Audiologic and Otologic Evaluation of Cleft Palate Children

JOYCE C. HELLER, Ph.D.
IRVING HOCHBERG, Ph.D.
GASTONE MILANO, M.D.
Union, New Jersey

Studies by Spriestersbach and his associates (*11*) and by Graham (*3*) have emphasized the importance of evaluating hearing loss among cleft palate children in relation to specific variables. Spriestersbach *et al* noted the importance of subclassifying cleft palate individuals when considering the incidence of hearing loss. They found that children between 33 and 77 months of age and those cleft palate children with associated anomalies had a significantly greater incidence and magnitude of hearing loss than did subjects who were older and those without associated anomalies. Graham studied a group of cleft palate children who received an essentially consistent program of medical care for eight or more years in order to determine the nature and extent of change in hearing as a function of increasing age. He, too, found a considerable fluctuation in hearing levels as a function of age, and suggested that age of otologic and audiologic examination and the type of cleft appear to be two important variables to be considered before generalizations are made from group data.

In light of these considerations the present investigation was undertaken to evaluate a group of cleft palate children audiologically and otologically by taking into account several variables which have not always characterized previous research. These included (a) the time of primary surgical repair; (b) the type of surgical repair; (c) the inclusion of a matched control group; (d) the inclusion of both air and bone conduction audiograms; and (e) the inclusion of otologic evaluation.

Method

Subjects. The subjects in this study were 60 children with congenital cleft lip and/or cleft palate who were patients at the Cleft Palate Center, St. Barnabas Medical Center, Livingston, New Jersey. The ages of the subjects ranged from 3 to 12 years, with a mean age of 7 years. Based on Veau's classification (*13*), the cleft palate group in-

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cluded 12 children with clefts of the soft palate, 19 with clefts of the soft and hard palate, 26 with complete unilateral clefts, and 3 with complete bilateral clefts. All cleft palate subjects had primary surgical repair prior to two years of age, and were operated upon by the same surgical staff employing the same surgical procedure, the modified Warren-Davis bone flap (*8*). A group of 60 non-cleft palate children were selected randomly from the campus elementary school of Newark State College and matched for age, sex and socioeconomic level (*5*). Two age groups were delineated for study: 30 children between 3 and 6 years of age (mean age of 5 years) and 30 children between 7 and 12 years of age (mean age of 9 years). Each age group was represented by an equal number of boys and girls.

Procedure. Audiologic and otorhinolaryngologic examinations were administered to both cleft palate and non-cleft palate subjects. Bilateral, pure tone, air and bone conduction threshold tests were conducted under quiet testing conditions in a sound-treated room employing a Maico 2B audiometer, which was calibrated to the ASA-1951 standard of normal hearing threshold. Air conduction thresholds were obtained for the octave frequencies 250–8000 Hz and bone conduction thresholds for 500–4000 Hz. A modified Hughson-Westlake ascending method was employed to determine threshold, although in a number of cases some form of play audiometry was required with several younger children.

Results

Table 1 summarizes the data concerning the three-frequency pure tone average hearing levels for cleft palate and non-cleft palate subjects. The results of t-test analysis for mean differences between groups indicate significantly poorer hearing levels for cleft palate subjects than for non-cleft palate subjects. It should be noted, however, that all hearing thresholds obtained are within the acceptable range of normal behavior.

In Table 2 the percentage of cleft palate subjects showing hearing losses of 20 db or greater relative to age is presented. These data and those reported in previous studies of Miller (*7*), Skolnik, (*10*), Spriesters-

TABLE 1. Comparison of mean air conduction thresholds for cleft palate and non-cleft palate subjects. Average of 500, 1000 and 2000 Hz.

subject group	*mean HL*	*S.D.*	*t*	*p*
better ear				
cleft palate	2.35	9.31	4.17	.01
non-cleft palate	−3.08	4.07		
worse ear				
cleft palate	11.75	13.73	5.20	.01
non-cleft palate	1.03	8.21		

bach *et al* (*11*), and Graham (*3*) demonstrate a tendency for older cleft palate children above the age of 6 or 7 years of age to show less severe hearing loss than younger children.

Table 3 shows the mean air conduction thresholds in relation to type of cleft. The results are in general agreement with most previous studies that subjects with cleft palate-only tend to demonstrate a greater loss of hearing than subjects with cleft lip and palate. This difference is most evident in the better ear for our subjects. A recent study by Sweitzer, Melrose and Morris (*12*) revealed a tendency for the cleft lip and palate group to show a greater loss than the palate-only group when the criterion was the threshold for the poorer ear.

The percentage of subjects with significant hearing losses of 20 db or greater in relation to cleft type is shown in Table 4. A higher percentage of subjects with cleft palate-only showed significant hearing losses in

TABLE 2. Percentage of cleft palate subjects showing hearing losses of 20 db or greater. Average of 500, 1000 and 2000 Hz.

subject age group	*percentage with hearing loss*	
	better ear	*worse ear*
Younger (3–6 years)	10.00	33.33
Older (7–12 years)	3.33	23.33

TABLE 3. Comparison of mean air conduction thresholds relative to specific type of cleft. Average of 500, 1000 and 2000 Hz.

cleft group	*N*	*mean hearing thresholds*	
		better ear	*worse ear*
Cleft palate only	31	4.58	12.87
Cleft lip and palate	29	−0.03	10.76

TABLE 4. Percentage of subjects with specific type of cleft showing hearing losses of 20 db or greater. Average of 500, 1000 and 2000 Hz.

cleft group	*percentage with hearing loss*	
	better ear	*worse ear*
Cleft palate only	12.90	29.03
Cleft lip and palate	00.00	27.58

both better and worse ears than did subjects with cleft lip and palate. This difference is again most evident in the better ear.

Table 5 compares the mean thresholds between type of cleft and age. A slight tendency is noted for the cleft palate-only group to have slightly poorer hearing thresholds than the cleft lip and palate group regardless of age. The older subjects, however, obtained lower mean thresholds than did the younger subjects regardless of type of cleft.

Table 6 shows the percentage of subjects in each age group with specific type of cleft having a significant hearing loss. In the younger group a higher percentage of subjects with cleft palate-only had hearing losses of 20 db or greater than did subjects with cleft lip and palate. In the older group, however, the reverse situation occurred. That is, a higher percentage of cleft lip and palate subjects had greater hearing losses than did the cleft palate-only group.

Subjects were classified according to positive or negative otologic findings, which are presented in Table 7. The data show a significantly higher incidence of positive otoscopic findings among cleft palate children than among non-cleft palate children for all ear conditions.

The distribution of abnormalities of the tympanic membrane observed for each subject group is shown in Table 8. There were 90 abnormalities (75%) found among 120 ears of the cleft palate subjects, whereas only 11 abnormalities (.09%) were observed for non-cleft palate subjects. The most common findings were retraction, reduced mobility, thickening, discoloration, and perforations.

TABLE 5. Comparison of mean air conduction thresholds of subjects with specific type of cleft relative to age. Average of 500, 1000 and 2000 Hz.

subject age group	*mean hearing thresholds*			
	N	*cleft palate only*	*N*	*cleft lip and palate*
Younger (3–6 years)	19	10.84	11	9.18
Older (7–12 years)	12	5.75	18	3.28

TABLE 6. Percentage of subjects with specific type of cleft showing hearing losses of 20 db or greater. Average of 500, 1000 and 2000 Hz.

subject age group	*percentage with hearing loss*	
	cleft palate only	*cleft lip and palate*
Younger (3–6 years)	63.33	36.66
Older (7–12 years)	40.00	60.00

TABLE 7. Otoscopic findings of the tympanic membrane in cleft palate and non-cleft palate subjects.

subject group	*otoscopic findings*					
	positive		*negative*			
	N	*percent*	*N*	*percent*	*chi square*	*p*
Right ear						
cleft palate	27	45.00	33	55.00	8.34	.001
non-cleft palate	6	10.00	54	90.00		
Left ear						
cleft palate	20	33.33	40	66.66	16.21	.025
non-cleft palate	4	6.66	56	93.33		
Bilateral						
cleft palate	16	26.66	44	73.33	21.92	.025
non-cleft palate	3	5.00	57	95.00		

TABLE 8. Abnormalities of the tympanic membrane observed for cleft palate and non-cleft palate subjects (120 ears).

abnormality of tympanic membrane	*cleft palate*	*non-cleft palate*
Retraction	22	3
Reduced mobility	15	1
Thickening	15	0
Discoloration	12	6
Perforations	11	0
No mobility	5	0
Scarring	3	0
Calcium plaques	3	1
Tympanosclerosis	2	0
Bulging	1	0
Discharge	1	0
Total	90 (75%)	11 (.09%)

The mean air-bone gap was determined for each ear by averaging the differences between the mean air conduction thresholds and the mean bone conduction thresholds of 500, 1000, 2000 and 4000 Hz. A significant air-bone gap was defined as an average of 15 db or greater. Table 9 indicates the distribution of cleft palate and non-cleft palate subjects according to the condition of the tympanic membrane and the presence or absence of a significant air-bone gap. The data show that approximately 52 percent of cleft palate children had pathology of the tympanic membrane, whereas only about 12 percent of non-cleft palate children had such pathology. Forty percent of cleft palate subjects showed a

TABLE 9. Abnormalities of the tympanic membrane and presence or absence of air-bone gap in cleft palate and non-cleft palate subjects.

*condition of tympanic membrane and air-bone gap condition**	*cleft palate*		*non-cleft palate*	
	N	*percent*	*N*	*percent*
Normal tympanic membrane	29	48.33	53	88.33
Insignificant air-bone gap	36	60.00	55	91.66
Abnormality of tympanic membrane	31	51.66	7	11.66
Bilateral abnormality	16	26.66	3	5.00
Unilateral abnormality	15	25.00	4	6.66
Significant air-bone gap	24	40.00	5	8.33
Bilateral air-bone gap	7	11.66	1	1.66
Unilateral air-bone gap	17	28.33	4	6.66

* A significant air-bone gap is an average air-bone gap of 15 db or greater at 500, 1000, 2000 and 4000 Hz.

TABLE 10. Comparison of negative and positive otoscopic findings and presence or absence of average air-bone gap in cleft palate and non-cleft palate subjects.

*otoscopic and air-bone gap condition**	*cleft palate*		*non-cleft palate*	
	N	*percent*	*N*	*percent*
Negative otoscopic and no air-bone gap	67	55.83	107	89.16
Negative otoscopic and air-bone gap	6	5.00	3	2.50
Positive otoscopic and no air-bone gap	22	18.33	7	5.83
Positive otoscopic and air-bone gap	25	20.83	3	2.50

* A significant air-bone gap is an average air-bone gap of 15 db or greater at 500, 1000, 2000 and 4000 Hz.

significant air-bone gap, whereas only 8 percent of non-cleft palate subjects demonstrated such a gap. Within the cleft palate group, 28 percent of the subjects had a unilateral air-bone gap, and approximately 12 percent had a bilateral air-bone gap.

Table 10 compares the otologic data in relation to the presence or absence of a significant air-bone gap. Cleft palate subjects had 56 percent normal ears, both audiologically and otologically. Non-cleft palate subjects had 89 percent normal ears. Among the cleft palate subjects 21 percent of the ears were both audiologically and otologically deviant, as opposed to two percent of such ears among non-cleft palate subjects.

A noteworthy finding concerns the 22 ears of cleft palate children which showed positive otologic findings and an absence of a significant air-bone gap, and six ears that demonstrated negative otologic findings and the presence of an air-bone gap. These results support the frequently encountered observation that there is no consistent one-to-one

relationship between otologic pathology and an audiometrically determined conductive component. In the present study approximately 23 percent of the 120 ears of cleft palate subjects showed inconsistent oto-audiological findings. It is noteworthy that about 8 percent of non-cleft palate children showed similar findings. Further analysis of the data revealed that a considerable number of cleft palate and non-cleft palate subjects would have been considered to have had normal or near normal hearing on the basis of air conduction thresholds alone, when in fact, they showed evidence of a significant air-bone gap, positive otological findings, or both. In this connection, the data of Sweitzer *et al* (*12*) showed that 78 percent of their cleft palate subjects demonstrated an average air-bone gap of 10 db at 500, 1000 and 2000 Hz, which was considered to be a medically significant hearing loss.

Discussion

The findings of the present study showed that although the mean hearing thresholds for both cleft palate and non-cleft palate children were within the usually accepted range of normal hearing, hearing sensitivity did improve with age in both groups of children. These data are in general agreement with previous reports by Spriestersbach *et al* (*11*), Graham (*4*) and others. In this connection, the findings of Eagles *et al* (*2*) study of over 4000 school children aged five to 14 years revealed that the least sensitive hearing levels occurred in children 5 years of age, with improved sensitivity occurring beyond that age up to a peak of about 12 years of age. Although the presence of a palatal cleft may be of primary importance in contributing to the higher incidence of hearing deviations among the cleft palate population, the variation in hearing sensitivity in relation to age is apparently common to both cleft palate and non-cleft palate children.

The incidence of hearing loss in relation to the type of cleft has not been clearly established. Some investigators have reported a higher incidence of hearing loss in those with clefts of both the lip and palate, whereas others have found a tendency for a greater incidence to occur in subjects with cleft of the palate only. Graham (*3*), on the other hand, reported that patients with clefts of the lip and palate or palate-only were very similar in the frequency with which they had significant hearing loss. The data in the present study partially agree with all of the above findings. Poorer mean thresholds and a higher incidence of hearing loss were found among subjects with cleft palate-only, as opposed to those with both cleft lip and palate. These differences were most evident for the better ear. When type of cleft was related to age, it was found that the cleft palate-only group obtained slightly poorer mean thresholds than did the cleft lip and palate group, regardless of age. However, a higher percentage of younger cleft palate-only subjects and older cleft lip and palate subjects had hearing losses than

did their respective counterparts. Finally, when the poorer ear is considered exclusively there was a tendency for subjects to approximate mean hearing thresholds and percentage with significant hearing loss regardless of type of cleft. These various findings reiterate the inconsistent relationship between hearing loss and the type of cleft, which has been observed in previous investigations.

Our cleft palate subjects, particularly the younger ones, showed a lower incidence of hearing loss than is generally reported. Several factors might account for this apparent disparity. First, all subjects in the present study had early surgical closure of the palate, prior to two years of age. Although the relationship between hearing impairment and time of surgical repair is not altogether clear, Skolnik (*10*), Graham and Lierle, (*4*), Spriestersbach *et al.* (*11*) and Peterson (*9*) cite evidence that early closure appears to reduce the incidence of hearing impairment in cleft palate children. Second, the Warren-Davis bone flap procedure, which was the technique employed for all our subjects, was designed to surgically lengthen as well as to close the palate in order to provide early restoration of normal function to the levator and tensor palatini muscles. Masters, Bingham, and Robinson (*6*) found a lower incidence of hearing loss among those children who had surgical closure with lengthening of the palate than when the method of repair was surgical closure without lengthening. It is possible that the procedure employed with our children created a potential for better hearing. Third, the subjects had a similar type of physical management, that of surgical closure. This tended to create a more homogeneous group of subjects than ordinarily found in previous investigations.

It is generally reported that the majority of hearing losses among cleft palate children are primarily bilateral. The present data indicate that 48 percent of cleft palate subjects had unilateral pathology and approximately 70 percent had significant unilateral air-bone gaps. A similar trend was noted for the non-cleft palate subjects. Of the 7 subjects with abnormalities of the tympanic membrane, 4 had unilateral pathology and 4 of 5 subjects had unilateral air-bone gaps. Our findings tend to support Graham's (*3*) observation that both otologic and audiologic manifestations of ear disease, acute or chronic, may differ not only from one cleft palate individual to another but also from one ear to another in the same individual.

The disparity between audiologic and otologic results in the same ear of a number of subjects in both cleft palate and non-cleft palate groups emphasizes the need to include both types of examination in order to evaluate accurately cleft palate children. The need to include bone conduction audiometry in such evaluation cannot be overemphasized. Chalet and Lounsbury (*1*) have pointed out that frequently children with obvious fluid in the middle ear respond by a routine air conduction test with normal or near normal hearing; thus, children

with suspected disease have been dismissed for lack of evidence of difficulty, though abnormality was presumably present. On testing the hearing of these same children by bone conduction at negative or better than normal levels a significant air-bone gap is frequently found, in spite of the fact that hearing by air conduction was considered within normal limits. It has been suggested recently by Sweitzer *et al* (12) that the air-bone gap appears to be a more useful criterion than the more traditional air conduction screening alone in evaluating medically significant hearing loss among cleft palate individuals.

Summary

This study involved audiologic and otologic evaluations of 60 cleft palate and 60 non-cleft palate children aged 3 to 12 years. The study was designed to take into account several variables which may have direct bearing on the interpretation of the obtained data. These included: (a) the time of primary surgical repair; (b) the type of surgical repair; (c) a control group matched for age, sex and socio-economic level; (d) the inclusion of both air and bone conduction audiograms; (e) the inclusion of otologic examination; and (f) the delineation of younger and older age groups for comparison.

The following findings and conclusions are drawn from the data:

1. Cleft palate children have significantly poorer hearing sensitivity than non-cleft palate children. On the basis of group performance, however, all threshold deviations were within normal hearing limits for both cleft palate and non-cleft palate children.
2. There is an improvement in hearing sensitivity in both cleft palate and non-cleft palate children as a function of increasing age. Such improvement is most evident among cleft palate children above six years of age.
3. There is a significantly greater incidence of conductive hearing impairment (significant air-bone gap) and aural pathology in cleft palate children than in non-cleft palate children. A greater number and variety of otoscopic abnormalities were observed for cleft palate children than for non-cleft palate children.
4. Otologic and audiologic findings frequently occur inconsistently. The data from this study indicated that approximately 23 percent of cleft palate children and 8 percent of non-cleft palate children had inconsistent oto-audiologic conditions.
5. Unilateral hearing impairment was more frequently observed among the subjects in this study than was bilateral impairment. Approximately 50 percent of the cleft palate and non-cleft palate children whose otoscopic findings were positive showed unilateral abnormalities. And 70 percent of cleft palate children and 80 percent of non-cleft palate children with significant air-bone gaps showed unilateral conductive hearing impairment.

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reprints: *Joyce C. Heller, Ph.D.*
Department of Speech Pathology
Newark State College
Union, New Jersey 07083

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