, of course, warranted. Historically, several authors have advocated for early parental education and instruction to avoid future language problems (Hahn, 1960, 1979; Philips, 1979; Brookshire et al., 1980; Lynch et al., 1993). The direct effect of this intervention is difficult to measure; however, no one would deny the potential value of early parental awareness and education.

There has been a paucity of studies focusing on efficacy of early language treatment. Scherer (1999) investigated the effect of teaching vocabulary within a milieu (child's interest in the context of conversational interaction) intervention program for three toddlers with cleft palate who demonstrated expressive language delay. She found this intervention resulted in an expansion of vocabulary and overall growth in phonetic repertoires without direct focus on speech production.

Future Language Issues

In 1989, Morris and Bardach suggested that a high priority for research is identification of factors that enhance or inhibit normal speech and language development. The future of language issues in persons with cleft lip and palate needs focus on those early conditions and environmental milieu that might optimize language learning. Healthy ears and normal hearing certainly contribute to optimal language learning and cognitive development although specific at-risk criteria have not been determined. We need to more clearly identify and document early middle ear status and hearing experience in children with cleft lip and palate and initiate aggressive treatment regimens when required. Advancing technologies, such as otoacoustic emissions, allowing us to identify hearing status at earlier ages should be helpful for this purpose.

The impact of early parental-caregiver communication and interaction behaviors such as maternal directiveness and responsiveness on language development needs further investigation with persons with cleft lip and palate. There remains concern about the consistent finding of reduced length of response and use of language for effective overall communication in children and adults with cleft lip and palate. Just as optimal articulatory proficiency is a goal for our patients, it is important that we focus on those skills that result in effective overall communication as well. Perhaps we need to more frequently follow patients into adulthood to assess language competence and offer intervention when appropriate to optimize communication skills in the broadest sense.

Attention is focused in the next sections on the velopharyngeal mechanism owing to its importance in the cleft palate population. A basic understanding of the anatomy and physiology of the velopharyngeal region in both normal individuals and those with cleft palate is crucial in providing the best treatment approaches. Therefore, the next section is devoted to this matter.

Velopharyngeal Anatomy and Physiology

Basic velopharyngeal anatomy and physiology for normal and cleft palate mechanisms has been reviewed in detail in several sources previously (see Moon and Kuehn, 1997 for review). Our purpose in this report is to provide only the more salient and recent findings.

Levator Veli Palatini Muscle

The levator veli palatini muscle forms a sling in which fibers cross the velar midline and intermingle with levator fibers from the opposite side. Kuehn et al. (1999) observed that levator muscle fibers are continuous across the midline and that a septum does not exist that would separate the two levator bundles in the midline. The levator muscle undoubtedly is the major muscle of velopharyngeal closure in the normal mechanism. However, it has been shown that the levator functions in synergy with other muscles, particularly the palatopharyngeus and the palatoglossus muscles to achieve proper velar positioning during speech (Seaver and Kuehn, 1980; Kuehn et al., 1982; Moon et al., 1994b). It is well-known that patterns of velopharyngeal closure might vary, perhaps related to underlying anatomy as well as to activation of muscles in varying degrees of synergistic coordination (Skolnick et al., 1973; Croft et al., 1981; Finkelstein et al., 1992, 1993, 1995).

In addition to its major role in elevating and drawing the velum posteriorly, it is possible that the levator muscle also might assist in opening the eustachian tube, specifically in the pharyngeal portion. Huang et al. (1997a) observed that, in all 15 of their cadaveric specimens, the levator veli palatini muscle did not originate from the quadrate area of the petrous portion of the temporal bone, as commonly reported, but from the junction of the cartilaginous and bony parts of the eustachian tube. The authors noted that, as viewed from above, the levator muscle crosses under the eustachian tube anteriorly and could help open the anterior-medial portion of the eustachian tube as the levator contracts. The action would involve lifting and rotating the eustachian tube at and near its pharyngeal end. This description is consistent with the histologic report of Sudo et al. (1998; see especially Figs. 2 and 7).

Several studies have demonstrated that levator muscle activity is influenced by intraoral or intranasal air pressure and air flow changes (Kuehn et al., 1993; Kuehn and Moon, 1994, 1995; Tachimura et al., 1995, 1997, 1999). Kuehn et al. (1993) demonstrated that in both normal subjects and subjects with cleft palate, introduction of increased air pressure in the nasal cavities led to increased activation levels of the levator muscle. This finding lends support to the use of continuous positive airway pressure as a therapeutic technique (Kuehn, 1991, 1997). Tachimura et al. (1995) showed that levator muscle activation levels increase with increases in nasal airflow that was induced with increasing aperture sizes in a speech appliance. The authors suggested that if levator activity does increase with increases in nasal airflow in certain patients, then those patients might be appropriate candidates for pharyngeal bulb reduction therapy as described later in this report.

Kuehn and Moon (1994) found that normal individuals tend to use levator activation levels for speech that are at the lower end of their operating range, as determined in relation to a blowing task. In contrast, subjects with cleft palate tend to use levator activation levels for speech that are at their higher levels of activation (Kuehn and Moon, 1995). This suggests that speakers with cleft palate expend more energy in activating the levator muscle for speech than is the case for subjects without cleft palate. It is possible that individuals with cleft palate might use lower levels of levator muscle activity during connected speech to avoid muscular fatigue. This point is discussed in a later section.

Tensor Veli Palatini Muscle

Huang et al. (1997b) described the tensor veli palatini muscle as triangular in shape, broad at the top and narrow at the hamulus, but with no indication of being a two-bellied structure. The latter observation remains controversial and is at odds with the report of Barsoumian et al. (1998). They observed that in 11 of their 16 specimens, the more posterior aspect of the muscle, called the ‘‘dilatator tubae’’ portion, was distinct from the more anterior portion called the ‘‘tensor veli palatini’’ proper. Dilatator tubae was observed to attach to the eustachian tube, and its tendon was freely mobile around the hamulus. In contrast, the more anterior portion was found to be attached to the medial pterygoid plate, and its tendon was firmly attached to the hamulus. Barsoumian et al. hypothesized that the anterior portion could provide an anchor and a stiffness gradient against which the dilatator tubae portion might exert its force in opening the eustachian tube.

There is general agreement that at least some portion of the tensor veli palatini muscle (dilatator tubae) is the major muscle in opening the eustachian tube, but it may be assisted in this function by the levator veli palatini muscle as mentioned above. Therefore, it is possible that the tensor muscle opens the tube at its more lateral portion because it attaches near the bony portion of the tube and that the levator muscle opens the tube at the pharyngeal portion because the tube opens into the upper pharynx. It is interesting to speculate that the freely mobile tendinous fibers of the dilatator tubae portion that wind around the hamulus and that insert into the velum might be pulled during swallowing thus reflexively helping to open the eustachian tube by activating the muscle spindles that are encased in the fleshy part of the muscle (Kuehn et al., 1990). This possibility fits well with the notion that the levator muscle might assist in opening the eustachian tube during activity such as swallowing but not during speech. That is, levator activity alone presumably does not open the eustachian tube in that the tube does not normally open during speech when levator is active and the tensor/dilatator tubae is not consistently active (Fritzell, 1969). During swallowing, however, both levator and the tensor-dilatator muscles are active, and both levator and tensor-dilatator might be necessary to fully open the eustachian tube. However, it is known that even swallowing does not always open the eustachian tube. Leider et al. (1993) reported that the eustachian tube dilated only 74% of the time during swallowing for their normal subjects.

Palatoglossus Muscle

Although it is well known that the palatoglossus muscle is contained within the anterior faucial pillar (Kuehn and Azzam, 1978), the details of its attachments both superiorly and inferiorly have not been well documented. Huang and his colleagues (submitted) studied the attachment of the palatoglossus muscle superiorly. It is commonly held that the muscle attaches to the velum superiorly. However, Huang et al. (submitted) observed in all 18 of their cadaveric specimens that the muscle attached mainly to the hamulus of the medial pterygoid plate. Therefore, the authors suggest referring to the muscle as the ‘‘hamuloglossus’’ rather than the palatoglossus. Obviously, if the muscle attaches to the tongue inferiorly and primarily to the hamulus superiorly, rather than to the velum, its major function would be to assist in tongue elevation rather than velar lowering. However, palatoglossus activity, at least as sampled with anterior faucial pillar insertion, has been observed in a number of electromyography (EMG) studies in association with velar-lowering events (e.g., Sitzmann and Moon, 1998). It should be pointed out that all of the 18 cadaveric specimens studied by Huang et al. were from individuals of Asian origin. Perhaps this was a factor in determining the particular anatomic attachment of the muscle to the hamulus and is certainly in need of further investigation.

Palatopharyngeus Muscle

The palatopharyngeus muscle has received surprisingly little attention in the anatomic literature. This is especially surprising given the increased prevalence of sphincter pharyngoplasty as a surgical procedure in treating velopharyngeal impairment. In this procedure, the posterior faucial pillars, containing the palatopharyngeus muscle, are dissected, elevated, rotated, and joined in the midline along the posterior pharyngeal wall. The muscle has been described as consisting of two major masses, a vertical component that lies within the posterior faucial pillar, and a transverse component that attaches to the velum anteriorly and to the pharynx laterally and posteriorly. Cassell et al. (1990) describe the vertical fibers that course through the posterior faucial pillar as attaching to the thyroid cartilage of the larynx and therefore suggest referring to this portion of the muscle as the ‘‘palatothyroideus’’ (see especially their Fig. 47-10). Therefore, that portion of the muscle would be in a position to assist in lowering the velum, raising the larynx, or both. The transverse portion, the palatopharyngeus proper, would be in a position to help retract the velum, to constrict the upper pharynx, or both along with the superior constrictor muscle.

Musculus Uvulae

The musculus uvulae is the only intrinsic muscle in the velum. Its muscle fibers course longitudinally along the dorsal aspect of the velum where they are cradled by and run perpendicular to the fibers of the levator veli palatini sling. Kuehn et al. (1999) observed histologically that there is a consistent circular connective tissue sheath that encapsulates the musculus uvulae along its entire length and persists in the uvula even though there is little muscle tissue in the uvula proper. Thus, this sheath presumably acts to bind the muscle, thereby offering more stability, perhaps, as the muscle acts in synergy with the levator veli palatini muscle (Kuehn et al., 1988). Kuehn et al. (1999) further observed that the muscle is not consistently bilateral (two bellied in the midline) even in a given individual soft palate specimen. Apparently, as long as the uvular muscle is positioned in the midsagittal plane, dorsal to the levator muscle, its bilaterality versus singular nature is not important. It would be interesting to follow this muscle embryologically over time and across individuals. It is possible that earlier in embyogenesis, the uvular muscle is primarily a singular structure (Langdon and Klueber, 1978) but later differentiates into a more bilateral structure (Azzam and Kuehn, 1977).

Huang et al. (1997b) pointed out that because the musculus uvulae runs parallel to the margin of the cleft velum on each side, the Furlow double-opposing Z-plasty surgical procedure places the musculus uvulae in an unfavorable position postsurgically. The muscle is placed obliquely to the midline rather than parallel to it following the Furlow surgical procedure. Whether this is a significant disadvantage with regard to speech outcome is not known at the present time and is in need of further investigation.

In the normal individual, the uvular muscle forms a pronounced convexity along the dorsal surface of the velum. Such convexity tends to be diminished in individuals with surgically repaired cleft palate and may actually be trough-like in some individuals particularly those with ‘‘occult’’ submucous cleft palate as has been observed by Croft et al. (1978) and several other investigators.

Superior Pharyngeal Constrictor and Salpingopharyngeus Muscles

The superior pharyngeal constrictor muscle is inconsistently active during speech in normal speakers (Kuehn et al., 1982). It is possible that this muscle assumes a more prominent role during speech in individuals with velopharyngeal impairment (Finkelstein et al., 1993) and might function in concert with the transverse fibers of the palatopharyngeus muscle in forming Passavant’s ridge. The salpingopharyngeus muscle has received very little attention in recent years, probably because of the fact that the salpingopharyngeal fold containing the muscle consists mainly of connective and glandular tissue and is sometimes void of muscle tissue altogether (Dickson and Dickson, 1972).

Muscle Spindles and Muscle Fiber Types

Muscle spindles have been found in the tensor veli palatini and palatoglossus muscles (Kuehn et al., 1990) and in the levator veli palatini muscle (Liss, 1990) but not in the palatopharyngeus, musculus uvulae, salpingopharyngeus, or the superior pharyngeal constrictor muscles (Kuehn et al., 1990). Given that Liss found spindles in the levator that were smaller than typical spindles found in other muscles of the body, it is possible that smaller spindles also might be present in the other muscles in the velopharyngeal region for which typical spindles are absent.

Moon et al. (1998) reported that, in the normal adult, the levator veli palatini muscle consists of approximately 60% type I (fatigue resistant) and 40% type II (fatigue sensitive) fibers. Tomodo et al. (1984) reported somewhat lower proportions for type I fibers and somewhat higher proportions for type II fibers, compared with the values reported by Moon et al.

Clearly, much more information is needed concerning the microanatomy of the velopharyngeal musculature. To our knowledge, not a single study has been conducted to identify the possible presence of Golgi tendon organs in the region.

Magnetic Resonance Imaging

Studying the anatomy of the velopharyngeal region with either gross dissection or histology has some major drawbacks. Because the region is not readily accessible, much overlying tissue must be removed or destroyed to observe the region using dissection. Thus, orientation is greatly compromised and familiar landmarks are often not readily available. With regard to microscopic investigation, because the region is fairly large, it does not lend itself very well to traditional histologic methods. And, of course, neither gross dissection nor histology allows investigation of structures from living human subjects.

Magnetic resonance imaging (MRI) shows promise in studying the anatomy of the region and overcomes some of the disadvantages of dissection and histology. Several studies (e.g., Story et al., 1996, 1998; Whalen et al., 1999) have been conducted in which MRI has been used to image and measure the vocal tract (upper airway), and other studies apply more directly to the velopharyngeal mechanism (Naito et al., 1987; Wein et al., 1991; McGowan et al., 1992; Yamawaki et al., 1996; Vadodaria et al., 1997; Yamawaki et al., 1997; Akguner et al., 1998).

Ettema et al. (1998) used MRI to image the levator veli palatini muscle in vivo during speech. Oblique coronal sectioning was used to image the levator veli palatini muscle. Measures of levator length, thickness, and angle of origin during speech and rest breathing in five male and five female normal adult subjects were obtained. The average length of the levator muscle at rest from its origin to the middle of the velum was 44.7 mm for the women and 45.8 mm for the men. Average thickness in the middle of the levator sling within the velum was 5.4 mm for both the women and men. The average angle at the origin, formed by the medial side of the levator bundle with the base of the skull, was 64.5 degrees for the women and more acute for the men at 60.4 degrees. Compared with resting length, the levator muscle was about the same or slightly longer for nasal consonants but, as expected, was progressively shorter than resting length for low vowels, high vowels, and shortest for the fricatives /f/ and /s/. Correspondingly, the angle of origin decreased as levator length decreased. This would be expected in that the vector of velar elevation is directed superiorly and the angles of the triangle formed by the levator sling with the base of the skull would decrease as the velum moved upward. Quantified measures of this type will be extremely useful as computerized models of velopharyngeal closure, such as that recently reported by Berry et al. (1999), are developed.

Velopharyngeal Closure Force and Fatigue

Moon et al. (1994a) reported on the use of a method to measure velopharyngeal closure force using a bulb that is inserted through the nasal passage and placed between the velum and posterior pharyngeal wall. Kuehn and Moon (1998) used that procedure to study normal velopharyngeal closure force for various phonetic contexts in a group of seven adult women and seven adult men. In general, it was found that velopharyngeal closure force tends to mirror velar elevation. For example, high vowels are produced with greater closure force than low vowels. Compared with women, men exhibited a larger number of significant differences in closure force in relation to various phonetic categories. Thus, closure force tended to be more constant in women. No significant differences in absolute values of closure force were found between the men and women. In a follow-up study involving subjects with cleft palate, Moon and Kuehn (1998b) found similar patterns of velopharyngeal closure force in subjects with cleft palate, compared with normal subjects, but the absolute levels of closure force were much lower for subjects with cleft palate and range of variability was more constrained. Thus, it appears that the same phonologic rules may be used in subjects with cleft palate in relation to velopharyngeal control, but presumably peripheral mechanical differences exist, compared with subjects without cleft palate.

Kuehn and Moon (in press) studied physiologic fatigue involving velopharyngeal closure using the force bulb procedure mentioned in the previous paragraph. The authors introduced various levels of aerodynamic loading (increased air pressures) into the nasal passages. They found that normal subjects are fairly resistant to induced fatigue especially for external loads up to 25 cm H_2O air pressure. In contrast, however, the authors found that subjects with cleft palate fatigue at much lower levels of external loading and exert much lower levels of velopharyngeal closure force (Moon and Kuehn, 1998a). The authors hypothesized that speakers with cleft palate may need to exert greater levels of muscle activity to achieve at least minimal velopharyngeal closure but that tight velopharyngeal closure might be avoided in subjects with borderline velopharyngeal competence so as to avoid excessive fatigue or, ultimately, physiologic exhaustion. If the latter occurred, the velum would not be able to elevate at all, and the velopharyngeal port would be rendered maximally opened.

Aerodynamic Studies

Controlling air pressures and airflows is critical to normal speech production. Individuals with cleft palate are particularly vulnerable to limitations in such control. The landmark article by Warren and DuBois (1964) set the stage for a large number of studies dealing with aerodynamics in relation to velopharyngeal functioning. More recently, Warren and his colleagues have proposed that individuals with cleft palate compensate for the limited ability to achieve sufficient intraoral air pressure for speech purposes. They suggest that such control tends to be regulated and active in the sense that strategic positioning of structures such as the tongue, and even more peripheral structures such as the nares, could increase vocal tract resistance thus helping to maintain sufficiently high intraoral air pressures for speech purposes (Warren, 1986, Warren et al., 1989, 1990, 1992; Dalston et al., 1990, 1992; Hinton and Warren, 1995; Kim et al., 1997).

The ‘‘active’’ theory of Warren and colleagues has not been unopposed. Moon et al. (1993) provided evidence that the human respiratory mechanism might function more as a constant air pressure source rather than a constant airflow source. As such, downstream changes in resistances would be less consequential and respiratory output pressure would still be fairly constant. Thus, aerodynamic control of vocal tract pressures would be more automatic, or ‘‘passive,’’ and less dependent on active articulatory adjustments downstream. Finnegan et al. (1998) also discuss this point and are supportive of a more passive mechanism.

The issue of active versus passive aerodynamic control is in need of further investigation. If ‘‘active’’ control is involved, it remains to be determined what specific sensory mechanisms could account for the needed rapid online feedback issued to the effectors (muscles). Moreover, what is the goal of regulatory control? Is it to regulate intraoral air pressure, as argued by Warren and colleagues, or might it be some other variable such as the acoustic output, as suggested by Netsell (1990).

Aerodynamic studies have contributed important information to understanding the timing and variability of velopharyngeal port control across subject groups. Warren et al. (1993, 1994) demonstrated that the degree of perceived hypernasality might be related more to the duration of velopharyngeal open time than to the amount of air escape through the velopharyngeal port. Also, adults were perceived as more hypernasal than children for a given degree of velopharyngeal impairment (Warren et al., 1994). However in normal adults, Hoit et al. (1994) found no difference in nasal airflow in four groups of subjects spanning the age range from 20 to over 80 years. These results do not support the suggestion of Hutchinson et al. (1978) that velopharyngeal function deteriorates with advancing age. Hoit et al. (1994) reported that nasal airflow occurred very rarely during the production of oral utterances in their normal subjects. Of course, nasal airflow was observed for nasal consonant contexts. Nasal airflow was significantly less during the production of /n/ for women, compared with men, but there was no difference between men and women for the production of the vowel /i/ in the context of the nasal consonant. Zajac and his colleagues also investigated age and gender effects, and several specific differences between these groups were reported (Zajac and Mayo, 1996; Zajac, 1997; Zajac et al., 1998). It may be that although normal individuals retain the ability from infancy to senescence to close the velopharyngeal port with sufficient force to prevent hypernasality, different control strategies are used to achieve that goal, depending on one's sex and age that are driven by anatomic underpinnings and physical changes that occur over the age span.

Although an air-tight velopharyngeal seal (no nasal airflow) can be expected for most normal individuals, as indicated above, some individuals with normal speech might exhibit rather substantial amounts of nasal airflow even during presumably ''oral'' speech utterances (Andreassen et al., 1992; Smith and Guyette, 1996). Again, underlying anatomic differences and resulting physiologic strategies might account for such interspeaker variability while still producing a normal speech output. A greater understanding of ''allowable'' limits of velopharyngeal airflow and air pressure leakage in the presence of perceptually acceptable speech output would be important in treating individuals with velopharyngeal impairments. Of course, when such anatomic differences become extreme (e.g., cleft palate sequelae) and physiologic mechanisms cannot accommodate, speech output will be affected.

Electromyographic Studies

Several EMG studies investigating activity of the velopharyngeal muscles have been conducted in recent years (Kuehn et al., 1982, 1988, 1993; Moon et al., 1994b; Kuehn and Moon, 1994b, 1995, 1998; Moon and Canady, 1995; Tachimura et al., 1995, 1997, 1998, 1999; Moon and Kuehn, 1998a, 1998b; Sitzmann and Moon, 1998; Hara, 1998). Some of these have been reviewed in other sections of this report. In general, these studies demonstrate the synergy and versatility of the velopharyngeal muscles and the fact that they can be and are influenced by external factors such as gravity (Moon and Canady, 1995); air pressures, both intranasal and intraoral; and airflows during speech. A greater understanding of such factors undoubtedly will be important in improving behavioral treatment approaches such as the use of continuous positive airway pressure (CPAP) procedures, which is discussed later in this report.

Individuals with cleft palate may utilize similar motor control programs as those with noncleft palate mechanisms, but the former may be more challenged in quantitative output terms. That is, speakers with cleft palate may need to exert relatively greater muscle effort to achieve the same level, or perhaps even lesser degrees, of velopharyngeal closure. A critical balance may exist between sufficient levels of muscle activation to reach at least minimal velopharyngeal closure without entering a state of rapid physiologic fatigue or exhaustion.

Kinematic Studies

Earlier kinematic studies of velopharyngeal movement have been reviewed by Kuehn and Dalston (1988) and Moon (1993). There have been relatively few velopharyngeal movement studies in recent years. This is likely related to the invasive nature of obtaining movement data and the difficulty of obtaining quantified information using less invasive techniques. Thus, many studies in the 1960s and 1970s made use of x-ray motion picture procedures to provide a large body of basic information related to velar and pharyngeal wall movement during various speech utterances. However, x-ray procedures have not been used extensively in recent years for that purpose, perhaps due in part to increasingly conservative attitudes regarding more invasive experimental procedures. Unfortunately, absolute measurements of kinematic variables such as displacement and velocity are difficult to obtain using biologically noninvasive procedures such as endoscopy. Another noninvasive procedure, ultrasound, provides only a limited field of view because of the inability of the ultrasonic signal to cross the vocal tract airway. Earlier ultrasound studies provided useful information concerning movement of the lateral pharyngeal walls, but imaging of the velum is not possible because of the airway problem.

Kollia et al. (1995) used a Velotrace (Horiguchi and Bell-Berti, 1987) to measure movement of the velum in relation to movement of the lips and mandible. The Velotrace is a mechanical device that consists of a rod inserted through the nasal passage and positioned on the nasal surface of the velum. Movement of the rod is recorded by externally located equipment. For both velar-raising as well as velar-lowering gestures, the authors found a statistically significant positive correlation between velocity and displacement. (i.e., the greater the displacement, the greater the velocity). These results are consistent with those of Kuehn (1976). Kollia et al. (1995) observed a consistent relation between the timing of velar raising to that of lip or jaw raising movements and an even closer relation between velar lowering to that of lip or jaw lowering movements. Kent et al. (1974) and Kuehn (1976) also observed such interarticulatory timing synchrony specifically between the velum and the tongue. Thus it appears that neuromotor timing commands are issued across articulators, including the velum, as well as to individual articulators, perhaps as a pacing mechanism to integrate gestures over relatively fixed time intervals.

Future Issues in Anatomy and Physiology

Most of our knowledge pertaining to velopharyngeal anatomy is derived from fetal specimens or older individuals in cadaveric studies. We know very little about the critical intervening years of development from the neonate to the preadolescent and through the adult years. Moreover, we know little about anatomic variability among different races that could, potentially, predispose individuals to a clefting condition. Given technologic advances in imaging, especially MRI, we are gaining the ability to study underlying tissue structures, such as muscle masses, in living individuals. This information will be very important in improving our management strategies and for heuristic research purposes such as constructing computerized models of the velopharyngeal region. Armed with better anatomic information, we should be more capable of generating testable hypotheses regarding function, both in normal individuals and in those with cleft palate. These types of studies will be important in determining which patients might benefit from behavioral therapeutic approaches versus those who are more likely to require physical management. Such determination should be made at the earliest possible age so that an individual patient might be provided with normal speech and language skills at the earliest possible age. Given careful anatomic and physiologic diagnostic work-ups, there should not be a ‘‘one-size-fits-all’’ treatment approach. Rather, the specific treatment should be designed to match as closely as possible the underlying anatomic and physiologic capabilities and potential of the individual patient.

Assessment of Velopharyngeal Function

Terminology

Several reports have dealt with terminology related to velopharyngeal disorders (Trost, 1981a; Kuehn and Dalston, 1988; Peterson-Falzone, 1988; Trost-Cardamone, 1989; Netsell, 1990; Witt and D'Antonio, 1993; Dalston, 1996; Tomes and Kuehn, 1996). Terms such as velopharyngeal impairment, inadequacy, insufficiency, incompetency, congenital palatopharyngeal incompetency, velopharyngeal dysfunction, and others have been used to describe various aspects of velopharyngeal disorders, and there is not universal agreement on definitions of these terms. We have frequently used the term velopharyngeal ‘‘impairment’’ in this report because the term appears to be generally encompassing of the wide range of velopharyngeal disorders; it has been used by several authors, especially recently; and it is consistent with the concept of impairments expressed by the World Health Organization (1980; 1999). We use the term velopharyngeal impairment in the general sense of ‘‘. . . any failure of the velopharyngeal mechanism to open or close in a normal fashion for speech. . . ’’ (Tomes and Kuehn, 1996). However, we will not totally abandon use of other descriptive terminology that might be more appropriate, depending on the context. For example, we use the terms ‘‘adequacy’’ versus ‘‘inadequacy’’ in an all-or-none fashion; either the mechanism is normal or it is not.

Speech Characteristics

Since the beginnings of interdisciplinary team care for persons with cleft palate in the 1930s, the major tasks and responsibilities of the speech pathologist have been to assess speech, determine the relationship between speech and structure, and to make appropriate recommendations for intervention. The structural concern discussed here will be the velopharyngeal mechanism. Individuals with cleft lip or palate rarely have speech problems related to the condition of the lip. The more anterior dental and occlusal factors, although important to assess, may present hazards but infrequently prevent the acquisition of acceptable speech articulation. Missing teeth during childhood may have little or no long-term effects on speech if the teeth are restored (Gable et al., 1995). However, the combination of dental and jaw anomalies may be more significant underlying causes of disordered speech and could affect tongue positioning, for example. As indicated previously, there are a number of reviews focusing on relationships among dental or occlusal deviations and speech production. In general, though, the major cause of speech disablement in the cleft palate population usually relates to velopharyngeal impairment. Although this report focuses primarily on cleft palate, it should be recognized that velopharyngeal impairment is associated with a large number of abnormalities. Tomes and Kuehn (1996) listed 19 such abnormalities in addition to overt cleft palate and submucous cleft palate.

It is widely accepted that the ear is the first and primary diagnostic tool (Moon, 1993). Clearly, the speech characteristics provide the most important diagnostic information for assessing velopharyngeal function and making statements about adequacy or inadequacy of closure for speech. There has been remarkable consistency of purpose and similarity in approach by speech diagnosticians over the last 40 to 50 years (Shelton et al., 1968a; Peterson-Falzone, 1988; Karnell and Seaver, 1990; Moller, 1991; Philips, 1980; Trost-Cardamone and Bernthal, 1993; Witzel and Stringer, 1990; Morris, 1990; McWilliams et al., 1990; Van Demark et al., 1985; Bzoch, 1997). What has changed is the extent and specificity of speech information available and at earlier ages than before. We now observe and document prelinguistic utterances and early development of speech patterns that relate to velopharyngeal issues. We are more cognizant about those speech characteristics that reveal information about speakers' current velopharyngeal problems such as (1) audible nasal air emission accompanying obstruent consonants, (2) weak obstruent consonant production, (3) substitutions of nasal consonants for nonnasal counterparts, and (4) hypernasal resonance distortion as opposed to those speech characteristics that suggest learned and compensatory behavior such as maladaptive posterior placement and voice deviations due to laryngeal hyperfunction in response to previous or current velopharyngeal problems.

Previous surveys of speech-language pathologists reveal that listener judgments of speech characteristics are used almost universally in assessment of velopharyngeal function (Schneider and Shprintzen, 1980; Pannbacker et al., 1984). In general, velopharyngeal closure problems are identified by speech assessment; delineation of the nature of the problems is revealed by direct techniques such as direct oral-pharyngeal examination, nasendoscopy, and radiography. Karnell and Seaver (1990) acknowledged that instrumental assessment of velopharyngeal function ‘‘serves to assist, never to replace, sound clinical judgment’’ (p. 785).

The speech approach espoused by most clinicians in assessing velopharyngeal function involves the following components: (1) articulation and phonologic assessment utilizing word or sentence tests and connected speech; (2) resonance assessment using isolated productions and connected speech; and (3) stimulation testing. Based on the results of these assessments, the primary task is to determine whether the physical speech mechanism is adequate to produce acceptable speech. Although that task sounds simple enough, it is indeed a complex one. The evaluation involves obtaining a sufficient sample of speech (Trost-Cardamone and Bernthal, 1993); determining the structural versus learned nature of the problem; predicting the potential for modification (Shelton et al., 1968a; Bzoch, 1997; Moller, 1990); and assessing the social, educational, and vocational acceptability of speech (Morris, 1990).

Over the last 50 years, what we have done diagnostically, what we currently do, and what we will likely continue to do well past the year 2000 in utilizing speech to assess velopharyngeal closure can be best summarized and discussed in two questions: (1) What is the speaker doing now? and (2) What can the speaker do?

What is the speaker doing now? With this question, the current status of velopharyngeal function can be assessed. Data can be gathered about clinical history of velopharyngeal closure concerns related to speech, performance on standardized articulation tests, phonologic analysis, specially constructed tests, sound inventories, and the eliciting of a sample of conversational speech (Morris et al., 1961; Van Demark, 1964, 1974a, 1974b, 1979, 1997a; Shelton et al., 1968a; Van Demark et al., 1985; Morris and Bardach, 1989; McWilliams et al., 1990; Moller, 1991; Trost-Cardamone and Bernthal, 1993; Bzoch, 1997). As with any child, analysis of articulation and phonologic characteristics provides information about number of errors, types of errors, phonologic processes, patterns of errors, and consistency of errors. The connected speech sample (reading passage, spontaneous speech, or both) allows for judgments about effect of phonetic complexity on articulation; phonologic processes; and overall perceptual judgments about articulation proficiency and defectiveness, speech intelligibility, resonance distortion, and voice deviation.

For speakers with cleft palate, the authors have focused on the nature of the sound errors and patterns of errors (Van Demark et al., 1985). For example, what is the nature of the distortions? Are sounds distorted by audible nasal air emission, or are they distortions that provide little differential diagnostic information about velopharyngeal function, such as frontal or lateral distortions of sibilants? Similarly, what is the nature of the substitutions? Are nasal consonants substituted for nonnasal consonants, clearly indicating lack of velopharyngeal closure, or do we hear pharyngeal and glottal stops and pharyngeal or velar fricatives for a variety of sounds? We recognize that compensatory posterior substitutions can exist in the presence of adequate or inadequate velopharyngeal closure because of the interaction of learning and structure. Are the articulation errors consistent or inconsistent? Are the errors developmental in nature and not related to velopharyngeal closure concerns (e.g., /th/ substitution for /s/).

Standard reading passages are useful because they provide a consistent speech sample for recording and subsequent judgments by others, and they allow for important comparison of speech characteristics before and after physical or behavioral intervention. Spontaneous conversational speech, although less controlled, offers the opportunity for judgments about speech as it occurs more naturally. Obtaining a sample of connected speech may yield important information about consistency or deterioration of articulation proficiency and changes in resonance characteristics. Deterioration of articulation may be attributed to velopharyngeal closure concerns or other oral-motor problems. Resonance distortion (pervasive hypernasality) not particularly noticeable on the word or sentence articulation tests may become clearly evident during spontaneous connected speech.

The above procedures have been used by speech-language pathologists almost universally and over many years to yield information about speakers' current articulation and resonance characteristics and how they vary during more complex speech tasks. Audio and video taping of the speech sample for subsequent analysis by multiple listeners should be obtained (Moller and Starr, 1984).

What can the speaker do? With this question, the clinician assesses speakers' potential to accomplish velopharyngeal closure for acceptable speech with current speech structures. That question is, perhaps, more important than the first. The answer will determine the appropriate course of intervention. Trost-Cardamone and Bernthal (1993) stated that ''the primary purpose for assessing phonologic behavior is to determine whether an individual needs intervention and, if so, the direction of such treatment'' (p. 317). Information about consistency of articulation, resonance distortion, or both provides important clues about potential. Speakers may produce a sound correctly in some contexts but not in others. For example, it might be noted that audible nasal air emission accompanies the /s/ sound in the word ''snowman'' but not in the word ''skate.'' In the former, the presence of nasal consonant /n/ reveals information about the speaker's velopharyngeal closure function in certain phonetic environments. This assimilation phenomenon can also occur with resonance in which the presence of a nasal consonant may result in perception of hypernasality on adjacent vowels. The important diagnostic information is any evidence of velopharyngeal closure occurring in certain speech contexts and, perhaps, limitations in potential for adequate closure.

Another important source of information about potential for velopharyngeal closure is performance on stimulation testing. Originally described by Milisen (1954), the purpose of stimulation testing is to determine the extent to which a speaker can modify sound errors with visual and auditory cues provided by the examiner. This procedure directly responds to the question, What can the speaker do? Morris (1990) noted that stimulation testing ''is especially useful because it yields information about the extent to which both physiologic and behavioral variability is possible.'' (p. 760). Van Demark and Swickard (1980) found that speakers' ability to produce normal /p/ and /b/ consonants consistently in words without nasal air emission was predictive about velopharyngeal closure adequacy for more complex speech tasks.

Following speech assessment, the speech clinician should have sufficient information to make judgments about current velopharyngeal function and potential to offer appropriate recommendations for treatment. Usually, treatment decisions regarding velopharyngeal closure fall into one of three general categories. First, it may be clear, based on the speech evaluation, that physical improvement of velopharyngeal closure is required. That is, velopharyngeal closure is judged to be impaired (inadequate, insufficient, or incompetent) for acceptable speech. This decision might be based on the observations of perceptual evidence of no velopharyngeal closure during any speech task, resulting in consistent audible nasal air emission accompanying obstruent consonants, substitution of nasal consonants for obstruent consonants or very weak consonants, and consistent moderate to severe hypernasality during connected speech. Second, it may be equally clear that physical improvement of velopharyngeal closure is not required. This might be based upon speech observations of normal or acceptable pressure consonant production with at least appropriate place skills, and acceptable resonance during connected speech. Although speech treatment may be required, it is judged that there is potential for normal or acceptable speech with current structures. Third, it may be quite unclear whether velopharyngeal closure is adequate or inadequate and whether physical management will be required. This decision may be based on observations of inconsistent evidence of velopharyngeal closure observed during the articulation, resonance, and stimulation assessments. Furthermore, it may be that velopharyngeal closure potential is unclear due to the presence of compensatory, maladaptive, posterior pattern of articulation. In this situation, speakers are not providing the speech-language pathologist with information about velopharyngeal function because they are producing the obstruency required for pressurized consonants at points inferior to the velopharyngeal port (pharyngeal or glottal). The potential for velopharyngeal closure is unclear, in these situations, because the speakers are not using the velopharyngeal structures (Henningsson and Isberg, 1986). Certainly, speech treatment is required to modify articulation placement, consistent with normal speech and, importantly, to clarify velopharyngeal potential. The variable performance of speakers in this category is often perplexing and, indeed, frustrating when attempting to arrive at appropriate decisions regarding velopharyngeal management (McWilliams et al., 1990; Morris, 1990). Young children for whom a sufficient sample of speech cannot be obtained would necessarily fall into this group until sufficient speech observations can be made. In addition, we believe it is this group that has caused the most confusion for parents and our interdisciplinary colleagues. In this group, velopharyngeal closure has been variously described as borderline (Dalston, 1983), marginal (Van Demark and Hardin, 1986; Hardin et al., 1990), ABNQ (almost but not quite), NBB (not bad, but), SBNA (sometimes but not always), SOS (same old story) (Morris, 1990), competent to borderline competent, borderline to borderline incompetent (McWilliams et al., 1990), and potential may be present versus potential may not be present (Moller, 1991). Although these descriptions to categorize speakers' velopharyngeal capability are intended to be helpful, they may serve to confuse patients, families, and surgical and dental colleagues. This is understandable, because definitive decisions regarding need for velopharyngeal management are difficult even for speech-language pathologists because of the myriad of factors that have an impact on that judgment (McWilliams et al., 1990).

Retrospective studies can be very helpful in making informed decisions about treatment. For example, Van Demark et al. (1975) found that a combination of ratings on x-rays and articulation scores at a younger age served as the best predictor for eventual secondary surgical management in their group of 75 subjects. If a patient received a score of less than 34% on the Iowa Pressure Articulation Test and exhibited a velopharyngeal gap greater than 2 mm, this was predictive of the need for subsequent secondary surgical management with an accuracy of 96%. Hardin et al. (1990) found that severity ratings of articulation defectiveness and nasality at 6 years of age, in a group of subjects diagnosed with ''marginal velopharyngeal competence,'' were predictive measures for those subjects who eventually developed ''velopharyngeal incompetence'' as assessed in their teenage years.

Because so much of the decision-making process about velopharyngeal function is perceptually based and dependent upon what the speaker is doing and potentially can or cannot do, it seems reasonable that categorization or ratings of velopharyngeal function (adequacy) be perceptually based as well. As Kuehn and Dalston (1988) implied, the decision to physically improve velopharyngeal closure would be ludicrous for a patient who showed evidence of velopharyngeal problems on instrumental and physiologic measures but demonstrated acceptable speech performance. Current categorizations of adequate, marginal-borderline, or inadequate appear more physiologic based, although inferred by our perceptual judgments.

Concern is frequently expressed about stability of velopharyngeal closure over time. At this time, we cannot predict with any certainty that velopharyngeal closure judged adequate at one evaluation will be similarly judged at subsequent visits or in other settings (Van Demark and Morris, 1983; Van Demark et al., 1988) or whether velopharyngeal closure will remain adequate over time and into adulthood (Karnell and Van Demark, 1986; Hardin-Jones et al., 1993). For some patients, normal atrophy of the lymphatic adenoid mass may result in velopharyngeal closure concerns (Mason and Warren, 1980). Therefore, it is important that patients continue to be monitored for speech through the growth and development years.

Hyponasality/Denasalized Consonants

The focus of the above discussion has been on speech characteristics associated with inadequate velopharyngeal closure. We have previously discussed the hyponasal and cul-de-sac resonance distortion that is frequently described in speakers with cleft palate. It is generally agreed that these distortions are related to excessive velopharyngeal closure such as adenoid hypertrophy, obturating pharyngeal flaps, or other secondary pharyngoplasties for velopharyngeal closure, nasal obstruction, or both resulting from hypertrophied turbinates, deviated nasal septum, and collapsing nasal valves. It is important these resonance distortions be observed, recorded, and perceptually judged in evaluation of velopharyngeal function. We must be mindful that modification or elimination of anatomic obstruction may result in perceptual speech changes and, indeed, velopharyngeal capability. Delineation of a specific etiology of hyponasality is dependent upon direct oral-pharyngeal-nasal examination and other imaging techniques.

Voice

Evaluation of voice characteristics is also important in assessment of velopharyngeal function. Perceptual judgments of hoarseness, breathiness, harshness, and loudness are more prevalent in speakers with clefts. Although velopharyngeal closure function cannot be directly inferred from these judgments, it is the possible compensatory laryngeal adjustments to velopharyngeal closure issues that are of concern.

Oral-Pharyngeal Examination

Most often, direct oral-pharyngeal examination is carried out following evaluation of speech. In 1980 a survey of speech-language pathologists' use of procedures for velopharyngeal closure showed that with the exception of listener judgments of speech, the oral examination was used most frequently (Schneider and Shprintzen, 1980). Ten years later, a subsequent survey (Pannbacker et al., 1990) found that almost 80% of speech-language pathologists believed the oral examination to be valuable in assessing velopharyngeal function; however, 20% believed it was of little or no value. A survey of services and practices of Cleft Palate-Craniofacial teams (Pannbacker et al., 1992) revealed the oral-pharyngeal examination was rated as very important or important by 74% of teams responding (30%; Pannbacker et al., 1992). Although clinical wisdom supports the use of the direct oral-pharyngeal examination in evaluating velopharyngeal function, there have been no systematic investigations of its usefulness. One might argue that its usefulness depends upon the nature and use of other direct imaging techniques. There is evidence suggesting that agreement between observer judgments and radiographic analysis of soft palate length and mobility, depth of nasopharynx, and velopharyngeal closure was only approximately 60% overall (Eisenbach and Williams, 1984). The relationship of oral-pharyngeal judgments to other procedures used in evaluating velopharyngeal closure need further investigation. However, careful oral-pharyngeal examination is certainly useful for delineation of dental or occlusal conditions that might contribute to what is observed in speech evaluation, most notably articulation. From a velopharyngeal function standpoint, observations and judgments of the length of the soft palate, mobility of soft palate, posterior and lateral pharyngeal walls during phonation of /a/, symmetry of structures and movements, presence and size of tonsillar and adenoidal tissue if possible, and depth of oronasopharynx are considered important and useful, although limited. It is important that the conditions under which the observations made are specified. Perhaps too often documentation of velar-pharyngeal movement occurs under conditions of gagging or crying, not phonation.

One of the most revealing and informative intraoral observations that can be made, which may impact velopharyngeal function, is the presence of oronasal fistulae. The observation of a sizable midpalatal fistula may totally corroborate speech observations of inconsistent audible nasal air emission during connected speech. There has been limited systematic investigation of the effect of fistulae on speech (Shelton and Blank, 1984; Karling et al., 1993), but there is consensus that fistulae can and do contribute to at least audible nasal air emission. When they occur in conjunction with velopharyngeal closure concerns, temporary obturation of fistulae to clarify contribution to speech has been advocated (Henningsson and Isberg, 1990). Another concern of oronasal fistulae is the extent to which they can alter velopharyngeal function. It has been demonstrated there is decreased velopharyngeal movement in the presence of oronasal fistulae (Isberg and Henningsson, 1987). Attempts to estimate or measure size and location of fistulae and their effect on speech need further study.

Occasionally, a previously undiagnosed submucous cleft palate is identified or suspected. The classic triad of intraoral observations of cleft uvula, bony notch in the posterior border of the hard palate, and thin bluish appearance to the palate is not always present. However, the ''occult'' submucous cleft palate may be present that can only be visualized with aided procedures such as nasendoscopic examination (Kaplan, 1975; Croft et al., 1978).

Instrumental Assessment Procedures

Dalston and Warren (1985) and Kuehn and Dalston (1988) reviewed several diagnostic procedures aimed at assessing velopharyngeal structure and function. These authors differentiated between direct measures, allowing visualization of structures, and indirect measures for which structural functioning must be inferred. Direct measures include endoscopy, videofluoroscopy, and ultrasound. Indirect measures include listener judgments, acoustic analyses (including nasometry), accelerometry, aerodynamic measures, and photodetector procedures. All of these could be used for research purposes as well. Diagnostically, listener judgments should always be used (Moll, 1964). If there is any doubt about the course of treatment, typically an instrumental assessment would be obtained, usually nasopharyngeal endoscopy or multiview videofluoroscopy, depending on the availability of equipment and to some degree on the cooperation of the patient. Nasometry also is being used with increasing regularity and aerodynamic measures also might be used, depending on the availability of that equipment.

Acoustics and Accelerometry

Although acoustic and accelerometric investigation of nasality typically fall in the realm of more basic research applications, it is possible that these might also be used diagnostically, and occasionally attempts are made to do so (Kunkel et al., 1998). Recent studies on the acoustic correlates of nasality have been published (Feng and Castelli, 1996; Kataoka et al., 1996; Chen, 1997). With the introduction of nasality, there tends to be a reduction in the amplitude of the first three formant frequencies and especially that of the first formant. Additional acoustic correlates have been reported, such as a nasal resonance peak in the low frequency region of 250 Hz, presumably associated with the longer resonating tube of the pharynx plus nasal cavities. Accelerometric measures have been reported recently (Mra et al., 1998) and acoustic rhinometry has been explored (Dalston, 1992; Seaver et al., 1995), but these have had very limited use either diagnostically or for research purposes.

Aerodynamics

Although aerodynamic measures (air pressure and airflow) certainly can provide useful diagnostic information (e.g., Andreassen et al., 1992; Smith and Guyette, 1993), such measurement requires specialized equipment that is not readily available at most clinical sites. As a result, relatively few centers use aerodynamic measures routinely for diagnostic purposes. However, investigators from these sites have provided a wealth of basic physiologic information, and several of these studies were reviewed in the velopharyngeal physiology section of this report.

Endoscopy, Videofluoroscopy, and Photodetection

Endoscopy (D'Antonio et al., 1993) and videofluoroscopy are readily available in hospital settings, and they offer the benefit of direct visualization of velopharyngeal structures. Therefore, these two methods (Golding-Kushner et al., 1990) and increasingly nasometry, because of its ease of usage and relatively low cost, appear to be the three main instrumental sources of diagnostic information used in most centers at this time. Endoscopy, specifically nasopharyngoscopy, is preferred over videofluoroscopy because of the lack of radiation for the former. A disadvantage of nasopharyngoscopy is the discomfort of nasal insertion so that most centers use topical anesthesia to aid in placement. Ramamurthy et al. (1997) reported that they were able to successfully scope 100% of their patients who were at least 8 years of age but only 9 of 16 patients in the 4- to 6-year-old range. However, Lotz et al. (1993) were able to scope children as young as 2 years of age with ''relative ease.'' They attributed failures more to the examiners' methods and limited skills than to the child's intolerance of the instrumentation. Given that as a possibility, some diagnosticians, nevertheless, might resort to using videofluoroscopy thus avoiding the subject's discomfort of scope insertion if the patient is ''uncooperative'' or has anatomic limitations preventing scope insertion. Thus, videofluoroscopy in spite of the disadvantage of radiation is still very commonly used for diagnosing velopharyngeal function.

Photodetection (Dalston, 1982) operates under the principle of variable transmission of light through the velopharyngeal aperture. Although it is very attractive theoretically as a diagnostic tool and provides information similar to that of aerodynamic procedures, like the latter it requires specialized equipment that is not readily available in most clinical settings. Therefore, it has had limited use diagnostically. Several reports have described combined use of photodetection with endoscopy (Karnell et al., 1988; Covello et al., 1992; Karnell and Seaver, 1993).

Nasometry

A large number of nasometric studies have been published over the last decade (e.g., Seaver et al., 1991; Dalston et al., 1993; Kummer et al., 1993b; Watterson et al., 1993; van Doorn and Purcell, 1998; Nichols, 1999). The metric provided by nasometry is called ''nasalance'' and is the number that typically is reported in the literature. Specifically, nasalance is a ratio of the nasal acoustic output relative to oral plus nasal acoustic output and is expressed as a percentage. Thus, the higher the nasalance score, the greater the relative degree of nasality. Neither the length of the connected speech sample (Wozny et al., 1994; Watterson et al., 1999) nor the loudness of production (Watterson et al., 1994) have a significant influence on nasalance scores. Although the presence of nasal phonemes in the speech sample will logically increase nasalance scores, the influence of nonnasal consonants, specifically obstruent versus sonorant consonants, is less certain (Karnell, 1995; Watterson et al., 1998) and requires additional investigation. There may be subtle differences in relation to age and gender, and these variables require additional research as well. Scarsellone et al. (1999), in their review of the literature, pointed out that older subjects tend to exhibit higher nasalance scores. In their own research, however, they found little difference in nasalance scores in elderly subjects with dentures in versus dentures removed. None of their subjects presented with a history of speech or hearing disorders, and all mean nasalance scores for the ''Zoo'' passage were below 13.

The standard Zoo passage, which is void of nasal phonemes, typically is used to determine nasalance scores. Various nasalance cut-off scores have been reported to help differentiate between clinically significant hypernasality and normal resonance balance. Thus, Dalston et al. (1991) used a cut-off score of 32, whereas Hardin et al. (1992) used a less conservative score of 26 and Watterson et al. (1996) used a score of 22. Sensitivity and specificity coefficients were provided in these studies. The coefficients will vary, obviously, depending on the cut-off score used. It would appear safe to conclude that if a nonnasal speech sample is used, such as the Zoo passage, and if nasalance scores are at least in the 40s and above, the patient probably would be perceived as exhibiting clinically significant hypernasality. In the experience of one of the authors (D.P.K.), the highest nasalance score recorded for the Zoo passage was for a 25-year-old woman with a nonmovable soft palate and thus a fully open velopharyngeal port (Wachtel et al., in press). That score was 75 on the Zoo passage.

Nasometry might be used to assess hyponasality (Dalston et al., 1991) as well as hypernasality. However, this has received much less attention in the literature.

Treatment: Behavioral Management

General Considerations in Speech Treatment

As we enter a new millennium, knowing direct speech treatment has been advocated and provided to children and adults with cleft palate for the better part of the 20th century, it is disconcerting to note there have been so few studies with primary focus on effectiveness or efficacy of speech treatment (Prins and Bloomer, 1965; Shelton et al., 1969; Chisum et al., 1969; Van Demark, 1974b; Albery and Enderby, 1984; Van Demark and Hardin, 1986; Kuehn, 1997). No one would deny the importance of speech intervention; however, scientific evidence about which specific procedures work best, for whom and under what conditions, is indeed lacking (Kuehn and Dalston, 1988; Peterson-Falzone, 1988; McWilliams et al., 1990; Starr, 1993; Tomes et al., 1997).

Speech-language pathologists and researchers agree about the difficulty applying experimental procedures and controls to the clinical process (Hardin et al., 1986). In fact, Siegel (1987) believed clinical outcome research is confounded by so many variables that cannot be controlled that conclusions may be meaningless. However, Kent (1990) argued that it is appropriate to investigate effectiveness of treatments and that answers are possible through outcome research.

At the current time, there is no evidence to suggest that speech treatment focusing on articulation results in measurable improvement in velopharyngeal closure (Peterson-Falzone, 1988; McWilliams et al., 1990; Starr, 1993; Tomes et al., 1997; Van Demark, 1997b). However, we must recognize that much of what is done in speech treatment clarifies what may be required regarding the velopharyngeal mechanism. As a general rule, speech treatment needs to focus on what the speaker can do and to clarify what, perhaps, the speaker cannot do with the current structural mechanism to produce acceptable speech. Clearly, speech-language pathologists use speech treatment in some form for persons with cleft palate. In a survey conducted 20 years ago (Schneider and Shprintzen, 1980), more than 80% of speech-language pathologists reported using articulation treatment for persons with velopharyngeal inadequacy. Ten years later, another survey (Pannbacker et al., 1990) revealed that speech-language pathologists varied on their opinion about the effectiveness of speech treatment. In this survey more than 60% believed speech treatment to improve velopharyngeal function was effective occasionally, frequently, or always; 35% believed treatment was effective rarely or never. Neither survey, however, provided information about specific criteria for treatment or nature of the treatment or even which speech structures are targeted.

There have been several book chapters and reviews over the last 10 years focusing on behavioral approaches to improving velopharyngeal function (Kuehn and Dalston, 1988; Peterson-Falzone, 1988; McWilliams et al., 1990; Starr, 1990, 1993; Ruscello, 1997; Tomes et al., 1997). In general, they have examined the assumptions underlying the approaches, rationale for use, specific procedures utilized, and empiric data available. Tomes et al. (1997) present a thorough review of behavioral attempts to bring about changes in velopharyngeal function and include those related to articulation and resonance change.

Articulation Treatment

Articulation treatment for persons with cleft palate has been an integral component of clinical management since the 1940s. However, research studies focusing on the direct effect of articulation treatment have been limited. In general, the literature has shown that articulation treatment results in overall improvement (Prins and Bloomer, 1965; Chisum et al., 1969; Shelton et al., 1969; Van Demark, 1971, 1974b; Albery and Enderby, 1984; Van Demark and Hardin, 1986; Ysunza et al., 1992); however, the specific nature of the treatment and nature of the change is infrequently reported. Shelton et al. (1968a) concluded that articulation procedures used with persons with cleft palate who have adequate velopharyngeal closure is similar to persons without cleft palate with functional articulation problems. Furthermore, procedures used with those who demonstrate less than adequate velopharyngeal closure involve teaching the best possible articulation, including accurate articulation placement. They also commented that acceptable phonetic placement for consonant articulation, even though speech is characterized by nasality, is more intelligible than speech with unacceptable placement.

Review of the literature reveals several clinical reports, using limited numbers of subjects, showing improvements in speech utilizing a variety of phonetic or phonologic approaches (Hodson et al., 1983; Hoch et al., 1986; Trost-Cardamone and Bernthal, 1993; Golding-Kushner, 1995). Trost-Cardamone and Bernthal (1993) advocate an eclectic approach to modification of the child's sound production based on analysis of the child's current repertoire and needs. They note that a phonetic approach may be appropriate for some children, but when classes of sounds are in error, a phonologic approach may be more helpful.

Within the context of an articulation or phonologic approach, speech clinicians have addressed modification of compensatory articulation patterns (Hoch et al., 1986; Trost-Cardamone and Bernthal, 1993). Focus of treatment is to modify place of articulation to more anterior positions that are consistent with normal speech. With more appropriate placement, two outcomes can occur. First, there may be an increase in the perception of audible nasal air emission and hypernasality during connected speech if, indeed, the velopharyngeal closure mechanism is inadequate. In this event, it is important the speech clinician make sure patients, parents-caregivers and others understand that although progress in articulation is occurring, overall it may appear that speech is getting worse. Second, more appropriate anterior placement may reveal that the velopharyngeal closure mechanism is adequate, or potentially adequate, for acceptable conversational speech.

The intensiveness with which speech treatment is offered has been the subject of some investigations. Albery and Enderby (1984) found that more frequent than weekly treatment resulted in greater speech improvement and was maintained over a longer period. Van Demark and Hardin (1986) found that intensive speech treatment provided during a 2-week residential setting resulted in articulation improvement; however, it was not always maintained when retested approximately 1 year later. Several of their subjects had marginal velopharyngeal closure at the time treatment occurred.

From an articulation perspective, we currently have a better appreciation for what can and perhaps cannot be modified based upon speakers' velopharyngeal capabilities. Basically, articulation treatment serves two purposes: maximizing articulation placement and clarifying velopharyngeal closure potential. Broen et al., (1993) reported on a 3-year-old child with a habitual compensatory posterior pattern of articulation and, consequently, uncertain velopharyngeal closure potential. Home procedures designed to encourage anterior placement were successful and revealed adequate velopharyngeal closure. However, the opposite could have occurred; improved placement could have revealed inadequate closure.

Persons who exhibit ''phoneme-specific'' velopharyngeal disorders provide an excellent example of establishing treatment goals and expectations based on speech performance (Trost-Cardamone, 1986; Peterson-Falzone, 1988; Peterson-Falzone and Graham, 1990). These are speakers who, perceptually, accomplish velopharyngeal closure for an abundant number of obstruent consonants but do not for specific phonemes, usually /s/ and /z/ and perhaps some additional fricatives. Speech-language pathologists agree that, although these errors may be resistant to change (Van Demark and Hardin, 1990), they almost always will respond to articulation treatment. Attempts to modify audible nasal air emission may be perfectly appropriate if there is evidence that the person is inconsistent in this dimension or demonstrates the capability to reduce or eliminate it (Shprintzen et al., 1975; Shprintzen, 1989). A common procedure for eliminating phoneme-specific nasal emission of air on the consonant /s/ is to teach the subject to make a gradual transition from /t/ to /s/ (assuming that /t/ can be produced without nasal air leak) by releasing tongue-to-palate contact for /t/ and then sustaining the fricative /s/ (Hall and Tomblin, 1975; Kummer and Lee, 1996; Trost-Cardamone and Witzel, 1998).

It is important to differentiate phoneme-specific nasal emission of air from more pervasive and serious problems that may be more amenable to other types of behavioral or physical management. In this regard, Trost-Cardamone and Witzel (1998) differentiated between ''obligatory'' errors, including hypernasality, pervasive nasal emission of air, and weak obstruent consonants versus ''optional/learned'' errors that include compensatory misarticulations. The former more likely might require physical management whereas the latter (which includes phoneme-specific nasal emission of air) are more segmental in nature. That is, compensatory articulations tend to be associated with specific speech sounds and may be more amenable to treatment involving fairly traditional speech treatment procedures.

Resonance Treatment

Historically, speech treatment procedures to modify hypernasal resonance distortion have received little support in the literature (Tomes et al., 1997). Early writers (McDonald and Koepp-Baker, 1951) suggested that increased mouth opening decreased perception of nasality. Although the effect of this maneuver was supported to some extent by later empiric studies, the technique has not enjoyed wide use or success. Tomes et al. (1997) also observed there has been evidence to suggest that speakers with better articulation skills are perceived as less nasal than those with poor articulation; however, as noted previously, listeners have difficulty judging severity of nasality in the presence of articulation defectiveness. Starr (1993) and Tomes et al. (1997) concluded there is insufficient evidence that modifying pitch, intensity, oral-nasal resonance control (orality), and voice quality will alter listeners' perception of the severity of nasality in predictable ways.

Tomes et al. (1997) provided a comprehensive review of behavioral management for velopharyngeal impairment. The reader is encouraged to refer to that source for detailed coverage of this topic. The authors pointed out, as did Peterson-Falzone (1988) in a previous report, that there appear to be three phases of opinions about the effectiveness of behavioral management in attempts to reduce hypernasality. The first phase, 1940s to 1960s, was that speech therapy works. The second phase, 1960s to 1970s, was that speech therapy does not work to reduce hypernasality but that therapy might improve other disordered aspects of speech, such as articulation problems, and that in turn might reduce the overall deleterious effects of hypernasality on speech. The third phase, from the 1970s to the present, is that therapy might reduce hypernasality but treatment efficacy data are needed. The discouragement during phase 2 relates to the inability of clinicians and researchers to demonstrate a positive effect on reducing hypernasality using nonspeech tasks. Use of nonspeech activities such as blowing, sucking, swallowing, and gagging in an attempt to increase velopharyngeal movements were popular in the 1950s and early 1960s. The rationale appeared to be that more extensive velopharyngeal movement during these activities would carry over to speech. The validity of these procedures and nature of velopharyngeal physiology during these activities was investigated later in the 1960s and early 1970s (McWilliams and Bradley, 1965; Moll, 1965; Powers and Starr, 1974; Shprintzen et al., 1975) Findings suggested that patterns of velopharyngeal closure were variable across subjects, neuromuscular processes involved in speech probably differed from nonspeech tasks, and that use of these activities with expectations of speech benefit was questionable. This information was important because it redirected, or should have redirected, clinicians to treat speech within the speech context. Thus, renewed optimism during the current phase is likely related to the use of instrumental procedures and the realization that therapeutic procedures will probably have to utilize speech drills in training sessions and not rely primarily on nonspeech tasks.

Several studies have been published in which endoscopy, either with a rigid scope or a flexible scope, has been used to provide feedback to the individual concerning the functioning of his or her velopharynx during speech (Yamaoka et al., 1983; Hoch et al., 1986; Witzel et al., 1988; 1989; Brunner et al., 1994; Golding-Kushner, 1995; Ysunza et al., 1997; Trost-Cardamone and Witzel, 1998). The most promising approach appears to be that of nasal insertion, as opposed to oral insertion, using a flexible scope. Several other feedback procedures including nasal airflow, velar strain gauge, and light transmission devices were reviewed by Tomes et al. (1997). The obvious advantage of feedback procedures is that both the subject and the clinician can monitor activities during ongoing speech, which ostensibly should aid in changing speech behavior. A disadvantage with most feedback procedures is that they use equipment that requires visits to facilities to use expensive equipment that is not readily available to practitioners working in nonhospital or nonclinic settings such as public schools nor in the subject's home. Another disadvantage is that some procedures are invasive, especially nasendoscopy. Moreover, if an individual's mechanism is inadequate physically, such as lacking sufficient strength and endurance, then feedback procedures alone may not be effective in changing behavior.

Kuehn (1991, 1997) introduced a therapy procedure designed to reduce hypernasality that makes use of resistance exercise principles. A continuous positive airway pressure (CPAP) is applied to the nasal passages during speech, using commercially available CPAP equipment, that provides a resistance against which the muscles of velopharyngeal closure must work. Important advantages of this treatment approach are that drillwork is conducted during speech, rather than during nonspeech activities, and the drillwork is conducted in the patient's home allowing frequent and regular treatment sessions. A study involving six cleft palate centers in the midwestern United States to investigate the efficacy of the procedure was conducted. Results (in preparation) indicated that perceived nasality in the subject group as a whole was reduced following the 8-week home therapy regimen.

With regard to hyponasality, direct speech treatment to modify this type of resonance disorder will likely prove futile. Hyponasality is the result of transitory or more permanent obstruction in the nasopharyngeal and nasal component of the vocal tract. Appropriate treatment almost invariably requires physical intervention and removal or modification of the obstruction. There is a need for systematic perceptual, acoustic, and physiologic investigations of the effect of these procedures on resonance. For example, although correction of a deviated nasal septum is sometimes a recommendation for adolescents and young adults with cleft lip and palate, the specific effect on resonance has not been studied.

Voice Treatment

The voice deviations of hoarseness, harshness, breathiness, and reduced loudness frequently seen in persons with cleft palate are best attributed to compensatory laryngeal or perhaps respiratory function in response to velopharyngeal dysfunction. Review of direct voice treatment procedures is not within the purview of this discussion. If voice treatment is a focus, the clinician needs to be aware of the possible velopharyngeal etiology and that improvement in voice may increase the perception of hypernasality. In that sense, the velopharyngeal sequelae of voice treatment is similar to that of modifying compensatory posterior articulation.

Treatment for Neurologic Disorders

Velopharyngeal impairment often is one component of dysarthria, which is a generalized neuromuscular disorder affecting speech. Discussion of dysarthria is beyond the scope of this report, but speech pathologists who manage patients with cleft palate frequently are involved in management of neurologically based speech disorders as well. A common treatment for neurologically based velopharyngeal dysfunction is the use of a palatal lift appliance. The use of prosthetic devices is reviewed later in this report.

McHenry (1997) reported that 89% of her 28 subjects with traumatic brain injury decreased velopharyngeal orifice area by increasing vocal loudness. The author stated that ''in several cases, the change would likely affect perceived hypernasality.'' It should be emphasized, however, that McHenry's subjects were neurologically impaired, not with cleft palate. In subjects who are not neurologically impaired, the effects of changes in vocal loudness and pitch on hypernasality have been inconsistent and not very pronounced as demonstrated in several earlier studies (Kuehn, 1982). It appears that neither loudness nor pitch drillwork is likely to produce large changes in velopharyngeal function in individuals with cleft palate.

Treatment for Stuttering

Srivatsa (1995) implicated velopharyngeal impairment as an underlying cause of stuttering. The author argued rather circuitously that velopharyngeal impairment could affect auditory feedback which, in turn, could have a disruptive effect on speech, thereby leading to stuttering behavior. The author recommended using a cervical collar to ''. . . hyperextend the neck so that the presumptive closure plane of the [velopharyngeal] isthmus in relation to Passavant's ridge is raised.'' It is difficult to take such a recommendation seriously either as a treatment procedure for hypernasality or stuttering. Indeed the relatively low co-occurrence of stuttering with velopharyngeal impairment was pointed out by Dalston et al. (1987) in their reported patient group, over one-third of whom were diagnosed as having ''borderline'' or ''inadequate'' velopharyngeal function.

Early Intervention

The previous discussion has focused on individuals of sufficient age and cooperation to participate in treatment. In the last 20 years, there has been increased focus on ''treatment'' for very young children and intervention with parents-caregivers (Philips and Kent, 1984; O'Gara and Logemann, 1988; Philips, 1990; Chapman, 1991; Chapman and Hardin, 1992; Broen and Moller, 1993; Chapman, 1993; Trost-Cardamone and Bernthal, 1993; Van Demark et al., 1993; Neiman and Savage, 1997). Intervention during the first 24 months is directed more to the parents than the child. Early focus is with education of parents and caregivers in a variety of areas: (1) normal speech and language development, (2) role of the speech structures in producing speech, (3) effect of an unrepaired cleft palate and possible effect of a repaired cleft palate on speech, (4) high frequency of middle ear disease and hearing loss and importance of identifying and treating ear problems, and (5) importance of speech-language stimulation in the home (Hahn, 1979; Brookshire et al., 1980; D'Antonio and Scherer, 1995; Girolametto, 1995; Dixon-Wood, 1997). There has been very limited observation and examination of early mother-child communicative interaction and responses to early speech production efforts by their child. Specifically, parental responses to compensatory posterior productions may contribute to maintenance of this pattern. Studies examining parental preferences (Paynter and Kinard, 1979; Diegel, 1984; Paynter, 1987) suggest rather strongly that the compensatory pattern is preferred over the pattern of correct placement produced with excessive nasality and audible nasal air emission. Parents need to be instructed repeatedly about the undesirability of development of the compensatory pattern. Data obtained from systematic studies focusing on these early concerns should help identify important variables that will facilitate more optimal communication skills at earlier ages.

Future Needs in Behavioral Management

The role of the speech-language pathologist is to assess how the patient is currently using the speech structures to produce speech but also to determine what the patient can do and clarify the possible limitations of the structural mechanism. The decision that improved speech is, or is not, dependent upon a physically improved mechanism clearly belongs with the speech-language pathologist and must be based upon a considerable amount of diagnostic and speech treatment information.

Speech outcome research is now limited and needs to be a focus for future effort. Recent reports suggest a range of overall speech performance in adolescent groups where less than satisfactory outcome was found in 25% to slightly more than 50% (Van Demark et al., 1979; Dalston, 1990; Riski, 1995; Peterson-Falzone, 1995). This is not, and should not, be acceptable. We need to determine what factors contribute to these findings. Is it the speech criteria we as professionals use for acceptable speech? Is it the criteria patients and families use, or their expectations for satisfactory speech? Do we have less than acceptable surgical or speech treatment approaches to achieve acceptable speech in greater numbers of patients? Peterson-Falzone (1995) speculated that inconsistent team care and patient and family noncompliance or difficulty in following through with treatment recommendations might contribute. Riski (1995) believed speech clinicians working with patients in schools and other settings are not adequately informed and knowledgeable about diagnostic techniques and treatment strategies. Speech-language pathologists assessing and treating persons with cleft palate have a crucial role in speech development, remediation, and providing the interdisciplinary team with information that facilitate appropriate and timely decisions regarding the need for physical management of velopharyngeal problems.

Although there have been clinical reports of improved speech intelligibility, articulation, and resonance following certain regimens of treatment, the evidence is not overwhelming and reports suffer from insufficient number of subjects, specific perceptual and physiologic criteria for subject selection, experimental controls and quantitative outcome measures. Clearly, more prospective research regarding speech treatment is needed. More specific criteria for speech treatment decisions and approaches must be developed (Morris and Bardach, 1989). We must be able to specify the important antecedent conditions (structural, physiologic, perceptual, behavioral, psychoeducational, and family factors), apply clearly defined treatment procedures (physical, behavioral, or both), and measure outcome in meaningful ways. Speech professionals need to be more innovative in developing and applying behavioral treatment procedures for velopharyngeal impairment, especially for the more mild or moderate cases that might otherwise be overtreated by surgical management or perhaps not treated at all by any procedure. Too often there is an attitude of resignation that surgery is the only approach for management. However, surgery does have significant side effects occasionally, is expensive, and sometimes just does not work and leads to an even worse condition. Given more detailed anatomic and physiologic information, speech professionals should be in a better position to develop more effective therapeutic approaches and to use these at the earliest possible age. It will be important, then, to demonstrate that new or modified therapy approaches are in fact effective in managing the speech disorder being treated.

Speech outcome measures need not await a final result when physical growth and development is complete, but rather it would be wise to periodically assess speech at stages of growth and development; perhaps 0 to 3 years, preschool, school age, and adult. This would enable adjusting treatments as appropriate. Importantly, outcome measures for speech must include not only professional judgments but patient or family judgments as well (ACPA Parameters, 1993). As with any clinical outcome research, this will help answer the ultimately important questions: Does it work? With whom? Under what conditions?

Treatment: Surgical Management

Primary Palatal Surgery

The profile of surgical treatment practices has changed somewhat over the last several years with regard to both primary and secondary surgical procedures. Information obtained from large-scale surveys has reflected some of these changes. Although there are still proponents of two-stage (or multiple-stage) palatal procedures (e.g., Lohmander-Agerskov et al., 1997; Lohmander-Agerskov, 1998), Huebener and Marsh (1997) reported that 87% of the 118 cleft palate teams that responded to their survey (250 questionnaires sent) use a one-stage procedure. This compares with the 76% of the 122 teams that responded (228 questionnaires sent) in a similar previous survey (Huebener and Marsh, 1993). In 1997 the average age of the patient at primary surgery was 10.4 months, compared with 11.5 months in 1993. In 1997 the breakdown for the most common types of primary surgery were as follows: Von Langenbeck, 33%; Wardill (V-Y pushback), 32%; and Furlow, 25%. This compares with Von Langenbeck, Wardill, and ''other'' procedures (Furlow not singled out) with ''equal frequency'' in 1993. Thus, in agreement with another large-scale survey (Spira et al., 1995), the trend for primary surgery seems to be toward a one-stage procedure at an earlier age, with Furlow procedures (Furlow, 1995) increasing in frequency, such that there is a similar preference across the Von Langenbeck, Wardill (V-Y), and Furlow procedures at the present time.

A detailed and comprehensive coverage of surgical procedures for cleft palate is beyond the scope of this report and will be dealt with in another article in this journal's state-of-the-art series. It should be noted, however, that many factors potentially could affect the particular surgical type performed. Seagle (1996) pointed out that many nuances exist among surgical procedures even though they may be classified as a certain type and that a large randomized, double-blind study will be necessary to provide more definitive information concerning the superiority of one surgical procedure, compared with others. Logically, the skill and experience of the surgeon could affect surgical outcome (Witt et al., 1998b). Also, the timing of primary palatoplasy may be an important variable but an optimum age at which surgery should be performed in the infant has not been clearly demonstrated or agreed upon (Peterson-Falzone, 1996). In relation to the trend toward earlier surgery, Denk and Magee (1996) reported on their experience in performing primary surgery on 21 neonates at an average age of 7.5 days with a range of 1 to 28 days. Although primary palatoplasty in the first month of life certainly is not typical, Kemp-Fincham et al. (1990) argue that there may be an optimum age of surgery that occurs as early as 4 to 6 months of age.

Concerning intravelar veloplasty (IVV), it appears logical that dissecting levator fibers off of the cleft bony palate and then retropositioning those fibers across the midline would provide more favorable velopharyngeal closure and thus better speech results (Cutting et al., 1995). However, Marsh et al. (1989) reported no benefits in speech between a group of patients receiving IVV versus those receiving a more conservative operative procedure without IVV. This issue is in need of further investigation.

Secondary Surgery

Although the exact figure varies across studies, it is generally reported that approximately 25% of individuals who receive primary palatoplasty for cleft palate will require a subsequent surgical procedure (''secondary'' surgery) to treat continuing velopharyngeal impairment for speech (McWilliams, 1990). For many years, the secondary surgical treatment of choice among most surgeons was the superiorly based posterior pharyngeal flap. This procedure is still frequently used. Morris et al. (1995) reported that 83.1% of their 65 subjects achieved velopharyngeal function ''within normal limits'' following pharyngeal flap procedures and that 66.1% showed ''normal or near normal speech production.'' Speech results following sphincter pharyngoplasty also have been published. Riski et al. (1992b) reported ''resolution'' of velopharyngeal impairment in 78.4% of their patients following sphincter pharyngoplasty and Sie et al. (1998) reported that 62.5% of their patients had ''complete resolution'' of their velopharyngeal impairment. Witt et al. (1994) reported that, following sphincter pharyngoplasty procedures, 65% of their patients were still considered candidates for additional surgery. Riski et al. (1992a) indicated that in those cases that were considered to be failures following sphincter pharyngoplasty, problems included a velopharyngeal gap that was too large preoperatively and a flap that was positioned too low to be effective in velopharyngeal closure.

Currently, more surgeons are performing pharyngeal flap, sphincter pharyngoplasty, and other procedures in a selective manner in an attempt to more accurately match surgical treatment to the patient's particular pathophysiology (Witt et al., 1995a). For example, if the velum moves fairly well but the lateral pharyngeal walls do not (coronal closure pattern), the preferred treatment might be a sphincter pharyngoplasty. Conversely, if the velum does not move very well but the lateral pharyngeal walls do (sagittal closure pattern), the treatment of choice is more likely to be a pharyngeal flap. Surgeons are beginning to focus more attention on providing integrity of the levator muscle sling, such as performing a V-Y intravelar veloplasty or a Furlow, as a secondary procedure (Sommerlad et al., 1994; Hudson et al., 1995; Boorman et al., 1997; Chen et al., 1997; D'Antonio, 1997; D'Antonio et al., 1997b) or as a primary procedure in patients with submucous cleft palate

(Pensler and Bauer, 1988; Chen et al., 1996; Gosain et al., 1996; D'Antonio et al., 1997a; Sommerlad et al., 1997).

Various materials have been implanted or injected into the posterior pharyngeal wall to augment the area, theoretically facilitating velum to pharyngeal wall contact. These materials have included petroleum jelly, paraffin, cartilage, fat, Silastic, Teflon, collagen, and proplast (see Witt et al., 1997 for review). In spite of all of these attempts that span at least one century, implantable or injectable materials typically fail because they tend to migrate, are absorbed, or are extruded. To overcome these problems, a surgical procedure of lifting a superiorly based flap from the posterior pharyngeal wall and folding or rolling it upon itself has been tried with mixed results so far. Witt et al. (1997) reported little or no improvement in speech using this procedure whereas Gray et al. (1998) did report improvement.

Huang et al. (1997) called into question how surgical ''success'' should be defined following sphincter pharyngoplasties and other types of secondary surgeries for velopharyngeal impairment. Although the goal should be reducing or eliminating hypernasality, if a patient is rendered hyponasal, this should not be viewed as a success. Subsequent surgery, such as taking down a pharyngeal flap, may be necessary. Also, the secondary procedure may fail to provide sufficient reduction in hypernasality. In some of these cases, further reduction in hypernasality might be achieved using behavioral therapy procedures (see that section in this report). In other cases, additional surgery will be required. Witt et al. (1998a) reported that 20% of their patients who received pharyngeal flap and 16% of their patients who received sphincter pharyngoplasty required surgical revision. The main cause of the failure for both procedures was partial or complete dehiscence of the flap. Unfortunately, as reported by the authors, revisional surgery of this type is usually associated with hyponasal speech.

Maxillary Advancement and Distraction Osteogenesis

Individuals with cleft palate sometimes require maxillary advancement to treat midfacial hypoplasia. In such cases, there is often concern that advancing the maxilla and, consequently, the hard palate as well will draw the velum forward thereby leading to inadequate velar-pharyngeal contact and perhaps a reoccurrence of hypernasality. Haapanen et al. (1997) and Maegawa et al. (1998) reported that approximately 25% of their two patient groups were rendered hypernasal following Le Fort I maxillary advancement osteotomy. Kummer et al. (1989) reported a deterioration in velopharyngeal function for speech in some of their patients but they reported an improvement in articulation after Le Fort I surgery in 7 of 11 patients who presented with preoperative articulation errors. Guyette et al. (1997) also reported an improvement in articulation with maxillary advancement and only a minimal effect on velopharyngeal functioning in patients with good preoperative velopharyngeal closure. However, patients who were hypernasal preoperatively were rendered even more hypernasal postoperatively. Thus, there may be a trade-off in some patients: improved oral articulation at the expense of deterioration of velopharyngeal function and the latter may depend on velopharyngeal status preoperatively. If the resulting velopharyngeal impairment is severe enough following maxillary advancement, a secondary surgical procedure may be required to treat the velopharyngeal impairment.

Several studies involving distraction osteogenesis procedures (Aronson, 1994) in subjects with cleft palate and other craniofacial anomalies have been conducted recently (e.g., Cohen, 1997; Molina et al., 1998). As with abrupt maxillary advancement using the Le Fort I osteotomy procedure, gradual distraction of the maxilla also may result in velopharyngeal degradation for speech in some individuals. Guyette et al. (1998) reported increased estimated velopharyngeal orifice size and increased nasalance scores following maxillary distraction. Williams et al. (1998) reported some long-term deterioration in velopharyngeal function in 14% (3 of 21) of their patients following maxillary distraction. With regard to mandibular distraction, Guyette et al. (1996) reported a declination in articulation skills in two patients following unilateral mandibular distraction of 35 mm and 45 mm of lengthening.

A particularly innovative application of the distraction procedure was reported by Carls et al. (1997a, 1997b). These investigators performed distraction on the hard palates of six dogs over a total of 6 to 8 weeks at a rate of 0.25 mm to 0.75 mm per day achieving a total lengthening of the hard palate up to 8 mm. They reported no major complications. The authors discussed the possible application of this procedure to humans in whom the velum moves but is short of making contact with the posterior pharyngeal wall. Lengthening the hard palate, theoretically, would then bring the velum into close proximity to the posterior pharyngeal wall thereby possibly enabling velopharyngeal closure.

Tonsillectomy and Adenoidectomy

It has long been known that adenoidectomy can unmask hypernasality in at-risk individuals, especially those with repaired cleft palate (Finkelstein et al., 1996) but also in noncleft palate individuals (Ren et al., 1995). In these situations, with sudden reduction of the adenoid mass, the velum is too short to reach good contact with the posterior pharyngeal wall. Thus, a conservative approach in not removing adenoidal tissue in at-risk patients should be taken unless necessary for medically sound reasons. Long-term adenoid involution in individuals with cleft palate also may lead to the inability to make good velar-pharyngeal contact. Mason and Warren (1980) described two such cases. Morris et al. (1990) reported that 7 of 39 subjects with cleft palate, followed up longitudinally, demonstrated ''significant deterioration of velopharyngeal status'' by their middle or late adolescence due to adenoid involution. Incomplete surgical removal of adenoid tissue (Ren et al., 1995) or irregular growth of adenoid tissue (Kummer, 1998) can both produce an uneven surface against which the velum makes contact thereby resulting in incomplete velopharyngeal closure.

Whereas removal or reduction of adenoid tissue may have a deleterious effect on velopharyngeal function, the opposite has been reported for tonsils in that enlarged tonsils can hinder velopharyngeal closure in some cases (Kummer et al., 1993a; Finkelstein et al., 1994; Ren et al., 1995). Therefore, tonsillectomy can be beneficial in these individuals in improving velopharyngeal function for speech. It appears that if tonsils are not hindering velopharyngeal closure, their removal generally will have little or no effect on velopharyngeal functioning (D'Antonio et al., 1996).

Less well known or reported is the fact that tonsillectomy alone (i.e., without accompanying adenoidectomy) can lead to severe velopharyngeal impairment (Haapanen et al., 1994; Wachtel et al., in press). Wachtel et al. (in press) described a 25-year-old woman with normal speech preoperatively who was rendered extremely hypernasal immediately following tonsillectomy alone. She presented with a postoperative nasalance score of 75 and an immovable soft palate. The authors concluded that the patient sustained neurologic damage during surgery. However, the woman regained motor function for speech after a period of 15 months. At that time, her nasalance score was 18, well within normal limits; she exhibited good velopharyngeal closure endoscopically; and her speech was perceived as normal, although some sensory deprivation persisted resulting in some swallowing difficulties. The importance of this case report is that spontaneous recovery from a neural insult can be very dramatic but quite lengthy (in this case 15 months). Therefore, if there is suspected neurologic trauma, it may be advisable to follow the patient for a considerable amount of time to monitor continuous progress as was demonstrated for this patient, before performing a surgical procedure or other management for the velopharyngeal disorder.

Treatment: Prosthodontic Management

The dental specialty of prosthodontics has been a component of management for patients with cleft lip and palate for well over 100 years. In fact, when interdisciplinary teams were becoming more formally established in the 1930s and 1940s, prosthodontic treatment was at the very forefront of care (Harkins and Koepp-Baker, 1948). In many instances prostheses were constructed to "close" the original cleft defect both anteriorly and posteriorly either as an alternative to surgery or to supplant unsuccessful surgical closure of the cleft. Indeed, the Academy of Cleft Palate Prosthesis, established in 1943, was the interdisciplinary association predecessor to the American Cleft Palate Association and currently the American Cleft Palate-Craniofacial Association. As surgical techniques and results improved over subsequent decades, prosthetic treatment of clefts of the alveolus and hard and soft palate became less frequent. Today, prosthetic management is almost never used, at least in the United States, for the congenital cleft defect other than initial feeding aids prior to surgery (Delgado et al., 1992). However, prosthodontics remains an essential intervention for optimal dental and occlusal relationships; facial form and function; and, in some instances, speech.

Relationships among dental or occlusal conditions and speech performance will not be reviewed here. However, the reader is referred to several recent discussions of these relationships (Peterson-Falzone, 1988; Leeper et al., 1993; Moller, 1994). Leeper et al. (1993) provide a thorough discussion of the clinical and research aspects of prosthodontic procedures for anterior palatal problems and relationships to speech for persons with cleft palate and other congenital or acquired maxillofacial defects.

The focus of this discussion will be prosthetic treatment to achieve optimal oral-nasal separation for acceptable speech. We will emphasize historical aspects, current status, and speculation about speech prostheses designed to improve velopharyngeal closure. However, a brief discussion of obturation of a palatal defect such as oral-nasal fistulae is also in order. Oronasal fistulae following primary hard and soft palate surgical repair are less prevalent than previously, but when present, they can present problems for speech production and assessment of the adequacy of velopharyngeal closure. A temporary prosthesis to obturate the opening is an effective treatment to eliminate any contribution to audible nasal air emission, and possible resonance distortion, and allow for more accurate assessment of velopharyngeal function. These prostheses are usually fairly simple to construct, and a variety of intraoral designs, retention, and materials utilized have been reported in the last 20 years (Bless et al., 1980; Reisberg et al., 1985). Recent reports have described improved articulation, resonance, and soft palate and lateral pharyngeal wall movement with temporary fistula obturation (Lohmander-Agerskov et al., 1996) and improved articulation and resonance with obturation of a duration of 4 to 7 weeks (Pinborough-Zimmerman et al., 1998). These intraoral prostheses can, and will continue to, serve as helpful interim treatment until more permanent surgical closure can be accomplished.

Velopharyngeal Treatment

Most interdisciplinary texts include discussion of prosthodontic treatment to improve velopharyngeal closure for speech with use of speech bulbs and palatal lifts. Although the term obturator has frequently been applied to velopharyngeal prostheses, the term obturator should be reserved for prostheses that, indeed, do obturate or totally occlude an opening such as oronasal fistulae. Speech bulbs and palatal lifts, in general, assist or aid velopharyngeal closure and do not obturate. The term bulb, although a tolerable term over many years, might best be described as a speech prosthesis with a pharyngeal (behind velar tissue) section. Palatal lifts connote elevation (and posterior positioning) of the soft palate to approximate the posterior pharyngeal wall.

The use of speech prostheses for velopharyngeal problems has had a long and interesting history. Early in the century and even into the 1950s and 1960s, several reports advocated use of speech bulbs as an effective treatment either as an alternative to surgery or as a secondary procedure to improve closure for speech (Rosen and Bzoch, 1958; Aram and Subtelny, 1959; Olin, 1960; Harkins et al., 1960; Mazaheri, 1962; Falter and Shelton, 1964; Arndt et al., 1965). In an extensive study of 23 persons who wore speech bulbs, Subtelny et al. (1966) reported significant improvement in speech intelligibility, articulation, and resonance but also noted the important research implications and opportunity to study a variety of physiologic measures and perceptual judgments of speech in two experimental conditions in the same subject—with prosthesis in versus out. In general, reports of the effectiveness of speech bulbs to improve velopharyngeal closure for speech were descriptive and based primarily on listener judgments in before and after conditions.

The palatal lift prosthesis has had a considerably shorter history. Originally described in 1958 by Gibbons and Bloomer, additional clinical reports of its use did not appear until the late 1960s and 1970s. Early reports of palatal lifts were with patients having sufficient soft palate length but lacking sufficient mobility. Although some persons with repaired cleft palate demonstrate sufficient length and could be considered candidates for palatal lifts, the majority of the reports described noncleft palate patients with neuromuscular etiologies affecting velopharyngeal function (Hardy et al., 1969; Marshall and Jones, 1971; Kipfmueller and Lang, 1972; LaVelle and Hardy, 1979). Prior to the description of the palatal lift, persons with normal soft palate length but mobility problems were treated with speech bulbs positioned in the oronasopharynx behind the soft palate. The velar extension connecting the hard palatal portion and the pharyngeal section usually followed the oral surface of the resting soft palate. This resulted in a number of speech prostheses that were judged to be inadequate and uncomfortable and that interfered with articulation due to the low position of the velar extension. The advent of the palatal lift prosthesis seemed to solve these problems but created others. Dental specialists were concerned that consistent elevation of the soft palate would result in excessive pressure causing dislodgment of the prosthesis, inflammation of the oral surface of the soft palate, and displacement of teeth. In an important study, Gonzalez and Aronson (1970) reported on 35 noncleft palate patients treated with a palatal lift. They demonstrated that consistent elevation of the palatal tissue did not result in dislodgment, tissue inflammation, or displacement of dentition if the velar portion or the prostheses displaced tissue over a wider area and the retention system was satisfactory. These authors described the lift-bulb prosthesis to eliminate low-positioned velar extensions. If velar length was not sufficient, a pharyngeal extension was added to the posterior aspect of the lift. Since that time, and dependent upon the patients' velar length, lifts or lift-bulbs generally have been utilized. It can be concluded that fabrication and fitting of a speech prosthesis remains a viable physical treatment option to improve velopharyngeal closure for speech. It is probably true that some centers utilize the prosthesis approach more frequently than others. Infrequent usage might be because of practical issues such as availability of an experienced, well-trained prosthodontist rather than philosophical reasons.

Although it is well recognized that speech prostheses may provide optimal velopharyngeal closure for speech, their use on a temporary basis for diagnostic purposes and potential to serve a ‘‘training’’ function should also be considered. Almost 40 years ago, Blakeley (1960) reported on a 4-year-old child for whom a speech prosthesis was constructed. Following approximately 1 to 2 years of speech treatment with significant improvement, the prosthesis was removed and no significant deterioration of speech was noted. Later Blakeley (1964) described three children who, following periodic reductions in the size of their speech bulbs, maintained acceptable speech. Due to the need for orthodontic treatment, patient or family preference, or both, further reductions were not carried out and pharyngeal flaps were performed. Blakeley suggested that the speech prosthesis could serve a training function and ‘‘stimulate’’ velopharyngeal movements.

Since 1964, additional clinical reports of speech prostheses (bulbs, lifts, or lift-bulbs) designed to first improve velopharyngeal closure and second to serve a training function with systematic reduction have appeared (Weiss, 1971; Wong and Weiss, 1972; Mazaheri and Mazaheri, 1976; Moller et al., 1977; McGrath and Anderson, 1990; Wolfaardt et al., 1993; Tachimura et al., 1995, 1999). Success of this procedure has usually been reported as the percentage of patients who were able to eliminate the prostheses and maintain acceptable speech and has ranged from 20% to 95%. It is difficult to reconcile the large difference, but it is likely due to variable and incomplete patient selection criteria, treatment specificity, and speech outcome measures. Nonetheless, it appears clear that there are some patients who, following development of an optimal speech prosthesis, are able to maintain acceptable speech with systematic reductions and perhaps eventual elimination of the prosthesis.

Shelton and colleagues (1968b) experimentally investigated systematic bulb reduction. They studied articulation performance in 19 subjects with unrepaired and repaired cleft palate who wore speech prostheses. They found that articulation scores were not significantly different following bulb reductions and that some subjects were able to compensate for more extensive reductions than others. Shelton et al. (1971a, 1971b) assessed physiologic changes in velopharyngeal function following bulb reduction and found no significant differences in posterior pharyngeal wall movement following bulb reduction or with use of exchangeable pharyngeal sections. Although the data did not support the notion that speech prosthesis reduction produced or stimulated significant increases in posterior pharyngeal wall movement, they did report that one subject was able to train out of the prosthesis without adversely affecting speech performance. However, the explanation as to how or why this occurred was not clear.

In general, the use of speech prostheses in the 1970s and 1980s continued to be a viable but not widely used treatment option for physical improvement of velopharyngeal closure for patients with cleft palate. The prosthodontic approach, especially palatal lift, was used more frequently in the noncleft palate population because patients with velopharyngeal closure problems of neuromuscular origin were generally considered less than ideal candidates for surgical improvement due to an adynamic velopharyngeal complex. Schneider and Shprintzen (1980) surveyed speech-language pathologists and found that only 14% used prosthodontic treatment to improve velopharyngeal closure for speech. Ten years later (Pannbacker et al., 1990), a survey questionnaire revealed only 11% of speech-language pathologists reported utilizing prosthodontic treatment for velopharyngeal impairment.

Procedures to guide development of optimal size of the speech prosthesis for best speech and during subsequent systematic reductions have been largely perceptual in nature. Cooperative efforts between the speech-language pathologist and the prosthodontist have been strongly advocated and encouraged in clinical management of patients with prostheses (Moller et al., 1977; Dalston, 1977). However, improved imaging techniques to assess velopharyngeal anatomy and physiology during speech, which were developed in the 1970s and 1980s, were also used to guide size and position requirements more effectively. Use of multiview videofluoroscopy and flexible nasendoscopy (Beery et al., 1983, 1985; Karnell et al., 1987; McGrath and Anderson, 1990; Witt et al., 1995b) has been described. Riski et al. (1989) also discussed the value of pressure-flow information in conjunction with perceptual judgments and endoscopy in fabricating optimal speech prostheses.

The prosthodontic approach to improve velopharyngeal closure for speech appears to have had a resurgence of interest and use in the last 10 to 15 years. There is general agreement that velopharyngeal closure can be improved with the prosthodontic approach given satisfactory patient cooperation and motivation and parental support. In many respects, successful treatment with the prosthodontic approach depends on patient or family variables. It is important, however, there are satisfactory dental and oral health and other dental factors to assure satisfactory retention. In addition, there must be an experienced prosthodontist as an active member of the interdisciplinary team. Other criteria for proceeding with a speech prosthesis might include diagnostic aid to determine the effect of velopharyngeal closure on speech and prediction of success of surgical approaches (Curtis and Chierici, 1964; Shelton et al., 1968b; Moller, 1977; Leeper et al., 1993; Rosen and Bzoch, 1997) if the prosthesis is not intended for long-term usage. Another important criterion is the potential to benefit from systematic reduction and possible elimination of the prosthesis (avoiding surgery).

The question about whether a speech prosthesis can stimulate or increase velopharyngeal movements beneficial to speech resurfaced recently. Witt et al. (1995b) obtained videonasendoscopic and videofluoroscopic recordings of 25 noncleft palate patients treated with palatal lifts. The recordings were obtained before the prosthesis was placed and following optimal development of the prosthesis. No reduction program was initiated. Time between recordings averaged approximately 11 months. Several velopharyngeal parameters were rated by experienced clinicians. They found no strong evidence to suggest that velopharyngeal gap or velopharyngeal orifice size changed from preprosthetic to postprosthetic management. No detailed speech information was presented and was recognized as a limitation of the study. The authors did indicate there was improvement in articulation with the prosthesis. They concluded that the results did not support the concept that palatal lifts stimulate velopharyngeal neuromuscular patterning or the feasibility of initiating a reduction program. They appropriately called for further studies to document what speech prostheses can, and perhaps cannot, accomplish.

Tachimura et al. (1995) studied 15 subjects with cleft palate who wore speech bulbs. They examined EMG recordings from the levator veli palatini muscle, oral air pressure, and nasal airflow rates during three experimental conditions—no opening in the bulb portion and 4 and 7 mm openings created in the bulb section. Subjects produced the syllable /pu/ 20 times. They found that increasing nasal airflow rates and decreasing oral air pressures were associated with increased levator muscle activity. They postulated that one of the explanations why some subjects are successful in training out of prostheses is that the presence of nasal airflow around a reduced bulb might stimulate velopharyngeal function in patients accustomed to wearing the prosthesis, by increasing levator muscle activity. This is consistent with the regulation and control phenomenon reported by Warren (1986) and the clinical procedure of initially creating some overclosure with the lift or bulb before initiating a reduction program (Moller et al., 1977). Tachimura et al. recognized that other factors such as auditory perception or compensatory physiologic changes might also contribute to successful reduction. This study is an excellent example of the type of investigation needed to clarify which factors may contribute to success of training approaches utilizing speech prostheses.

Future Issues in Surgical and Prosthodontic Management

It is important for the speech professional to work in partnership with surgeons and dental colleagues to plan the best treatment strategy for the individual patient. The team approach for total patient care is strongly advocated. The speech prosthesis approach as a physical intervention to improve velopharyngeal closure will continue to be a viable approach valuable for selected patients and indeed may be the choice of the patient. The extent to which speech prostheses can serve as a training approach to bring about acceptable speech, and the underlying physiologic, aerodynamic mechanisms that account for this needs further investigation. Hopefully, future findings will allow us to predict those patients who will likely be successful in speech bulb reduction programs or to prepare the way for successful surgical outcome. Combinations of treatments, such as speech bulb reduction or palatal lift appliances in combination with behavioral muscle-strengthening regimens, for example, may prove to be useful supplements or replacements, in some cases, to surgical intervention. Advancements in aerodynamic assessment and imaging technology will be important adjuncts to listener perceptual judgments. The full range of diagnostic procedures and detailed pretreatment and treatment protocols and outcome measures must be included in future investigations.

Acknowledgments. Supported by PHS Research Grant DC-00976 from the National Institute on Deafness and Other Communication Disorders.

References

Akguner M, Karaca C, Barutcu A, Ozaksoy D, Yurt A, Vayvada H. Evaluation of velopharyngeal pathophysiology and velopharyngeal insufficiency with magnetic resonance imaging. *Eur J Plast Surg.* 1998;21:118–128.

Albery L, Enderby P. Intensive speech therapy for cleft palate children. *Br J Disord Comm.* 1984;19:115–124.

American Cleft Palate-Craniofacial Association. *Parameters for Evaluation and Treatment of Patients with Cleft Lip and Palate or Other Craniofacial Anomalies.* March 1993.

Andreassen ML, Smith BE, Guyette TW. Pressure-flow measurements for selected oral and nasal sound segments produced by normal adults. *Cleft Palate Craniofac J.* 1992;29:1–9.

Aram A, Subtelny J. Velopharyngeal function and cleft palate prosthesis. *J Prosth Dent.* 1959;9:149–158.

Arndt WB, Shelton RL, Bradford L. Articulation, voiceand obturation in persons with acquired and congenital palate defects. *Cleft Palate J.* 1965;2: 377–383.

Aronson J. Experimental and clinical experience with distraction osteogenesis. *Cleft Palate Craniofac J.* 1994;31:473–481.

Azzam NA, Kuehn DP. The morphology of the musculus uvulae. *Cleft Palate J.* 1977;14:79–87.

Barsoumian R, Kuehn DP, Moon JB, Canady JW. An anatomic study of the tensor veli palatini and dilatator tubae muscles in relation to eustachian tube and velar function. *Cleft Palate Craniofac J.* 1998;35:101–110.

Beery QC, Aramany MA, Katzenberg B. Oral endoscopy in prosthodontic management of the soft palate defect. *J Prosth Dent.* 1985;54:241–244.

Beery QC, Rood SR, Schramm VL. Pharyngeal wall motion in prosthetically managed cleft palate adults. *Cleft Palate J.* 1983;20:7–17.

Bernthal JE, Beukelman DR. The effect of changes in velopharyngeal orifice area on vocal intensity. *Cleft Palate J.* 1977;14:63–77.

Berry DA, Moon JB, Kuehn DP. A finite element model of the soft palate. *Cleft Palate Craniofac J.* 1999;36:217–223.

Blakeley R. Temporary speech prosthesis as an aid in speech training. *Cleft Palate Bull.* 1960;10:63–65.

Blakeley R. The complementary use of speech prostheses and pharyngeal flaps in palatal insufficiency. *Cleft Palate J.* 1964:194–198.

Blakeley RW, Brockman JH. Normal speech and hearing by age 5 as a goal for children with cleft palate: a demonstration project. *Am J Speech Lang Path.* 1995:25–32.

Bless DM, Ewanowski SJ, Dibbell DG. A technique for temporary obturation of fistulae—a clinical note. *Cleft Palate J.* 1980;17:297–300.

Boorman J, Sommerlad B, Birch M, Fenn C, Pandya A. Velar function following secondary palate repair by intravelar veloplasty versus Furlow. Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies, 1997; Singapore.

Bradford LJ, Brooks AR, Shelton RL. Clinical judgment of hypernasality in cleft palate children. *Cleft Palate J.* 1964;1:329–335.

Brennan D, Cullinan W. Object identification and naming in cleft palate children. *Cleft Palate J.* 1974;11:188–195.

Broen PA, Doyle S, Carlstrom J, Prouty J, Moller KT. Acquisition of linguistic and cognitive skills by children with cleft palate. *J Speech Hear Lang Res.* 1998;41:676–687.

Broen PA, Felsenfeld S, Kittelson-Bacon C. Predicting from the phonological patterns observed in children with cleft palate. In: *Proceedings of the 11th University of Wisconsin Symposium on Research in Child Language Disorders,* Madison: University of Wisconsin; 1986.

Broen PA, Moller KT. Early phonological development and the child with cleft palate. In: Moller KT, StarrCD, eds. *Cleft Palate: Interdisciplinary Issues and Treatment.* Austin, TX: Pro-Ed; 1993:219–249.

Broen PA, Moller KT, Carlstrom J, Doyle S, Devers M, Keenan K. A comparison of the hearing histories of children with and without cleft palate. *Cleft Palate Craniofac J.* 1996;33:127–133.

Brookshire BL, Lynch JI, Fox DR. *A Parent-Child Cleft Palate Curriculum: Developing Speech and Language.* Tigard, OR: C. C. Publications; 1980.

Brunner M, Stellzig A, Decker W, Strate B, Komposch G, Wirth G, Verres R. Video feedback therapy with the flexible nasopharyngoscope: possibilities of influencing the velopharyngeal closure and articulation deficiencies in cleft palate patients. *Fortschritte der Kieferorthopadie.* 1994;55:197–201.

Byrne MC, Shelton RL, Diedrich WM. Articulatory skill, physicalmanagement and classification of children with cleft palates. *J Speech Hear Disord.* 1961; 26:326–333.

Bzoch KR. *An Investigation of the Speech of Preschool Cleft Palate Children.* Evanston, IL: Northwestern University; 1956. Dissertation.

Bzoch KR. Articulation proficiency and error patterns of preschool cleft palate and normal children. *Cleft Palate J.* 1965;2:340–349.

Bzoch KR. Categorical aspects of cleft palate speech. In: Grabb W, RosensteinS, BzochKR, eds. *Cleft Lip and Palate.* Boston: Little, Brown; 1971.

Bzoch KR. Clinical assessment, evaluation, andmanagement of 11 categorical aspects of cleft palate speech disorders. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate* Austin, TX: Pro-Ed; 1997:261–312.

Bzoch KR. Measurement and assessment of categorical aspects of cleft palate speech. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown; 1979:161–191.

Carls FR, Jackson IT, Topf JS. Distraction osteogenesis for lengthening of the hard palate: part I. A possible new treatment concept for velopharyngeal incompetence. Experimental study in dogs. *Plast Reconstr Surg.* 1997a;100: 1635–1647.

Carls FR, Schupbach P, Sailer HF, Jackson IT. Distraction osteogenesis for lengthening of the hard palate: part II. Histological study of the hard and soft palate after distraction. *Plast Reconstr Surg.* 1997b;100:1648–1654.

Cassell MD, Moon JB, Elkadi H. Anatomy and physiology of the velopharynx. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990.

Chapman KL. Phonologic processes in children with cleft palate. *Cleft Palate Craniofac J.* 1993;30:64–72.

Chapman KL. Vocalizations for toddlers with cleft palate. *Cleft Palate Craniofac J.* 1991;28:172–178.

Chapman KL, Graham KT, Gooch J, Visconte C. Conversational skills of preschool and school-age children with cleft lip and palate. *Cleft Palate Craniofac J.* 1998;35:503–516.

Chapman K, Hardin M. Communicative competence in children with cleft lip and palate. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:721–726.

Chapman KL, Hardin MA. Phonetic and phonologic skills in two-year-olds with cleft palate. *Cleft Palate Craniofac J.* 1992;29:435–443.

Chen MY. Acoustic correlates of English and French nasalized vowels. *J Acoust Soc Am.* 1997;102:2360–2370.

Chen PKT, Wu J, Hung KF, Chen YR, Noordhoff MS. Surgical correction of submucous cleft palate with Furlow palatoplasty. *Plast Reconstr Surg.* 1996; 97:1136–1146.

Chen PKT, Wu J, Hung KF, Lo LJ, Noordhoff MS, Chen YR. Further experience on using the Furlow palatoplasty to correct velopharyngeal insufficiency. Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies; 1997, Singapore.

Chisum L, Shelton RL, Arndt WB, Elbert MA. The relationship between remedial speech instruction activities and articulation change. *Cleft Palate J.* 1969;6:57–64.

Clifford E. Psychological aspects of cleft lip and palate. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown; 1979:37–51.

Compton A. Generative studies of children's phonological disorders. *J Speech Hear Disord.* 1970;35:315–339.

Conti-Ramsden G, Friel-Patti S. Mother's discourse adjustments to language-impaired and non-language impaired children. *J Speech Hear Disord.* 1983; 48:360–367.

Counihan DT. A Clinical Study of the Speech Efficiency and Structural Adequacy of Operated Adolescent Adult Cleft Palate Persons. Evanston, IL: Northwestern University; 1956. Unpublished doctoral dissertation.

Counihan DT, Cullinan WL. Reliability and dispersion of nasality ratings. *Cleft Palate J.* 1970;7:261–270.

Covello LV, Karnell MP, Seaver EJ. Videoendoscopy and photodetection: linearity of a new integrated system. *Cleft Palate Craniofac J.* 1992;29:168–173.

Croft CB, Shprintzen RJ, Daniller A, Lewin ML. The occult submucous cleft palate and the musculus uvulae. *Cleft Palate J.* 1978;15:150–154.

Croft CB, Shprintzen RJ, Rakoff SJ. Patterns of velopharyngeal valving in normals and cleft palate subjects: a multiview videofluoroscopic and nasendoscopic study. *Laryngoscope.* 1981;91:265–271.

Curtis JF. Acoustics of speech production and nasalization. In: Spriestersbach DC, ShermanD, eds. *Cleft Palate and Communication.* New York: Academic Press; 1968;27–60.

Curtis T, Chierici G. Prosthetics as a diagnostic aid in pharyngeal flap surgery. *Cleft Palate J.* 1964;1:95–98.

Cutting CB, Rosenbaum J, Rovati L. The technique of muscle repair in the cleft soft palate. *Oper Tech Plast Reconstr Surg.* 1995;2:215–222.

Dalston RM. Acoustic assessment of the nasal airway. *Cleft Palate Craniofac J.* 1992;29:520–526.

Dalston RM. Communication skills of children with cleft lip and palate: a status report. In: Bardach J, Morris HL. *Multidisciplinary Management of Cleft Lip and Palate* Philadelphia: WB Saunders; 1990;746–749.

Dalston RM. Computer-generated reports of speech and language evaluations. *Cleft Palate J.* 1983;20:227–237.

Dalston RM. Photodetector assessment of velopharyngeal activity. *Cleft Palate J.* 1982;19:1–8.

Dalston RM. Prosthodontic management of the cleft palate patients: a speech pathologist's view. *J Prosth Dent.* 1977;37:190–195.

Dalston RM. Velopharyngeal impairment in the orthodontic population. *Semin Orthod.* 1996;2:220–227.

Dalston RM, Marsh JL, Vig KW, Witzel MA, Bumsted RM. . Minimal standards for reporting the results of surgery on patients with cleft lip, cleft palate, or both: a proposal. *Cleft Palate J.* 1988;25:3–7.

Dalston RM, Martinkosky SJ, Hinton VA. Stuttering prevalence among patients at risk for velopharyngeal inadequacy. *Cleft Palate J.* 1987;24:233–239.

Dalston RM, Neiman GS, Gonzalez-Landa G. Nasometric sensitivity and specificity: a cross-dialect and cross-culture study. *Cleft Palate Craniofac J.* 1993;30:285–291.

Dalston RM, Warren DW. The diagnosis of velopharyngeal inadequacy. *Clin Plast Surg.* 1985;12:685–695.

Dalston RM, Warren DW. Comparison of Tonar II, pressureflow, andlistener judgments of hypernasality in the assessment of velopharyngeal function. *Cleft Palate J.* 1986;23:108–115.

Dalston RW, Warren DW, Dalston ET. A preliminary study of nasal airway patency and its potential effect on speech performance. *Cleft Palate Craniofac J.* 1992;29:330–335.

Dalston RM, Warren DW, Dalston ET. The identification of nasal obstruction through clinical judgments of hyponasality and nasometric assessment of speech acoustics. *Am J Orthod Dentofac Orthop.* 1991;100:59–65.

Dalston RM, Warren DW, Smith LR. The aerodynamic characteristics of speech produced by normal speakers and cleft palate speakers with adequate velopharyngeal function. *Cleft Palate J.* 1990;27:393–399.

D'Antonio LL. Correction of velopharyngeal insufficiency using the Furlow double-opposing Z-plasty. *West J Med.* 1997;167:101–102.

D'Antonio LL, Achauer BM, Vander Kam VM. Results of a survey of cleft palate teams concerning the use of nasendoscopy. *Cleft Palate Craniofac J.* 1993;30:35–39.

D'Antonio LL, Muntz HR, Province MA, March JL. Laryngeal/voice findings in patients with velopharyngeal dysfunction. *Laryngoscope.* 1988;98:432–438.

D'Antonio L, Patel S, Folk SM, Herber S, Hardesty R. Indications and outcome of Furlow Z-plasty for treatment of velopharyngeal insufficiency. Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies; 1997a, Singapore.

D'Antonio L, Riski J, Zajac D, Patel S, Herber S, Hardesty R, Mason R, Clark D. Changes in anatomy and function of the velopharynx following Furlow Z-plasty for treatment of VPI. Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies; 1997b, Singapore.

D'Antonio LL, Scherer NJ. The evaluation of speech disorders associated with clefting. In: Shprintzen RJ, Bardach J. *Cleft Palate Speech Management.* St. Louis: Mosby; 1995:176–220.

D'Antonio LL, Snyder LS, Samadani S. Tonsillectomy in children with or at risk for velopharyngeal insufficiency: effects on speech. *Otolaryngol Head Neck Surg.* 1996;115:319–323.

Delgado AA, Schaaf NG. Trends in prosthodontic treatment of cleft palate patients at one institution: a twenty-one year review. *Cleft Palate J.* 1992; 29:425–428.

Denk MJ, Magee WP. Cleft palate closure in the neonate: preliminary report. *Cleft Palate Craniofac J.* 1996;33:57–61.

Dickson DR. An acoustic study of nasality. *J Speech Hear Res.* 1962;5:102–111.

Dickson DR. A radiographic study of nasality. *Cleft Palate J.* 1969;6:160–165.

Dickson DR, Dickson WM. Velopharyngeal anatomy. *J Speech Hear Res.* 1972;15:372–381.

Diegel C. *Parental Preferences and Severity Ratings for Hypernasal and Compensatory Patterns of Articulation in the Speech of Children With Cleft Palate.* Minneapolis: University of Minnesota; 1984. Unpublished Thesis.

Dinnsen DA. Methods and empirical issues in analyzing functional misarticulation. In: Elbert M, DinnsenDA, WeismerG, eds. *Phonological Theory and the Misarticulating Child.* ASHA Monograph N. 22. Rockville, MD: American Speech-Language-Hearing Association; 1984.

Dixon-Wood VL. Counseling and early management of feeding and language skill development for infants and toddlers with cleft palate. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Austin, TX: Pro-Ed; 1997:465–474.

Dorf D, Curtin SW. Early cleft palate repair and speech outcome. *Plast Reconstr Surg.* 1982;70:74–79.

Eisenbach CR, Williams WN. Comparing the unaided visual exam to lateral cinefluorography in estimating several parameters of velopharyngeal closure function. *J Speech Hear Disord.* 1984;49:136–139.

Estrem T, Broen PA. Early speech productions of children with cleft palate. *J Speech Hear Res.* 1989;32:12–23.

Ettema SL, Kuehn DP, Perlman AL, Alperin N. Magnetic resonance imaging of the levator veli palatini muscle during speech. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association, 1998; Baltimore, MD.

Evans D, Renfrew C. The timing of primary cleft palate repair. *Scand J Plast Reconstr Surg.* 1974;8:153–155.

Faircloth SR, Faircloth MA. Delayed language and linguistic variations. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown; 1971:130–135.

Falter J, Shelton RL. Bulb fitting and placement in prosthetic treatment of cleft palate. *Cleft Palate J.* 1964;1:441–447.

Fant G. *Acoustic Theory of Speech Production.* The Hague: Mouton; 1960.

Feng G, Castelli E. Some acoustic features of nasal and nasalized vowels: a target for vowel nasalization. *J Acoust Soc Am.* 1996;99:3694–3706.

Ferguson CA, Farwell CB. Words and sounds in early language acquisition: English initial consonants in the first fifty words. *Language.* 1975;51:419–439.

Fey M. *Language Intervention With Young Children.* Needham, MA: Allyn and Bacon; 1986.

Fey M, Gandour J. Rule discovery in early phonological acquisition. *J Child Lang.* 1982;9:71–82.

Finkelstein Y, Berger G, Nachmani A, Ophir D. The functional role of the adenoids in speech. *Int J Pediatr Otorhinolaryngol* 1996;34:61–74.

Finkelstein Y, Lerner MA, Ophir D, Nachmani A, Hauben DJ, Zohar Y. Nasopharyngeal profile and velopharyngeal valve mechanism. *Plast Reconstr Surg.* 1993;92:603–614.

Finkelstein Y, Nachmani A, Ophir D. The functional role of the tonsils in speech. *Arch Otolaryngol Head Neck Surg.* 1994;120:846–851.

Finkelstein Y, Shapiro-Feinberg M, Talmi YP, Nachmani A, DeRowe A, Ophir D. Axial configuration of the velopharyngeal valve and its valving mechanism. *Cleft Palate Craniofac J.* 1995;32:299–305.

Finkelstein Y, Talmi YP, Nachmani A, Hauben DJ, Zohar Y. On the variability of velopharyngeal valve anatomy and function: a combined perioral and nasendoscopic study. *Plast Reconstr Surg.* 1992;89:631–639.

Finnegan E, Luschei E, Hoffman H. Estimation of alveolar pressure from direct measures of tracheal pressure during speech. *NCVS (Nat Ctr Voice Speech) Stat Prog Rept.* 1998;12:1–10.

Fletcher SG. ''Nasalance'' vs. listener judgments of nasality. *Cleft Palate J.* 1976;13:31–44.

Fletcher SG, Berkowitz S, Bradley DP, Burdi AR, Koch L, Maue-Dickson W. Cleft lip and palate research: an updated state of the art. *Cleft Palate J.* 1977;14:261–321.

Fox DR, Lynch JI, Brookshire BL. Selected developmental factors of cleft palate children between 2 and 33 months. *Cleft Palate J.* 1978;15:239–245.

Freil-Patti S, Finitzo-Hieber T, Conti G, Brown KC. Language delay in infants associated with middle ear disease and mild, fluctuatinghearing impairment. *Pediatr Infect Dis.* 1982;1:104–109.

Fritzell B. The velopharyngeal muscles in speech: an electromyographic-cineradiographic study. *Acta Otolaryngol. Suppl (Stockh.)* 1969;250:1.

Furlow LR. Cleft palate repair by double opposing Z-plasty. *Oper Tech Plast Reconstr Surg.* 1995;2:223–232.

Gable TO, Kummer AW, Lee L, Creaghead NA, Moore LJ. Premature loss of the maxillary primary incisors: effect on speech production. *ASDC J Dent Child.* 1995;62:173–179.

Gibbons P, Bloomer HH. The palatal lift, asupportive type speech aid. *J Prosth Dent.* 1958;8:362–369.

Girolametto L. The evaluation and remediation of language impairment. In: Shprintzen RJ, BardachJ, eds. *Cleft Palate Speech Management.* St. Louis: Mosby; 1995:167–175.

Golding-Kushner KJ. Treatment of articulation and resonance disorders associated with cleft palate and VPI. In: Shprintzen RJ, Bardach J, eds. *Cleft Palate Speech Management: A Multidisciplinary Approach.* St. Louis: Mosby; 1995.

Golding-Kushner KJ, Argamaso RV, Cotton RT, Grames LM, Henningsson G, Jones DL, Karnell MP, Klaiman PG, Lewin ML, Marsh JL, et al. Standardization for the reporting of nasopharyngoscopy and multiview videofluoroscopy: a report from an International Working Group. *Cleft Palate J.* 1990; 27:337–347.

Gonzalez J, Aronson A. Palatal lift prosthesis for treatment of anterior and neurologic palatopharyngeal insufficiency. *Cleft Palate J.* 1970;7:91–104.

Goodstein LD. Intellectual impairment in children with cleft palate. *J Speech Hear Res.* 1961;4:287–294.

Gosain AK, Conley SF, Marks S, Larson DL. Submucous cleft palate: diagnostic methods and outcomes of surgical treatment. *Plast Reconstr Surg.* 1996;97:1497–1509.

Gray SD, Pinborough-Zimmerman J, Catten M. Posterior wall augmentation for treatment of velopharyngeal insufficiency. *National Center for Voice and Speech (NCVS) Status Prog Rep.* 1998;12:181–185.

Grunwell P, Russell J. Vocalizations before and after cleft palate surgery: a pilot study. *Br J Dis Comm.* 1987;22:1–17.

Guyette TW, Polley JW, Figueroa AA, Cohen MN. Mandibular distraction osteogenesis: effects on articulation and velopharyngeal function. *J Craniofac Surg.* 1996;7:186–191.

Guyette T, Polley J, Figueroa A, Smith B. Changes in the speech of cleft palate patients following maxillary distraction. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998, Baltimore, MD.

Guyette T, Polley J, Figueroa A, Smith B, Cohen M. Changes in speech following maxillary advancement surgery. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1997; New Orleans, LA.

Haapanen ML, Ignatius J, Rihkanen H, Ertama L. Velopharyngeal insufficiency following palatine tonsillectomy. *Eur Arch Otorhinolaryngol.* 1994;25:186–189.

Haapanen ML, Kalland M, Heliovaara A, Hukki J, Ranta R. Velopharyngeal function in cleft patients undergoing maxillary advancement. *Folia Phoniatr Logop.* 1997;49:42–47.

Hahn E. Directed home training program for infants with cleft lip and palate. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown; 1979:311–317.

Hahn E. Speech therapy for the pre-school child. *J Speech Hear Disord.* 1960; 23:605–609.

Hall PK, Tomblin JB. Case study: therapy procedures for remediation of a nasal lisp. *Lang Speech Hear Serv Schools.* 1975;6:29–32.

Hara H. Effect of head position on levator veli palatini muscle activity in speakers with BVP. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998; Baltimore, MD.

Hardin MA, Lachenbruch PA, Morris HL. Contribution of selected variables to the prediction of speech proficiency for adolescents with cleft palate. *Cleft Palate J.* 1986;23:10–23.

Hardin MA, Van Demark D, Morris HL. Long-term speech results of cleft palate speakers with marginal velopharyngeal competence. *J Commun Disord.* 1990;23:401–416.

Hardin MA, Van Demark DR, Morris HL, Payne MM. Correspondence between nasalance scores and listener judgments of hypernasality and hyponasality. *Cleft Palate Craniofac J.* 1992;29:346–351.

Hardin-Jones MA, Brown CK, Van Demark D, Morris HL. Long-term speech results of cleft palate patients with primary palatoplasty. *Cleft Palate Craniofac J.* 1993;30:55–63.

Harding A, Grunwell P. Characteristics of cleft palate speech. *Eur J Disord Community.* 1996;31:331–357.

Hardy JC, Netsell R, Schweiger JW, Morris HL. Management of velopharyngeal dysfunction in cerebral palsy. *J Speech Hear Disord.* 1969;34:123–136.

Harkins CS, Harkins WR, Harkins JF. *Principles of Cleft Palate Prosthesis.* New York: Columbia University Press; 1960.

Harkins CS, Koepp-Baker H. Twenty-five years of cleft palate prosthesis. *J Speech Hear Disord.* 1948;13:23–30.

Hart B, Risley TR. *Meaningful Differences in Everyday Experience of Young American Children.* Baltimore, MD: Brookes; 1995.

Henningsson G, Hutters B. Perceptual assessment of cleft palate speech, with special reference to minimum standards for inter-centre comparisons of speech outcome. International Task Force Report. Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies; 1997; Singapore.

Henningsson G, Isberg A. Oronasal fistulas and speech production. In: Bardach J, Morris HL. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:787–791.

Henningsson GE, Isberg AM. Velopharyngeal movement patterns in patients alternating between oral and glottal articulation: a clinical and cineradiographical study. *Cleft Palate J.* 1986;23:1–9.

Hess DA. Pitch, intensity, andcleft palate voice quality. *J Speech Hear Res.* 1959;2:113–125.

Hess DA. Quanti-scaling of articulation defectiveness in cleft palate speakers. *Cleft Palate J.* 1973;10:253–260.

Hinton VA, Warren DW. Relationships between integrated oral-nasal differential pressure and velopharyngeal closure. *Cleft Palate Craniofac J.* 1995; 32:306–310.

Hirschberg J, Van Demark DR. A proposal for standardization of speech and hearing evaluations to assess velopharyngeal function. *Folia Phoniatr Logop.* 1997;49:158–167.

Hoch L, Golding-Kushner K, Siegel-Sadewitz VL, Shprintzen RJ. Speech therapy. *Sem Speech Lang.* 1986;7:313–325.

Hodson BW, Chin L, Redmond B, Simpson R. Phonological evolution and remediation of speech deviations of a child with a repaired cleft palate: a case study. *J Speech Hear Disord.* 1983;48:210–214.

Hoit JD, Watson PJ, Hixon KE, McMahon P, Johnson CL. Age and velopharyngeal function during speech production. *J Speech Hear Res.* 1994;37: 295–302.

Horiguchi S, Bell-Berti F. The Velotrace: a device for monitoring velar position. *Cleft Palate J.* 1987;24:104–111.

House AS, Stevens KN. Analog studies of the nasalization of vowels. *J Speech Hear Disord.* 1956;21:218–232.

Huang MHS, Lee ST, Rajendran K. A fresh cadaveric study of the paratubal muscles: implications for eustachian tube function in cleft palate. *Plastic Reconstr Surg.* 1997a;100:833–842.

Huang MHS, Lee ST, Rajendran K. An anatomic study of the palatoglossus muscle: implications for its role in speech physiology. *Cleft Palate Craniofac J.* Submitted.

Huang MHS, Lee ST, Rajendran K. Anatomic basis of cleft palate and velopharyngeal surgery: Implications from a fresh cadaveric study. *Plastic Reconstr Surg.* 1998;101:613–627.

Huang MHS, Lee ST, Rajendran K. Structure of the musculus uvulae: functional and surgical implications of an anatomic study. *Cleft Palate Craniofac J.* 1997b;34:466–474.

Huang MHS, Riski JE, Cohen SR, Simms CA, Burstein FD. A qualitative and quantitative analysis of the efficacy of the sphincter pharyngoplasty. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1997; New Orleans, LA.

Hudson DA, Grobbelaar AO, Fernandes DB, Lentin R. Treatment of velopharyngeal incompetence by the Furlow Z-plasty. *Ann Plast Surg.* 1995;34:23–26.

Huebener DV, Marsh JL. Management for cleft lip/palate: the first 18 months. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1993; Pittsburgh, PA.

Huebener DV, Marsh JL. Management for cleft lip/palate: the first 18 months. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1997; New Orleans, LA.

Hutchinson J, Robinson K, Nerbonne M. Patterns of nasalance in a sample of normal gerontologic speakers. *J Commun Dis.* 1978;11:469–481.

Ingram D. Fronting in child phonology. *J Child Lang.* 1974a;1:49–64.

Ingram D. Phonological rules in young children. *J Child Lang.* 1974b;1:233–241.

Isberg A, Henningsson G. Influence of palatal fistulae on velopharyngeal movement. A cineradiographic study. *Plast Reconstr Surg.* 1987;79:525–530.

Jakobson R. *Child Language, Aphasia, and Phonological Universals.*; The Hague: Mouton; 1968.

Jocelyn LJ, Penko MA, Rode HL. Cognition, communication, andhearing in young children with cleft lip and palate and in control children: a longitudinal study. *Pediatrics.* 1996;97:529–534.

Jones DL, Folkins JW. Effect of speaking rate on judgments of disordered speech in children with cleft palate. *Cleft Palate J.* 1985;22:246–252.

Kanter CE. Diagnosis and prognosis in cleft palate speech. *J Speech Hear Dis.* 1948;13:211–222.

Kaplan EN. The occult submucous cleft palate. *Cleft Palate J.* 1975;12:356–368.

Karling J, Larson O, Henningsson G. Oronasal fistulas in cleft palate patients and their influence on speech. *Scand J Plast Reconstructr Surg.* 1993;27:193–201.

Karnell MP. Nasometric discrimination of hypernasality and turbulent nasal airflow. *Cleft Palate Craniofac J.* 1995;32:145–148.

Karnell MP, Rosenstein H, Fine L. Nasal videoendoscopy in prosthetic management of palatopharyngeal dysfunction. *J Prosth Dent.* 1987;58:479–484.

Karnell MP, Seaver EJ. Integrated endoscopic/photodetector evaluation of velopharyngeal function. *Cleft Palate Craniofac J.* 1993;30:337–342.

Karnell MP, Seaver EJ. Measurement problems in estimating velopharyngeal function. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:776–786.

Karnell MP, Seaver EJ, Dalston RM. A comparison of photodetector and endoscopic evaluations of velopharyngeal function. *J Speech Hear Res.* 1988;31:503–510.

Karnell MP, Van Demark DR. Longitudinal speech performance in patients with cleft palate: comparisons based on secondary management. *Cleft Palate J.* 1986;23:278–288.

Kataoka R, Michi K, Okabe K, Miura T, Yoshida H. Spectral properties and quantitative evaluation of hypernasality in vowels. *Cleft Palate Craniofac J.* 1996;33:43–50.

Kemp-Fincham SI, Kuehn DP, Trost-Cardamone JE. Speech development and timing of primary veloplasty. In: Bardach J, Morris HL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990: 736–745.

Kent RD. Fragmentation of clinical service and clinical science in communicative disorders. *Natl Student Speech Lang Hear Assoc J.* 1990;17:4–16.

Kent RD, Carney PJ, Severeid LR. Velar movement and timing: evaluation of a model for binary control. *J Speech Hear Res.* 1974;17:470–488.

Kim JR, Zajac DJ, Warren DW, Mayo R, Essick GK. The response to sudden change in vocal tract resistance during stop consonant production. *J Speech Lang Hear Res.* 1997;40:848–857.

Kipfmueller LJ, Lang BR. Treating velopharyngeal inadequacy with a palatal lift prosthesis. *J Prosth Dent.* 1972;27:467–477.

Kollia HB, Gracco VL, Harris KS. Articulatory organization of mandibular, labial, andvelar movements during speech. *J Acoust Soc Am.* 1995;98:1313–1324.

Kommers M, Sullivan M. Written language skills of children with cleft palate. *Cleft Palate J.* 1979;16:81–85.

Kuehn DP. A cineradiographic investigation of velar movement variables in two normals. *Cleft Palate J.* 1976;13:88–103.

Kuehn DP. Assessment of resonance disorders. In: Lass N, McReynoldsL, NorthernJ, YoderD, eds. *Speech, Language and Hearing* vol. II. Philadelphia: WB Saunders; 1982.

Kuehn DP. New therapy for treating hypernasal speech using continuous positive airway pressure (CPAP). *Plast Reconstr Surg.* 1991;88:959–966.

Kuehn DP. The development of a new technique for treating hypernasality: CPAP. *Am J Speech Lang Path.* 1997;6:5–8.

Kuehn DP, Azzam NA. Anatomical characteristics of palatoglossus and the anterior faucial pillar. *Cleft Palate J.* 1978;15:349–359.

Kuehn DP, Dalston RM. Cleft palate and studies related to velopharyngeal function. In: Winitz H, ed. *Human Communication and Its Disorders.* Norwood, NJ: Ablex Publishing; 1988:1–107.

Kuehn DP, Folkins JW, Cutting CB. Relationships between muscle activity and velar position. *Cleft Palate J.* 1982;19:25–35.

Kuehn DP, Folkins JW, Linville RN. An electromyographic study of the musculus uvulae. *Cleft Palate J.* 1988;25:348–355.

Kuehn DP, Moon JB. Levator veli palatini muscle activity in relation to intraoral air pressure variation. *J Speech Hear Res.* 1994;37:1260–1270.

Kuehn DP, Moon JB. Levator veli palatini muscle activity in relation to intraoral air pressure variation in cleft palate subjects. *Cleft Palate Craniofac J.* 1995; 32:376–381.

Kuehn DP, Moon JB. Induced fatigue effects on velopharyngeal closure force. *J Speech Lang Hear Res.* In press.

Kuehn DP, Moon JB. Velopharyngeal closure force and levator veli palatini activation levels in varying phonetic contexts. *J Speech Lang Hear Res.* 1998;41:51–62.

Kuehn DP, Moon JB, Folkins JW. Levator veli palatini muscle activity in relation to intranasal air pressure variation. *Cleft Palate Craniofac J.* 1993; 30:361–368.

Kuehn DP, Moon JB, Thompson SA. Histologic investigation of velar midline structures in normal adult human specimens. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1999; Scottsdale, AZ.

Kuehn DP, Templeton PJ, Maynard JA. Muscle spindles in the velopharyngeal musculature of humans. *J Speech Hear Res.* 1990;33:488–493.

Kummer AW. Irregular adenoids as a cause of velopharyngeal insufficiency. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998; Baltimore, MD.

Kummer AW, Billmire DA, Myer CM. Hypertrophic tonsils: the effect on resonance and velopharyngeal closure. *Plast Reconstr Surg.* 1993a;91:608–611.

Kummer AW, Lee L. Evaluation and treatment of resonance disorders. *Lang Speech Hear Serv Schools.* 1996;27:271–281.

Kummer AW, Myer CM, Smith ME, Shott SR. Changes in nasal resonance secondary to adenotonsillectomy. *Am J Otolaryngol.* 1993b;14:285–290.

Kummer AW, Strife JL, Grau WH, Creaghead NA, Lee L. The effects of Le Fort I osteotomy with maxillary movement on articulation, resonance, andvelopharyngeal function. *Cleft Palate J.* 1989;26:193–199.

Kunkel M, Wahlmann U, Wagner W. Objective, noninvasiveevaluation of velopharyngeal function in cleft and noncleft patients. *Cleft Palate Craniofac J.* 1998;35:35–39.

Lamb M, Wilson F, Leeper H. The intellectual function of cleft palate children compared on the basis of the cleft type and sex. *Cleft Palate J.* 1973;10: 367–377.

Lang BK, Starr CD, Moller KT. Effects of pubertal changes on the speech of persons with cleft palate. *Cleft Palate Craniofac J.* 1992;29:268–270.

Langdon HL, Klueber K. The longitudinal fibromuscular component of the soft palate in the fifteen-week human fetus: musculus uvulae and palatine raphe. *Cleft Palate J.* 1978;15:337–348.

Lass N, Noll D. A comparative study of rate characteristics in cleft palate and noncleft speakers. *Cleft Palate J.* 1970;7:275–283.

LaVelle WE, Hardy JC. Palatal lift prostheses for treatment of palatopharyngeal incompetence. *J Prosth Dent.* 1979;42:308–315.

Leeper HA, Nieuwesteeg Y, Bishop L, Lass NJ, Beckwith S. The use of time-expanded speech in judgments of hypernasality. *J Comm Dis.* 1980a;13: 335–339.

Leeper HA, Pannbacker M, Roginski J. Oral language characteristics of adult cleft palate speakers compared on the basis of cleft type and sex. *J Commun Dis.* 1980b;13:133–146.

Leeper HA, Sills PS, Charles DH. Prosthodontic management of maxillofacial and palatal defects. In: Moller KT, Starr CD, eds. *Cleft Palate: Interdisciplinary Issues and Treatment.* Austin, TX: Pro-Ed; 1993:145–188.

Leider J, Hamlet S, Schwan S. The effect of swallowing bolus and head position on eustachian tube function via sonotubometry. *Otolaryngol Head Neck Surg.* 1993;109:66–70.

Lieberman P. On the development of vowel production in young children. In: Yeni-Komshian G, Kavanaugh JF, Ferguson CA, eds. *Child Phonology.* New York: Academic Press. 1980.

Lintz LB, Sherman D. Phonetic elements and perception of nasality. *J Speech Hear Res.* 1961;4:381–396.

Liss J. Muscle spindles in the human levator veli palatini and palatoglossus muscles. *J Speech Hear Res.* 1990;33:736–746.

Locke JL. Clinical phonology: the explanation and treatment of speech sound disorders. *J Speech Hear Dis.* 1983;48:339–341.

Lohmander-Agerskov A. Speech outcome after cleft palate surgery with the Goteborg regimen including delayed hard palate closure. *Scand J Plast Reconstr Surg Hand Surg.* 1998;32:63–80.

Lohmander-Agerskov A, Doteval H, Lith A, Soderpalm E. Speech and velopharyngeal function in children with an open residual cleft in the hard palate, andthe influence of temporary covering. *Cleft Palate Craniofac J.* 1996;33: 324–332.

Lohmander-Agerskov A, Friede H, Soderpalm E, Lilja J. Residual clefts in the hard palate: correlation between cleft size and speech. *Cleft Palate Craniofac J.* 1997;34:122–128.

Long NV, Dalston RM. Comprehension abilities of one-year-old infants with cleft lip and palate. *Cleft Palate J.* 1983;20:303–306.

Long NV, Dalston RM. Gestural communication in twelve-month-old cleft lip and palate children. *Cleft Palate J.* 1982b;19:57–61.

Long NV, Dalston RM. Paired gestural and vocal behavior in one-year-old cleft lip and palate children. *J Speech Hear Dis.* 1982a;47:403–406.

Lotz WK, D'Antonio LL, Chait DH, Netsell RW. Successful nasoendoscopic and aerodynamic examinations of children with speech/voice disorders. *Int J Pediatr Otorhinolaryngol.* 1993;26:165–172.

Ludwigson H. *Parental Communication/Interaction With Children With Cleft Palate.* Minneapolis: University of Minnesota; 1998. Unpublished Thesis.

Lynch JI, Brookshire BL, Fox DR. *A Curriculum for Infants and Toddlers With Cleft Palate.* Austin, TX: Pro-Ed; 1993.

Maegawa J, Sells RK, David DJ. Speech changes after maxillary advancement in 40 cleft lip and palate patients. *J Craniofac Surg.* 1998;9:177–182.

Marrinan EM, LaBrie RA, Mulliken JB. Velopharyngeal function in nonsyndromic cleft palate: relevance of surgical technique, ageat repair, andcleft type. *Cleft Palate Craniofac J.* 1998;35:95–100.

Marsh JL, Grames LM, Holtman B. Intravelar veloplasty: A prospective study. *Cleft Palate J.* 1989;26:46–50.

Marshall RC, Jones RN. Effects of palatal lift prosthesis upon the speech intelligibility of a dysarthric patient. *J Prosth Dent.* 1971;25:327–333.

Mason RM, Warren DW. Adenoid involution and developing hypernasality. *J Speech Hear Dis.* 1980;45:469–480.

Mazaheri M. Indications and contraindications for prosthetic speech appliances in cleft palate. *Plast Reconstr Surg.* 1962;30:663–669.

Mazaheri M, Mazaheri EH. Prosthodontic aspects of palatal elevation and palatopharyngeal stimulation. *J Prosth Dent.* 1976;35:319–326.

McCann KK, Scorfield DM, Warr-Leeper GA, Leeper HA. Language characteristics of selected cleft lip and palate adolescents. Presented at American Speech-Language-Hearing Association Annual Meeting; 1988; Williamsburg, VA.

McCarthy D. Language development in children. In: Carmichael I, ed. *Manual of Child Psychology.* New York: Wiley; 1954.

McCauley RJ, Swisher L. Use and misuse of norm-referenced tests in clinical assessment: a hypothetical case. *J Speech Hear Dis.* 1984;49:338–348.

McDonald ET, Koepp-Baker H. Cleft palate speech: an integration of research and clinical observation. *J Speech Hear Dis.* 1951;16:9–20.

McGowan JC, Hatabu H, Yousem DM, Randall P, Kressel HY. Evaluation of soft palate function with MRI: application to the cleft palate patient. *J Comput Assist Tomogr.* 1992;16:877–882.

McGrath CO, Anderson MW. Prosthetic treatment of velopharyngeal incompetence. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:809–815.

McHenry MA. The effect of increased vocal effort on estimated velopharyngeal orifice area. *Am J Speech Lang Path.* 1997;6:55–61.

McReynolds L, Houston K. Distinctive feature analysis of children's misarticulations. *J Speech Hear Disord.* 1971;36:155–166.

McWilliams BJ. Articulation problems of a group of cleft palate adults. *J Speech Hear Res.* 1958;1:68–74.

McWilliams BJ. Some factors in the intelligibility of cleft palate speech. *J Speech Hear Disord.* 1954;19:524–527.

McWilliams BJ. The long-term speech results of primary and secondary surgical correction of palatal clefts. In: Bardach J, Morris HL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:815–819.

McWilliams BJ, Bradley DP. Ratings of velopharyngeal closure during blowing and speech. *Cleft Palate J* 1965;2:46–55.

McWilliams BJ, Glaser ER, Philips BJ, Lawrence C, Lavorato AS, Beery QC, Skolnick ML. A comparative study of four methods of evaluating velopharyngeal closure. *Plast Reconstr Surg.* 1981;68:1–9.

McWilliams BJ, Morris HL, Shelton RL. *Cleft Palate Speech.* 2nd ed. Philadelphia: BC Decker; 1990.

McWilliams BJ, Musgrave R. Psychological implications of articulation disorders in cleft palate children. *Cleft Palate J.* 1972;9:294–303.

McWilliams BJ, Philips BJ. *Velopharyngeal Incompetence. Audio Seminars in Speech Pathology.* Philadelphia: WB Saunders; 1979.

Menn L. Development of articulatory, phonetic, andphonological capabilities. In: Butterworth B, ed. *Language Production: Vol. 2. Development, Writing, and Other Language Processes.* New York: Academic Press; 1983.

Menyuk P. The role of distinct features in children's acquisition of phonology. *J Speech Hear Res.* 1968;11:138–146.

Milisen R. A rationale for articulation disorders. *J Speech Hear Disord. (Monograph suppl)* 1954;4:6–17.

Moll KL. A cinefluorographic study of velopharyngeal function in normals during various activities. *Cleft Palate J.* 1965;2:112–122.

Moll KL. 'Objective' measures of nasality. *Cleft Palate J.* 1964;1:371–374.

Moll KL. Speech characteristics of individuals with cleft lip and palate. In: Spriestersbach DC, ShermanD, eds. *Cleft Palate and Communication.* New York: Academic Press; 1968:61–118.

Moll KL. Velopharyngeal closure on vowels. *J Speech Hear Res.* 1962;5:30–37.

Moller KT. An approach to evaluation of velopharyngeal adequacy for speech. *Clin Comm Disord.* 1991;1:61–75.

Moller KT. Dental-occlusal and other oral conditions and speech. In: Bernthal JE, Bankson, eds. *Child Phonology: Characteristics, Assessment, and Intervention With Special Populations.* New York: Thieme; 1994.

Moller KT. Early speech development: the interaction of learning and structure. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:726–731.

Moller KT, Broen PA, Kittelson C. Early phonological development of children with cleft palate. Study session presented at the 41st Annual Meeting of the American Cleft Palate Association; May 1984; Seattle, Washington.

Moller KT, Geist GA, Kersten RB, Starr CD. Use of palatal lift appliance for persons with velopharyngeal inadequacy. Presented at the Annual Meeting of the American Cleft Palate Association; June 5–10, 1977; Toronto, Canada.

Moller KT, Starr CD. The effects of listening conditions on speech ratings obtained in a clinical setting. *Cleft Palate J.* 1984;21:65–69.

Moon JB. Evaluation of velopharyngeal function. In: Moller KT, Starr CD, eds *Cleft Palate: Interdisciplinary Issues and Treatment* Austin TX: Pro-Ed; 1993:251–306.

Moon JB, Canady JW. Effects of gravity on velopharyngeal muscle activity during speech. *Cleft Palate Craniofac J.* 1995;32:371–375.

Moon JB, Folkins JW, Smith AE, Luschei ES. Air pressure regulation during speech production. *J Acoust Soc Am.* 1993;94:54–63.

Moon JB, Kuehn DP. Anatomy and physiology of normal and disordered velopharyngeal function for speech. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Austin, TX:Pro-Ed;1997.

Moon J, Kuehn D. Induced velopharyngeal fatigue effects in speakers with repaired palatal clefts. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998a; Baltimore, MD.

Moon J, Kuehn D. Velopharyngeal closure forces associated with varying phonetic contexts produced by speakers with repaired palatal clefts. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998b; Baltimore, MD.

Moon JB, Kuehn DP, Huisman JJ. Measurement of velopharyngeal closure force during vowel production. *Cleft Palate Craniofac J.* 1994a;31:356–363.

Moon JB, Smith AE, Folkins JW, Lemke JH, Gartlan M. Coordination of velopharyngeal activity during positioning of the soft palate. *Cleft Palate Craniofac J.* 1994b;31:45–55.

Moon JB, Thompson SA, Jaekel E, Canady JW. Muscle fiber type distribution in the normal human levator veli palatini muscle. *Cleft Palate Craniofac J.* 1998;35:419–424.

Moore WH, Sommers RK. Phonetic contexts: their effects on perceived nasality in cleft palate speakers. *Cleft Palate J.* 1973;10:72–83.

Morris HL. Clinical assessment by the speech pathologist. In: Bardach J, Morris HL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:757–762.

Morris HL. Communication skills of children with cleft lips and palates. *J Speech Hear Res.* 1962;5:79–90.

Morris HL. Etiological bases for speech problems. In: Spriestersbach DC, Sherman D, eds. *Cleft Palate and Communication.* New York: Academic Press; 1968:119–168.

Morris HL, Bardach J. Cleft lip and palate and related disorders: issues for future research of high priority. *Cleft Palate J.* 1989;26:141–144.

Morris HL, Bardach J, Jones D, Christiansen JL, Gray SD. Clinical results of pharyngeal flap surgery: the Iowa experience. *Plast Reconstr Surg.* 1995; 95:652–662.

Morris HL, Spriestersbach DC, Darley FL. An articulation test assessing competency of velopharyngeal closure. *J Speech Hear Res.* 1961;4:48–55.

Morris HL, Wroblewski SK, Brown CK, Van Demark DR. Velar-pharyngeal status in cleft palate patients with expected adenoidal involution. *Ann Otol Rhinol Laryngol.* 1990;99:432–437.

Mra Z, Sussman JE, Fenwick J. HONC measures in 4- to 6-year-old children. *Cleft Palate Craniofac J.* 1998;35:408–414.

Naito Y, Yoshinobu H, Iwao H, Mori C, Hoshino K, Nishimura K, Nakano Y. Magnetic resonance imaging of the eustachian tube. *Arch Otolaryngol Head Neck Surg.* 1987;113:1281–1284.

Nation J. Vocabulary comprehension and usage of preschool cleft palate and normal children. *Cleft Palate J.* 1970;7:639–644.

Neiman GS, Savage HE. Development of infants and toddlers with clefts from birth to three years of age. *Cleft Palate Craniofac J.* 1997;34:218–225.

Netsell R. Commentary. On maintaining speech pressures in the presence of velopharyngeal impairment. *Cleft Palate J.* 1990;27:58–60.

Nichols AC. Nasalance statistics for two Mexican populations. *Cleft Palate Craniofac J.* 1999;36:57–63.

Olin, WH. *Cleft Lip and Palate Rehabilitation.* Springfield, IL: Charles C Thomas; 1960.

Olson DA. *A Descriptive Study of the Speech Development of a Group of Infants With Unoperated Cleft Palates.* Evanston, IL: Northwestern University; 1965. Unpublished dissertation.

O'Gara MM, Logemann JA. Phonetic analysis of the speech development of babies with cleft palate. *Cleft Palate J.* 1988;25:122–138.

O'Gara MM, Logemann JA, Rademaker A. Phonetic features of babies with unilateral cleft lip and palate. *Cleft Palate Craniofac J.* 1994;31:446–451.

Paden EP, Novak MA, Beiter AL. Predictors of phonological inadequacy in young children prone to otitis media. *J Speech Hear Dis.* 1987;52:232–242.

Pannbacker M. Oral language skills of adult cleft palate speakers. *Cleft Palate J.* 1975;12:95–106.

Pannbacker M, Lass NJ, Middleton GF, Crutchfield E, Trapp DS, Scherbick KA. Current clinical practices in assessment of velopharyngeal closure. *Cleft Palate J.* 1984;21:33–37.

Pannbacker M, Lass N, Scheurle JF, English PJ. Survey of services and practices of cleft palate-craniofacial teams. *Cleft Palate Craniofac J.* 1992;29: 164–167.

Pannbacker M, Lass NJ, Stout BM. Speech-Language pathologists' opinions on the management of velopharyngeal insufficiency. *Cleft Palate J.* 1990; 27:68–70.

Paynter ET. Parental and child preference for speech produced by children with velopharyngeal incompetence. *Cleft Palate J.* 1987;24:112–118.

Paynter ET, Kinard MW. Perceptual preferences between compensatory articulation and nasal air escape of air in children with velopharyngeal incompetence. *Cleft Palate J.* 1979;16:262–266.

Pensler JM, Bauer BS. Levator repositioning and palatal lengthening for submucous clefts. *Plast Reconstr Surg.* 1988;82765–769.

Persoon JA. *Unsophisticated Listener Judgments for Hypernasal and Compensatory Patterns of Articulation in Speech of Children and Adults.* Minneapolis: University of Minnesota; 1986. Unpublished Thesis.

Peterson-Falzone SJ. Speech disorders related to craniofacial structural defects: part 2. In: Lass NJ, McReynolds LV, Northern JL, Yoder DE, eds. *Handbook of Speech-Language Pathology and Audiology.* Philadelphia: BC Decker; 1988:477–547.

Peterson-Falzone SJ. Speech outcomes in adolescents with cleft lip and palate. *Cleft Palate Craniofac J.* 1995;32:125–128.

Peterson-Falzone, SJ. The relationship between timing of cleft palate surgery and speech outcome: what have we learned, and where do we stand in the 1990s? *Sem Orthodont.* 1996;2:185–191.

Peterson-Falzone SJ, Graham MS. Phoneme-specific nasal emissions in children with and without physical anomalies of the velopharyngeal mechanism. *J Speech Hear Dis.* 1990;55:132–139.

Philips BJ. Early speech management. In: Bardach J, Morris HL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:732–735.

Philips BJ. Perceptual evaluation of velopharyngeal closure. *Ann Otolol Rhinol Laryngol.* 1980;69:153–157.

Philips BJ. Stimulating syntactic and phonological development in infants with cleft palate. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown; 1979:304–310.

Philips BJ, Bzoch KR. Reliability of judgments of articulation of cleft palate speakers. *Cleft Palate J.* 1969;6:24–34.

Philips BJ, Harrison RJ. Language skills of preschool cleft palate children. *Cleft Palate J.* 1969a;6:108–119.

Philips BJ, Harrison RJ. Articulation patterns of pre-school cleft palate children. *Cleft Palate J.* 1969b;6:245–253.

Philips BJ, Kent RD. Acoustic-phonetic descriptions of speech production in speakers with cleft palate and other velopharyngeal disorders. In: Lass N, ed. *Speech and Language: Advances in Basic Research and Practice.* New York: Academic Press; 1984.

Pinborough-Zimmerman J, Canady C, Yamashiro DK, Morales L. Articulation and nasality changes resulting from sustained palatal fistula obturation. *Cleft Palate Craniofac J* 1998;35:81–87.

Powers GL, Starr CD. The effects of muscle exercises on velopharyngeal gap and nasality. *Cleft Palate J* 1974;11:28–25.

Prins D, Bloomer HH. A word intelligibility approach to the study of speech change in oral cleft patients. *Cleft Palate J* 1965;2:357–363.

Ramamurthy L, Wyatt RA, Whitby D, Martin D, Davenport P. The evaluation of velopharyngeal function using flexible nasendoscopy. *J Laryngol Otol* 1997;111:739–745.

Reisberg D, Gold H, Dorf D. A technique for obturating palatal fistulas. *Cleft Palate J.* 1985;22:286–289.

Ren YF, Isberg A, Henningsson G. Velopharyngeal incompetence and persistent hypernasality after adenoidectomy in children without palatal defect. *Cleft Palate Craniofac J.* 1995;32:476–482.

Richman LC. Cognitive patterns and learning disabilities in cleft palate children with verbal deficits. *J Speech Hear Res.* 1980;23:447–456.

Richman LC, Eliason MJ. Psychological achievement, behavioraland personality variables. *Cleft Palate J.* 1982;19:249–257.

Riski JE. Articulation skills and oral-nasal resonance in children with pharyngeal flaps. *Cleft Palate J.* 1979;16:421–428.

Riski JE. Speech assessment of adolescents. *Cleft Palate Craniofac J.* 1995; 32:109–113.

Riski JE, DeLong E. Articulation development in children with cleft lip/palate. *Cleft Palate J.* 1984;21:57–64.

Riski JE, Hoke JA, Dolan EA. The role of pressure flow and endoscopic assessment in successful palatal obturator revision. *Cleft Palate J.* 1989;26: 56–62.

Riski JE, Ruff GL, Georgiade GS, Barwick WJ. Evaluation of failed sphincter pharyngoplasties. *Ann Plast Surg.* 1992a;28:545–553.

Riski JE, Ruff GL, Georgiade GS, Barwick WJ, Edwards PD. Evaluation of the sphincter pharyngoplasty. *Cleft Palate Craniofac J.* 1992b;29:254–261.

Roberts JE, Burchinal MR, Davis BP, Collier AM, Hendrickson FW. Otitis media in early childhood and later language. *J Speech Hear Res.* 1991;34: 1158–1168.

Rosen MS, Bzoch KR. Prosthodontic management of the individual with cleft lip and palate for speech habilitation needs. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Austin, TX: Pro-Ed; 1997: 153–167.

Rosen MS, Bzoch KR. The prosthetic speech appliance in rehabilitation of patients with cleft palate. *J Am Dent Assoc.* 1958;57:103–120.

Ruscello DM. Considerations for behavioral treatment of velopharyngeal closure for speech. In: Bzoch KR, ed. *Communication Disorders Related to Cleft Lip and Palate.* Austin, TX: Pro-Ed; 1997:509–528.

Scarsellone JM, Rochet AP, Wolfaardt JF. The influence of dentures on nasalance values in speech. *Cleft Palate Craniofac J.* 1999;36:51–56.

Scherer NJ. The speech and language status of toddlers with cleft lip and/or palate following early vocabulary intervention. *Am J Speech Lang Path.*; 1999.

Scherer NJ, D'Antonio LL. Parent questionnaire for screening early language development in children with cleft palate. *Cleft Palate Craniofac J.* 1995; 32:7–13.

Scherer NJ, D'Antonio LL. Language and play development in toddlers with cleft lip and/or palate. *Am J Speech Lang Path.* 1997;6:48–54.

Scheuerle J, Guilford AM, Worden L, Habal MB. Maternal discourse features used with language-normal preschoolers with facial deformities. *J Craniofac Surg.* 1992;2:190–193.

Schneider E, Shprintzen RJ. A survey of speech pathologists: current trends in the diagnosis and management of velopharyngeal insufficiency. *Cleft Palate J.* 1980;17:249–253.

Schwartz MF. Acoustic measures of nasalization and nasality. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Second ed. Boston: Little, Brown; 1979:263–268.

Seagle MB. ''Speech characteristics associated with the Furlow palatoplasty as compared with other surgical techniques.'' [Discussion of McWilliams et al.] *Plast Reconstr Surg.* 1996;98:620–621.

Seaver EJ, Dalston RM, Leeper HA, Adams LE. A study of nasometric values for normal nasal resonance. *J Speech Hear Res.* 1991;34:715–721.

Seaver EJ, Karnell MP, Gasparaitis A, Corey J. Acoustic rhinometric measurements of changes in velar positioning. *Cleft Palate Craniofac J.* 1995;32: 49–54.

Seaver EJ, Kuehn DP. A cineradiographic and electromyographic investigation of velar positioning in non-nasal speech. *Cleft Palate J.* 1980;17:216–226.

Shames GH, Rubin H. Psycholinguistic measures of language and speech. In: Bzoch KR, ed.*Communicative Disorders Related to Cleft Lip and Palate.* 2nd ed. Boston: Little, Brown; 1979.

Shelton RL, Blank J. Oronasal fistulas, intraoralair pressure, andnasal air flow during speech. *Cleft Palate J.* 1984;21:91–99.

Shelton RL, Chisum L, Youngstrom KA, Arndt WB, Elbert M. Effect of articulation therapy on palatopharyngeal closure, movementof the posterior pharyngeal wall, andtongue posture. *Cleft Palate J.* 1969;6:440–448.

Shelton RL, Hahn E, Morris HL. Diagnosis and therapy. In: Spriestersbach DC, ShermanD, eds. *Cleft Palate and Communication.* New York: Academic Press; 1968a.

Shelton RL, Lindquist AF, Arndt WB, Elbert MA, Youngstrom KA. Effect of speech bulb reduction on movement of the posterior wall of the pharynx and posture of the tongue. *Cleft Palate J.* 1971a;8:10–17.

Shelton RL, Lindquist AF, Chisum L, Arndt WB, Youngstrom KA, Stick SL. Effect of prosthetic speech bulb reduction on articulation. *Cleft Palate J.* 1968b;5:195–204.

Shelton RL, Lindquist AF, Knox A, Wright V, Arndt WB, Elbert MA, Youngstrom KA. The relationship between pharyngeal wall movements and exchangeable speech appliance sections. *Cleft Palate J.* 1971b;8:145–158.

Sherman D. Usefulness of the mean in psychological scaling of cleft palate speech. *Cleft Palate J.* 1970;7:622–625.

Shprintzen RJ. Research revisited. *Cleft Palate J.* 1989;26:148–149.

Shprintzen RJ, McCall GN, Skolnick ML. A new therapeutic technique for the treatment of velopharyngeal incompetence. *J Speech Hear Dis.* 1975;40: 69–83.

Shprintzen RJ, McCall GN, Skolnick ML, Lencione RM. Selective movement of the lateral aspects of the pharyngeal walls during velopharyngeal closure for speech, blowingand whistling in normals. *Cleft Palate J.* 1975;12:51–58.

Shriberg LD, Kwiatkowski J. *Natural Process Analysis.* New York: Wiley; 1980.

Shriner TH, Sherman D. An equation for assessing language development. *J Speech Hear Res.* 1967;10:41–48.

Sie KC, Tampakopoulou DA, deSerres LM, Gruss JS, Eblen LE, Yonick T. Sphincter pharyngoplasty: speech outcome and complications. *Laryngoscope.* 1998;108:1211–1217.

Siegel GM. The limits of science in communication disorders. *J Speech Hear Dis.* 1987;52:306–312.

Sitzmann B, Moon J. Contributions of levator veli palatini and palatoglossus muscles to velar lowering. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998; Baltimore, MD.

Skolnick ML, McCall GN, Barnes M. The sphincteric mechanism of velopharyngeal closure. *Cleft Palate J.* 1973;10:286–305.

Smith BE, Guyette TW. Component approach for partitioning nasal airway resistance: pharyngeal flap case studies. *Cleft Palate Craniofac J.* 1993;30: 78–81.

Smith BE, Guyette TW. Pressure-flow differences in performance during production of the CV syllables /pi/ and /pa/. *Cleft Palate Craniofac J.* 1996; 33:74–76.

Smith NV. *The Acquisition of Phonology.* Cambridge: Cambridge University Press; 1973.

Smith RM, McWilliams BJ. Psycholinguistic abilities of children with clefts. *Cleft Palate J.* 1968;5:238–249.

Sommerlad BC, Harland K, Sell D, Birch M, Fenn C. Submucous cleft palate: a review of a consecutive series of 40 patients. Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies; 1997; Singapore.

Sommerlad BC, Henley M, Birch M, Harland K, Moiemen N, Boorman JG. Cleft palate re-repair: a clinical and radiographic study of 32 consecutive cases. *Br J Plast Surg.* 1994;47:406–410.

Spira M, Stal S, Lyos A. Techniques and timing in cleft surgery: a multicenter review. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1995; Tampa, FL.

Spriestersbach DC, Darley FL, Morris HL. Language skills in children with cleft palate. *J Speech Hear Res.* 1958;1:279–285.

Spriestersbach DC, Darley FL, Rouse V. Articulation of a group of children with cleft lips and palates. *J Speech Hear Dis.* 1956;21:436–445.

Spriestersbach DC, Dickson DR, Fraser FC, Horowitz SL, McWilliams BJ, Paradise JL, Randall P. Clinical research in cleft lip and palate: the state of the art. *Cleft Palate J.* 1973;10:113–164.

Spriestersbach DC, Moll KL, Morris HL. Subject classification and articulation of speakers with cleft palates. *J Speech Hear Res.* 1961;4:362–372.

Spriestersbach DC, Powers GR. Nasality in isolated vowels and connected speech of children with cleft palates. *J Speech Hear Res.* 1959;2:40–45.

Srivatsa LP. A radically new, yetsimple, treatmentfor stuttering. *Med Hypotheses.* 1995;45:572–574.

Stampe D. The Acquisition of Phonetic Representation. Chicago Linguistic Society, 5th Regional Meeting; 1969:443–454.

Starr CD. *A Study of Some of the Characteristics of the Speech and Speech Mechanisms of a Group of Cleft Palate Children.* Evanston, IL: Northwestern University; 1956. Unpublished dissertation.

Starr CD. Behavioral approaches to treating velopharyngeal closure and nasality. In: Moller KT, StarrCD, eds. *Cleft Palate: Interdisciplinary Issues and Treatment.* Austin, TX: Pro-Ed; 1993:337–356.

Starr CD. Dental and occlusal hazards to normal speech production. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown; 1979.

Starr CD. Treatment by therapeutic exercises. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:792–798.

Starr CD, Moller KT, Dawson W, Graham J, Skaar S. Speech ratings by speech clinicians parents and children. *Cleft Palate J.* 1984;21:286–292.

Story BH, Titze IR, Hoffman EA. Vocal tract area functions for an adult female speaker based on volumetric imaging. *J Acoust Soc Am.* 1998;104:471–487.

Story BH, Titze IR, Hoffman EA. Vocal tract area functions from magnetic resonance imaging. *J Acoust Soc Am.* 1996;100:537–554.

Subtelny J, Koepp-Baker H, Subtelny JD. Palatal function and cleft palate speech. *J Speech Hear Dis.* 1961;26:213–224.

Subtelny JD, Sakuda M, Subtelny JD. Prosthetic treatment for palatopharyngeal incompetence: research and clinical implications. *Cleft Palate J.* 1966;3:130–158.

Subtelny JD, VanHattum RJ, Myers BB. Ratings and measures of cleft palate speech. *Cleft Palate J.* 1972;9:18–27.

Sudo M, Sando I, Suzuki C. Three-dimensional reconstruction and measurement study of human eustachian tube structures: a hypothesis of eustachian tube function. *Ann Otol Rhinol Laryngol.* 1998;107:547–554.

Tachimura T, Hara H, Koh H, Wada T. Effect of temporary closure of oronasal fistulae on levator veli palatini muscle activity. *Cleft Palate Craniofac J.* 1997;34:505–511.

Tachimura T, Hara H, Wada T. Change in levator veli palatini muscle activity in association with elevation of the velum using a palatal lift prosthesis for normal speakers. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998; Baltimore, MD.

Tachimura T, Hara H, Wada T. Oral air pressure and nasal air flow rate on levator veli palatini muscle activity in patients wearing a speech appliance. *Cleft Palate Craniofac J.* 1995;32:382–389.

Tachimura T, Nohara K, Hara H, Wada T. Effect of placement of a speech appliance on levator veli palatini muscle activity during blowing. *Cleft Palate Craniofac J.* 1999;36:224–232.

Takagi Y, McGlone RE, Millard RT. A survey of the speech disorders of individuals with clefts. *Cleft Palate J* 1965;2:28–31.

Tarlow A, Saxman J. A comparative study of the speaking fundamental frequency characteristics in children with cleft palate. *Cleft Palate J.* 1970;7:696–705.

Teele DW, Klein JO, Rosner BA. Otitis media and effusion during the first three years of life and development of speech and language. *Pediatrics.* 1984;74:282–287.

Templin M. *Certain Language Skills in Children.* Child Welfare Monograph Series, Number 26. Minneapolis: University of Minnesota Press; 1957.

Tomes LA, Kuehn DP. Velopharyngeal impairment. *Curr Opin Otolaryngol Head Neck Surg.* 1996;4:155–165.

Tomes LA, Kuehn DP, Peterson-Falzone SJ. Behavioral treatments of velopharyngeal impairment. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate* Austin, TX: Pro-Ed; 1997:529–562.

Tomodo K, Morii S, Yamashita T, Kumazawa T. Histology of human eustachian tube muscles: effect of aging. *Ann Otol Rhinol Laryngol.* 1984;93:17–24.

Trost JE. Articulatory additions to the classical description of the speech of persons with cleft palate. *Cleft Palate J.* 1981a;18:193–203.

Trost JE. Differential diagnosis of velopharyngeal disorders. *Commun Disord Audio J Contin Ed.* 1981b.

Trost-Cardamone JE. Coming to terms with VPI: a response to Loney and Bloem. *Cleft Palate J.* 1989;26:68–70.

Trost-Cardamone JE. Effects of velopharyngeal incompetence on speech. *J Child Commun Dis.* 1986;10:31–49.

Trost-Cardamone JE, Bernthal JE. Articulation assessment procedures and treatment decisions. In: Moller KT, StarrCD, eds. *Cleft Palate: Interdisciplinary Issues and Treatment.* Austin TX: Pro-Ed; 1993:307–336.

Trost-Cardamone J, Witzel MA. Cleft palate misarticulations: Identification and therapy. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1998; Baltimore, MD.

Vadodaria S, Goodacre TEE, Anslow P. Does magnetic resonance imaging add value to palatal investigation? Presented at the 8th International Congress on Cleft Palate and Related Craniofacial Anomalies; 1997; Singapore.

Van Demark DR. Articulatory changes in the therapeutic process. *Cleft Palate J.* 1971;8:159–165.

Van Demark DR. Assessment of articulation for children with cleft palate. *Cleft Palate J.* 1974a;11:200–208.

Van Demark DR. Consistency of articulation of subjects with cleft palate. *Cleft Palate J.* 1969;6:254–262.

Van Demark DR. Diagnostic value of articulation tests with individuals having clefts. *Folia Phoniatr Logop.* 1997a;49:147–157.

Van Demark DR. Misarticulations and listener judgments of the speech of individuals with cleft palates. *Cleft Palate J.* 1964;1:232–245.

Van Demark DR. Predictability of velopharyngeal competency. *Cleft Palate J.* 1979;16:429–435.

Van Demark DR. Some results of speech therapy for children with cleft palate. *Cleft Palate J.* 1974b;11:41–49.

Van Demark DR. Speech and voice therapy techniques for school-age and adult patients with remaining cleft palate speech disorders. In: Bzoch KR, ed. *Communicative Disorders Related to Cleft Lip and Palate.* Austin, TX: Pro-Ed; 1997b:493–508.

Van Demark D, Bzoch K, Daly D, Fletcher S, McWilliams BJ, Pannbacker M, Weinberg B. Methods of assessing speech in relation to velopharyngeal function. *Cleft Palate J.* 1985;22:281–285.

Van Demark D, Hardin MA. Effectiveness of intensive articulation therapy for children with cleft palate. *Cleft Palate J.* 1986;23:215–224.

Van Demark D, Hardin MA. Speech therapy for the child with cleft lip and palate. In: Bardach J, Morris HL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:799–809.

Van Demark D, Hardin MA, Morris HL. Assessment of velopharyngeal competence: a long-term process. *Cleft Palate J.* 1988;25:362–373.

Van Demark D, Hardin-Jones MA, O'Gara MM, Logemann JA, Chapman KL. Identification of children with and without cleft palate from tape-recorded samples of early vocalizations and speech. *Cleft Palate Craniofac J.* 1993;30:557–563.

Van Demark D, Kuehn DP, Tharp RF. Prediction of velopharyngeal competency. *Cleft Palate J.* 1975;12:5–11.

Van Demark D, Morris HL. Stability of velopharyngeal competency. *Cleft Palate J.* 1983;20:18–22.

Van Demark D, Morris HL, Vandehaar C. Patterns of articulatory abilities in speakers with cleft palate. *Cleft Palate J.* 1979;16:230–239.

Van Demark D, Swickard S. A pre-school articulation test to assess velopharyngeal competency: normative data. *Cleft Palate J.* 1980;17:175–179.

Van Demark D, Van Demark AH. Misarticulations of cleft palate children achieving velopharyngeal closure and children with functional speech problems. *Cleft Palate J.* 1967;4:31–37.

van Doorn J, Purcell A. Nasalance levels in the speech of normal Australian children. *Cleft Palate Craniofac J.* 1998;35:287–292.

Van Hattum RJ. Articulation and nasality in cleft palate speakers. *J Speech Hear Res.* 1959;2:113–125.

Wachtel JM, Kuehn DP, Weiss KS. Hypernasality following tonsillectomy without adenoidectomy in an adult: a case report. *Otolarygol Head Neck Surg.* In press.

Warr-Leeper GA, Crone L, Carruthers A, Leeper HA. A comparison of the performance of preschool children with cleft lip and/or palate on the test of pragmatic skills. Presented at the American Cleft Palate Association; 1988; Williamsburg, VA.

Warren DW. Compensatory speech behaviors in individuals with cleft palate: a regulation/control phenomenon? *Cleft Palate J.* 1986;23:251–260.

Warren DW, Dalston RM, Dalston ET. Maintaining speech pressures in the presence of velopharyngeal impairment. *Cleft Palate J.* 1990;27:53–58.

Warren DW, Dalston RM, Mayo R. Hypernasality and velopharyngeal impairment. *Cleft Palate Craniofac J.* 1994;31:257–262.

Warren DW, Dalston RM, Mayo R. Hypernasality in the presence of ''adequate'' velopharyngeal closure. *Cleft Palate Craniofac J.* 1993;30:150–154.

Warren DW, Dalston RM, Morr KE, Hairfield WM, Smith LR. The speech regulating system: temporal and aerodynamic responses to velopharyngeal inadequacy. *J Speech Hear Res.* 1989;32:566–575.

Warren DW, Devereaux JL. An analog study of cleft palate speech. *Cleft Palate J.* 1966;3:103–114.

Warren DW, DuBois AB. A pressure-flow technique for measuring orifice area during continuous speech. *Cleft Palate J.* 1964;1:52–71.

Warren DW, Rochet AP, Dalston RM, Mayo R. Controlling changes in vocal tract resistance. *J Acoust Soc Am.* 1992;91:2947–2953.

Wasserman GA, Allen R, Linares LO. Maternal interaction and language development in children with and without speech-related anomalies. *J Commun Disord.* 1988;21:319–331.

Watterson T, Hinton J, McFarlane S. Novel stimuli for obtaining nasalance measures from young children. *Cleft Palate Craniofac J.* 1996;33:67–73.

Watterson T, Lewis KE, Deutsch C. Nasalance and nasality in low pressure and high pressure speech. *Cleft Palate Craniofac J.* 1998;35:293–298.

Watterson T, Lewis KE, Foley-Homan N. Effect of stimulus length on nasalance scores. *Cleft Palate Craniofac J.* 1999;36:243–247.

Watterson T, McFarlane SC, Wright DS. The relationship between nasalance and nasality in children with cleft palate. *J Commun Disord.* 1993;26:13–28.

Watterson T, York SL, McFarlane SC. Effects of vocal loudness on nasalance measures. *J Commun Disord.* 1994;27:257–262.

Webb M, Starr CD, Moller KT. Effects of extended speaking on resonance of patients with cleft palate. *Cleft Palate Craniofac J.* 1992;29:22–26.

Wein BB, Drobnitzky M, Klajman S, Angerstein W. Evaluation of functional positions of tongue and soft palate with MR imaging: initial clinical results. *J Magnetic Reson Imag.* 1991;1:381–383.

Weiss CE. Success of an obturator relation program *Cleft Palate J.* 1971;8: 291–297.

Whalen DH, Kang AM, Magen HS, Fulbright RK, Gore JC. Predicting midsagittal pharynx shape from tongue position during vowel production. *J Speech Lang Hear Res.* 1999;42:592–603.

Williams WG, Lo LJ, Hung KF, Chen KT, Lin WY, Wu J, Yun C, Wang R, Chen YR, Noordhoff MS. The effect of maxillary distraction on velopharyngeal function. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association, Baltimore, 1998.

Witt PD, D'Antonio LL. Velopharyngeal insufficiency and secondary palatal management. A new look at an old problem. *Clin Plast Surg.* 1993;20:707–721.

Witt PD, D'Antonio LL, Zimmerman GJ, Marsh JL. Sphincter pharyngoplasty: a preoperative and postoperative analysis of perceptual speech characteristics and endoscopic studies of velopharyngeal function. *Plast Reconstr Surg.* 1994;93:1154–1168.

Witt PD, Marsh JL, Marty-Grames L, Muntz HR, Gay WD. Management of the hypodynamic velopharynx. *Cleft Palate Craniofac J.* 1995a;32:179–157.

Witt PD, Myckatyn T, Marsh JL. Salvaging the failed pharyngoplasty: intervention outcome. *Cleft Palate Craniofac J* 1998a;35:447–453.

Witt PD, O'Daniel TG, Marsh JL, Grames LM, Muntz HR, Pilgram TK. Surgical management of velopharyngeal dysfunction: outcome analysis of autogenous posterior pharyngeal wall augmentation. *Plast Reconstr Surg.* 1997;99:1287–1300.

Witt PD, Rozelle AA, Marsh JL, Marty-Grames L, Muntz HR, Gay WD, Pilgram TK. Do palatal lift prostheses stimulate velopharyngeal neurotransmitter activity? *Cleft Palate J.* 1995b;32:469–475.

Witt PD, Wahlen JC, Marsh JL, Grames LM, Pilgram TK. The effect of surgeon experience on velopharyngeal functional outcome following palatoplasty: is there a learning curve? *Plast Reconstr Surg.* 1998b;102:1375–1384.

Witzel MA, Stringer DA. Methods of assessing velopharyngeal function. In: Bardach J, MorrisHL, eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: WB Saunders; 1990:763–776.

Witzel MA, Tobe J, Salyer K. The use of nasopharyngoscopy biofeedback therapy in the correction of inconsistent velopharyngeal closure. *Int J Pediatr Otorhinolaryngol.* 1988;15:137–142.

Witzel MA, Tobe J, Salyer KE. The use of videonasopharyngoscopy for biofeedback therapy in adults after pharyngeal flap surgery. *Cleft Palate J.* 1989;26:129–134.

Wolfaardt JF, Wilson FB, Rochet A, McPhee L. An appliance based approach to the management of palatopharyngeal incompetency: a clinical pilot project. *J Prosth Dent.* 1993;69:186–195.

Wong L, Weiss CE. A clinical assessment of obturator-wearing cleft palate patients. *J Prosth Dent.* 1972;27:632–639.

World Health Organization. *International classification of impairments, disabilities and handicaps.* Geneva; 1980.

World Health Organization. *International classification of impairments, disabilities and handicaps.* ICIDH 2: A Manual of Dimensions of Disablement and Functioning, β-1 Draft for Field Trials. Geneva; 1999. (See also http://www.who.int/msa/mnh/ems/icidh/icidh.htm.)

Wozny CG, Kuehn DP, Oishi JT, Arthur JL. Effect of passage length on nasalance values in normal adults. *ASHA.* 1994;36:193.

Wyatt R, Sell D, Russell J, Harding A, Harland K, Albery E. Cleft palate speech dissected: a review of current knowledge and analysis. *Br J Plast Surg.* 1996;49:143–149.

Yamaoka M, Matsuya T, Miyazaki T, Nishio J, Ibuki K. Visual training for velopharyngeal closure in cleft palate patients: a fiberscopic procedure (preliminary report). *J Maxillofac Surg.* 1983;11:191–193.

Yamawaki Y, Nishimura Y, Suzuki Y. Velopharyngeal closure and the longus capitis muscle. *Acta Otolarygolog (Stockh).* 1996;116:774–777.

Yamawaki Y, Nishimura Y, Suzuki Y, Sawada M, Yamawaki S. Rapid magnetic resonance imaging for assessment of velopharyngeal muscle movement on phonation. *Am J Otolaryngol.* 1997;18:210–213.

Yoshinaga-Itano C, Apuzzo ML. Identification of hearing loss after 18 months is not early enough. *Am Ann Deaf.* 1998;143:380–387.

Young MA. Observer agreement: cumulative effects of repeated ratings of speech sample and knowledge of group results. *J Speech Hear Res.* 1969; 12:144–155.

Ysunza A, Pamplona M, Femat T, Mayer J, Garcia-Velasco M. Videonasopharyngoscopy as an instrument for visual biofeedback during speech in cleft palate patients. *Int J Pediatr Otorhinolaryngol.* 1997;41:291–298.

Ysunza A, Pamplona C, Toledo E. Change in velopharyngeal valving after speech therapy in cleft palate patients: a videonasopharyngoscopic and multi-view videofluoroscopic study. *Int J Pediatr Otorhinolaryngol.* 1992;24: 45–54.

Zajac DJ. Velopharyngeal function in young and older adult speakers: evidence from aerodynamic studies. *J Acoust Soc Am.* 1997;102:1846–1852.

Zajac DJ, Mayo R. Aerodynamic and temporal aspects of velopharyngeal function in normal speakers. *J Speech Hear Res.* 1996;39:1199–1207.

Zajac DJ, Mayo R, Kataoka R. Nasal coarticulation in normal speakers: a re-examination of effects of gender. *J Speech Lang Hear Res.* 1998;41:503–510.

Zraick RI. Perception of hypernasal voice quality. Presented at the annual meeting of the American Cleft Palate-Craniofacial Association; 1999; Scottsdale, AZ.