Predictability of Velopharyngeal Competency

D. R. VAN DEMARK, Ph.D.
Iowa City, Iowa 52242

The specific purpose of this retrospective investigation was to try to discriminate between those cleft palate subjects who exhibited poor articulation scores and required further palatal management from those who did not. At age four, articulation scores indicated no significant differences between the two groups. However, when specific analysis of articulation errors was done, the group requiring secondary management exhibited significantly more errors on plosive and fricative phonemes. Specific *phonemes* which were *discriminating* were the */p/, /b/, /t/, /d/, /g/, /f/,* and */v/*. The groups requiring secondary management also exhibited significantly more *nasal distortions* on the *above phonemes* while the other group exhibited more oral distortions. The /p/ and /p/ phonemes appear to be of value in predicting competency in young children.

The purpose of this investigation was to determine if velopharyngeal adequacy could be predicted for a large group of children with cleft palate. The initial effort (Van Demark and Morris, 1977) indicated that, by the use of the Iowa Pressure Articulation Test (Morris, Spriestersbach, and Darley, 1961), risk rates could be calculated at various age levels. (See Table 1.) In this study it was of interest to note that no subject who, at age four, correctly articulated at least 20% of the phonemes tested on the Iowa Pressure Articulation Test (IPAT) needed further surgical management, whereas 95% of the subjects who achieved a zero articulation score at age four and one-half subsequently had secondary management.

Although age was a factor in the acquisition of articulation skills for these children, as it is for other children, this study demonstrated that children who subsequently needed secondary management improved very little (less than 5%) in consonant articulation with a three year-increase in age. (See Table 2.) Thus, even subjects who were seven years of age did not achieve scores above 20% on the IPAT prior to secondary management. On the other hand, subjects who did not require secondary management averaged a 55% increase in consonant articulation accuracy from age four to seven.

The results of this initial study indicated that, if a subject achieved a score of 20% or higher on the IPAT at age four, his risk of needing secondary management was minimal (approximately 5%). For those subjects who achieved scores of less than 20% on the IPAT at age four, the predictive value of the IPAT was less clear. Although a trend existed that the lower the articulation score, the greater the risk of needing secondary management, not all subjects who achieved scores of less than 20% on the IPAT at age four subsequently had or required secondary management.

The specific purpose of the present retrospective investigation was to try to discriminate between those subjects who needed further palatal management and those subjects who did not on the basis of an in-depth analysis of articulation tests. Specifically, the study was done to determine if those subjects who had poor articulation scores on the IPAT (less than 20%) differed in the manner and type of production errors.

Procedure

SUBJECT SELECTION. All subjects selected for this study had to have had articulation testing at both four and eight years of age. Subjects

* Dr. Van Demark is Professor, Department of Otolaryngology and Maxillofacial Surgery and Department of Speech Pathology and Audiology, University of Iowa, Iowa City, Iowa.

This paper was supported in part by Public Health Service DE-00853, National Institute of Dental Research.

Portions of this paper were presented at the Third International Congress on Cleft Palate and Related Craniofacial Anomalies, June 1977.

TABLE 1. The Need for Secondary Palatal Management as Determined by Scores on the IPAT*

IPAT Score % Correct	*N*	*No. of Patients with Pharyngeal Flaps at Time of Examination*	*No. of Patients Having Pharyngeal Flaps Later*	*Percentage of Subjects Who Had Pharyngeal Flaps*
		Age 4		
100–41	39	0	0	0.0
40–31	15	1	0	0.0
30–21	16	0	0	0.0
20–11	14	0	2	14.3
10–01	36	1	16	45.7
00–00	27	1	20	76.9
Total SS	147			
		Age 4½		
100–41	49	1	0	0.0
40–31	14	1	2	15.4
30–21	30	4	1	3.8
20–11	19	1	4	22.2
10–01	23	1	12	54.5
00–00	23	0	22	95.6
Total SS	158			

* Van Demark and Morris, 1977.

TABLE 2. Increases In Percentage of Correct IPAT Responses Between Tests. All Tests Were Done After Primary Surgery and Before Secondary Surgery*

Age Range (yrs.)	*Subjects with No Subsequent Secondary Surgery*		*Subjects with Subsequent Secondary Surgery*	
	n	*Increase in % Correct*	*n*	*Increase in % Correct*
4–4½	29	8.7	21	0.0
4½–5	39	10.3	20	0.0
5–6	29	18.2	16	1.5
6–7	24	17.6	15	3.3

* Van Demark and Morris, 1977.

could not have had pharyngeal flaps or any other secondary surgical procedures before age four and could not be wearing obturators. These criteria were met for 109 subjects. (See Table 3.)

Scores on the IPAT at age four revealed that 55 subjects achieved scores lower than 20%, while 54 subjects achieved 20% or better. Thirty-one subjects with scores below 20% subsequently had pharyngeal flap procedures and are referred to hereafter as Group A. Their mean age at the time of secondary surgery was six years, two months, with a range of 49 to 109 months. Group B consisted of 24 subjects who also had scores below 20% on the IPAT but who did not require further palatal surgery. Group C consisted of 51 subjects who achieved the criterion or better and who had no further surgery. Group D consisted of three subjects who achieved the criterion but had nevertheless subsequent secondary surgery. Because Group D was small, they were deleted in further data analysis. At initial test, Group A subjects had a mean age of 50.6 months, Group B 48.9 months, and Groups C 49.9 months.

Articulation Testing. Each subject was given the 149-element articulation test (Van Demark and Tharp, 1973) at age four and again at age eight. In this test, subjects respond to a given set of pictures in order to elicit a particular sound or sounds. If a four-year-old child does not respond appropriately, the examiner either provides a carrier phrase or asks the child to repeat a specific test word. The examiner rates each test element as either

TABLE 3. Subject Selection: Groups A and D Eventually Required Pharyngeal Flaps. Groups B and C Required No Further Palatal Management

Below 20% on IPAT at mean age	Group A (N = 31) Pre-flap 50.6 months	Group B (N = 24) Primary Only 48.9 months
Above 20% on IPAT at mean age	Group C (N = 51) Primary Only 49.9 months	Group D (N = 3) Pre-flap 53.3 months

correct or incorrect. If the element is incorrect, the type of error is noted as is described in the above reference. Examiner reliability has been previously reported (Van Demark, 1964, 1974, and Morris, 1960).

Sounds are presented in a variety of positions which includes both single items and blends. The test includes items which are found in the Templin-Darley Screening Test of Articulation and the IPAT as well as additional phonemes. The test includes 46 plosives, 44 fricatives, six affricatives, 32 glides, 12 nasals, and eight vowels.

Using the computer program described by Van Demark and Tharp (1973), scores may be obtained for the IPAT, the Templin-Darley Screening Test, and the 149-element test. Variations of this program can also provide data concerning correct production of specific phonemes, manner of production, and types of errors on specific sounds.

VELOPHARYNGEAL COMPETENCY AND MANAGEMENT DECISION. As part of the research protocol the clinical evaluation of velopharyngeal competency was made on the basis of a composite diagnostic evaluation. The examiner rated each subject as having velopharyngeal competency, marginal competency, or velopharyngeal incompetency, based on observations of the subject's conversational speech, word articulation tests, stimulability, manometer ratios, and evaluation of the oral mechanism. Observations of a subject's nasal grimace and/or nasal emission were also utilized by the examiner to rate each subject. These ratings were used to make the best possible clinical judgment of velopharyngeal adequacy in each subject. These clinical judgments have been related to other measures (Van Demark, Kuehn, and Tharp, 1975), and the reliability of the author in making these judgments has been reported (Van Demark, 1974).

The management decision or recommendation for a pharyngeal flap was usually made by members of the Iowa Cleft Palate Team. The team consisted of approximately ten members and included three speech pathologists. Although the exact criteria for recommending a pharyngeal flap in all probability varied among patients, as did diagnostic information such as lateral x-rays, cinefluorographic films, speech remediation, etc., no subject received a recommendation for a pharyngeal flap as the result only of scores obtained on an articulation test. The validity of staff judgment concerning additional management can always be questioned. However, the lack of improvement in articulation scores of subjects who did not receive additional management until after age seven (Van Demark and Morris, 1977) gives some support to the management decision. Likewise, the articulation data obtained at age four was collected on the average two years before a management decision was made. Articulation ratings and velopharyngeal competency ratings were made, on the average, six years before the study was begun.

Results

ARTICULATION SCORES. Three different articulation test scores derived from the 149-element articulation test (on a right-wrong basis) were considered in the initial data analysis. They consisted of the IPAT, the 50-item Templin-Darley Screening Test of Articulation, and the 149-element Articulation Test. These three sets of scores, obtained at age four, were compared for Group A and for Group B. Using appropriate *t*-tests there were no significant differences at either the .05 or .01 level of confidence between the two groups on any of the three tests.* Thus, as is demonstrated in Figure 1, Group A and B subjects

* *t*-tests were used to determine if significant differences occurred at the .01 or .05 level of confidence for all comparisons in this study. A member of the Dept. of Biostatistics examined all data and calculated the appropriate *t* test.

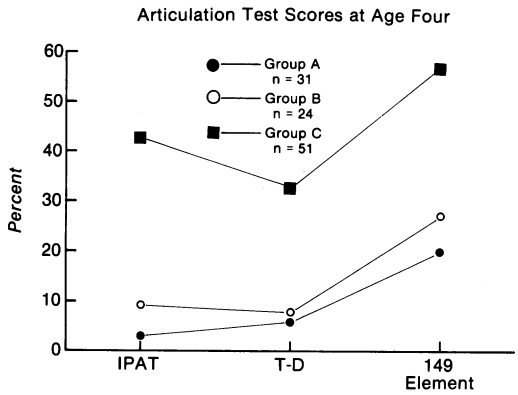

FIGURE 1. Articulation Test scores at age four on the IPAT, Templin-Darley Screening Test of Articulation, and the 149-element Articulation Test. Group C was significantly superior on all three tests. There were no significant differences between Groups A and B.

appeared similar from their initial articulation test scores. Group C, at age four, was significantly better (.01) than Group A or B on all three tests.

VELOPHARYNGEAL COMPETENCY. Examination of velopharyngeal competency ratings done at age four indicated that 13% of Group A were considered to have marginal velopharyngeal closure and 87% were thought to have incompetent mechanisms. In Group B, 42% were evaluated as having adequate closure, 50% marginal closure, and 8% inadequate closure. In Group C, 57% were evaluated as exhibiting adequate velopharyngeal closure, 39% marginal, and 4% inadequate. (See Table 4.)

SPECIFIC ANALYSIS OF ARTICULATION ERRORS—MANNER OF PRODUCTION. In an effort to determine if particular articulation errors might discriminate between subjects who later required pharyngeal flaps from those who did not, the 149-element articulation test was analyzed by manner of production. Figure 2 illustrates that subjects in Group B performed better on the production of plosives and fricatives than Group A subjects. This difference was significant at the .01 level of confidence. Although Group B also performed slightly better on affricatives, there were too few of these phonemes (6) for meaningful comparisons. The percentage of correct productions on fricatives and affricatives for both Groups A and B was very low. Production of nasals and vowels did not discriminate between groups, but Group A performed slightly better on glide productions (.05).

Examination of Figure 2 demonstrates the differences among the three groups. For example, in Group A, only 9% of the plosive sounds were correctly produced while 15% were produced correctly by Group B. In Group C, 74% of the plosive sounds were correctly produced. In addition, Group A achieved less than 1% correct fricative production while Group B produced 5% correctly. On the other hand, Group C averaged 31% correct production on fricative and affricative sounds. On nasal and vowel productions, there were no significant differences among groups. However, for glide productions, Group A achieved a mean of 40% compared to a mean of 26% for Group B (significant at the .05 level of confidence).

SPECIFIC SOUND PRODUCTION. Since there was a significant difference on plosive sounds between Groups A and B at age four, specific comparisons were made for each plosive sound. It can be seen in Figure 3 that Group B was 40% better on the /p/ sound and 35% better on the /p/ sound than Group A (sig-

TABLE 4. Velopharyngeal Competency Ratings at Age Four

Group	*N*	*Competent*	*Marginal*	*Incompetent*
A	31	0%	13%	87%
B	24	42%	50%	8%
C	51	57%	39%	4%

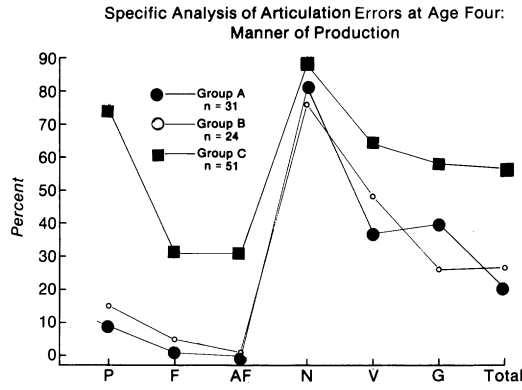

FIGURE 2. Specific analysis of articulation errors at age four: manner of production. Group B was significantly better in plosive and fricative production than Group A.

TABLE 5. Type of Articulatory Errors for Subjects Who Failed The Cut-Off Score at Age Four. OD = Oral Distortions, ND = Nasal Distortions and Are Significant (*) at The .05 Level of Confidence

Group	N	Total		Plosives		Fricatives	
		OD	ND	OD	ND	OD	ND
A	31		*		*		*
B	24	*		*		*	

nificant at the .01 level). On /t/ and /d/, Group B produced significantly more (.01) of these sounds correctly. For the plosives /k/ and /g/, Group B again had a better performance, but only the /g/ sound was significant at the .05 level.

The mean number of correct fricatives for any one sound was generally low for both the A and B Groups. However, the /f/ and /v/ sounds were discriminating at the .01 and .05 levels respectively. For example, the B Group achieved 24% correct production of the /f/ sound, while the A Group achieved less than 4% correct production. For the /v/ sound, the means were 10% and 1% respectively.

In the glide category Group A achieved higher scores than Group B; however, only /l/ production was significantly better at the .05 level of confidence.

TYPE OF ERROR. In order to determine if other discriminating variables existed, the types of articulation errors were compared for Groups A and B at four years of age. For the total 149-element test, no significant differences occurred for substitutions, nasal-substitutions, glottal-stop substitutions, pharyngeal-fricative substitutions, or omissions. Group A exhibited significantly more nasal-distortions (moderate and severe) than did Group B at the .05 level of confidence. Group B exhibited significantly more oral distortions. When phonemes were considered according to manner of production, again, the specific difference for plosive and fricative categories indicated that Group A exhibited significantly more nasal distortions, while Group B exhibited significantly more oral distortions at the .05 level of confidence. Examination of the types of errors on sounds indicated as being significantly different in Group A and Group B revealed that Group A exhibited more nasal distortions on the /p/, /b/, /t/, /d/, /k/, /g/, /f/, and /v/ sounds (see Figure 4). Group B exhibited significantly more substitutions on the /p/ sound and more omissions on the /l/ sound.

ARTICULATION TESTS—RESULTS AT AGE EIGHT. Comparison of articulation test scores at age eight for the IPAT, Templin-Darley Screening Test of Articulation, and 149-element Articulation Test indicated that the three groups of subjects maintained the same positions in articulation accuracy. Group C remained significantly superior to Groups A and B on all three tests (see Figure 5), while none of the tests revealed a significant difference between Groups A and B.

When within Group comparisons were made between the ages of four and eight, all three groups (A, B, and C) improved significantly (.01 level) on all articulation scores. Figure 6 demonstrates the similarities among the three groups when they are compared in the production of plosive, fricative, affricative, nasal, vowel, and glide sounds.

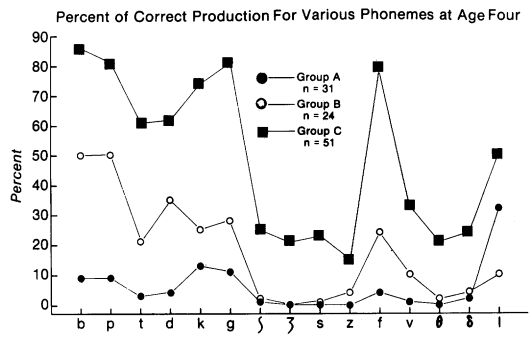

FIGURE 3. Percentages of correct phonemes at age four. Group B performed significantly better on productions of /p/, /b/, /t/, /d/, /g/, /f/, and /v/.

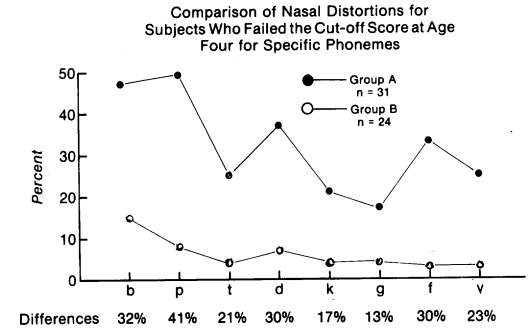

FIGURE 4. Comparison of nasal distortions for subjects who failed the cut-off score at age four for specific phonemes.

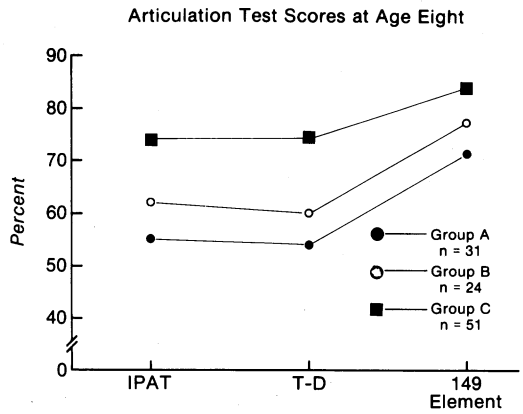

FIGURE 5. Articulation Test scores at age eight on the IPAT, Templin-Darley Screening Test of Articulation, and the 149-element Articulation Test. Group C was significantly superior on all three tests. There were no significant differences between Groups A and B.

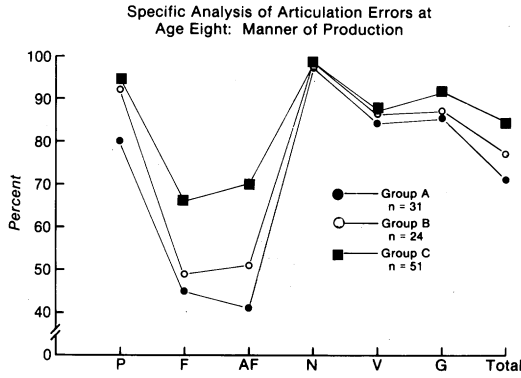

FIGURE 6. Specific analysis of articulation errors at age eight: manner of production.

VELOPHARYNGEAL COMPETENCY. Velopharyngeal competency ratings were examined for each subject for his last evaluation. For Group A, (average age = 10.6 years) 81% of the subjects who had had pharyngeal flaps were rated as achieving velopharyngeal closure, 16% as achieving marginal closure, and 3% as exhibiting inadequate velopharyngeal valving. For Group B (average age = 10.1 years), 62.5% were rated as competent and 37.5% were rated as marginal. For Group C 62.5% were rated as competent and 37.5% as marginal. (See Table 6.)

Discussion

It would appear that the majority of subjects who eventually had pharyngeal flaps did, in fact, achieve sufficiently adequate velopharyngeal closure for speech, yet articulation skills in this group were not as good as in the other two groups. The articulation of those subjects requiring pharyngeal flaps was not significantly different from subjects who had comparable articulation skills at age four, e.g. those subjects who had poor articulation but required no further surgical management of the velopharyngeal mechanism. The difference between the two groups of subjects appears to be that the pre-flap group (Group A) exhibited articulation errors chiefly because they had inadequate velopharyngeal valving mechanisms. This conclusion is based in part on the observation that Group A did not exhibit as many errors on non-pressure sounds, e.g. nasals and glides, as did Group B. Group A also made a significant improvement in articulation skills once they achieved adequate mechanisms, although they very likely had not learned to use that mechanism optimally. Articulation errors for the flap group could also be related to previous compensatory learning and/or to the multidimensional dental-facial complexities which are often present in more extreme clefts.

The articulation errors exhibited by Group B, at both ages four and eight, are not as easily explained, and this group merits further study. It appears that this group had articulation errors which were more likely related to learning, especially at age four when they were significantly poorer in the production of glide sounds. Although on last examination this group's velopharyngeal competency ratings were the same as Group C, yet their articulation scores remained significantly poorer. One could speculate that speech remediation could be influential. However, when these subjects were four years of age, speech services were essentially nonexistent to preschool children. On the other hand, there is no reason to assume that speech therapy services at school age differed among the three groups.

TABLE 6. Velopharyngeal Competency Ratings at Last Examination

Group	*N*	*Mean Age*	*Competent*	*Marginal*	*Incompetent*
A	31	10.6	81%	16%	3%
B	24	10.6	63%	37%	—
C	51	10.1	63%	37%	—

Although we have been administering articulation tests and have been making judgments about velopharyngeal competency for many years, not until this study was completed were we able to show why we might recommend a pharyngeal flap for one subject and speech remediation for another. It seems that more thorough analysis of the data reveals a rather obvious distinction among the groups. It is that children at age four can generally produce plosive sounds. Since the /p/ and /b/ sounds are among the first plosives learned and since they seem to discriminate between a competent and an incompetent valving mechanism, these two sounds are particularly meaningful in the differential diagnosis of velopharyngeal competency at an early age. Secondly, if nasal distortions occur on approximately 50% of these sounds, one more indication exists that the mechanism is inadequate. Thirdly, as has been demonstrated (Van Demark and Morris, 1977), children with clefts improve articulation scores as age increases if the velopharyngeal mechanism is adequate. Little improvement is made on pressure sounds if the mechanism is inadequate. One method to determine if progress can be made is to initiate trial therapy to determine if a child can adequately produce /p/ and /b/ sounds.

In summary, we feel that the /p/ and /b/ sounds can be most useful in predicting velopharyngeal competency in a young child. Secondly, the type of error should be an additional diagnostic and prognostic clue. It would, however, be naive to assume that every child who produces an adequate /p/ and /b/ at age four, will never need additional surgical management, nor do we suggest that the final decision concerning additional pharyngeal management can be made without additional diagnostic measures.

References

MORRIS, H. L., SPRIESTERSBACH, D. C., and DARLEY, F. L., An articulation test for assessing competency of velopharyngeal closure, *J. Sp. Hear. Res.*, *4*, 48–55, 1961.

VAN DEMARK, D. R., KUEHN, D. P., and THARP, R. F., Prediction of Velopharyngeal Competency, *Cleft Palate J.*, *12*, 5–11, 1975.

VAN DEMARK, D. R. and MORRIS, H. L., A preliminary study of the predictive value of the IPAT, *Cleft Palate J.*, *14*, 124–130, 1977.

VAN DEMARK, D. R. and THARP, R. F., A computer program for articulation tests, *Cleft Palate J.*, *10*, 378–389, 1973.

VAN DEMARK, D. R., Misarticulations and Listener Judgments of the Speech of Individuals with Cleft Palates, *Cleft Palate J.*, *1*, 232–245, 1964.

VAN DEMARK, D. R., Assessment of Articulation for Children with Cleft Palate, *Cleft Palate J.*, *11*, 200–208, 1974.

VAN DEMARK, D. R., Assessment of Velopharyngeal Competency for Children with Cleft Palate, *Cleft Palate J.*, *11*, 310–316, 1974.