Prevalence of Perceived Acoustic Deviations Related to Laryngeal Function Among Subjects with Palatal Anomalies

CAROL REA MARKS, M.A.
KENNETH BARKER, M.A.
M. E. TARDY, JR., M.D.

It is commonly accepted that speakers with inadequate velo-pharyngeal closure often employ compensatory adjustments of the speech mechanism in attempting to establish acceptable speech. One such compensatory movement is the glottal-stop (*2, 21, 22, 23*) which entails improper usage of the vocal cords. Spriestersbach, *et. al.*, (*22*) report the frequency of glottal-stops to be inversely related to the adequacy of velo-pharyngeal function or intraoral pressure. If the laryngeal area is a focal point for compensatory action, it is conceivable that other acoustic deviations may occur because of hyper- or hypo-function of laryngeal musculature (*2, 5, 6, 7, 15*).

In making a proper descriptive diagnosis of speakers with velo-pharyngeal inadequacy, characteristics other than hypernasality must be noted. Some of these characteristics are related to hyper- and/or hypo-function of the laryngeal musculature and are often described by such terms as hoarseness, huskiness, breathiness, throatiness, vocal fry, and/or stridency. Many authors have noted such voice qualities among speakers with velo-pharyngeal anomalies (*2, 5, 6, 7, 10, 12, 13, 14, 15, 23, 24, 25, 26*). Table 1 summarizes several studies documenting the prevalence of voice disorders other than hypernasality among both non-cleft and cleft palate subjects. The failure of these investigators to arrive at similar prevalence figures may be attributed to several factors: Differences in age of sample, failure to develop explicit definitions as to the nature of the voice disorders, and lack of standardized rating systems that could be readily duplicated by others.

The prevalence and description of voice disorders other than hypernasality has been reported; some authors feel these voice disorders mask or

Mrs. Marks is Research Speech Pathologist, Cleft Palate Clinic, Center of Craniofacial Anomalies, University of Illinois Medical Center. Mr. Barker is Speech Pathologist, Des Moines County School System. He was formerly Speech Pathologist, Department of Otolaryngology, The Jewish Hospital of St. Louis. Mr. Tardy is Assistant Professor of Otolaryngology and Consultant to the Cleft Palate Clinic, Center for Craniofacial Anomalies, University of Illinois Medical Center.

distort the judgements of hypernasality and thus lead to incorrect judgements of velo-pharyngeal functioning (*6, 7, 8*). These authors report acoustic confusion in distinguishing between hypernasality and breathiness. Likewise, Luse, *et. al.*, (*12*) feel that perceived hypernasality can be eliminated by reduction of laryngeal tension.

Purpose

We feel, as do many of the authors referred to above, that it is important to make note of the laryngeal voice quality of speakers with palatal anomalies. It was our clinical impression that acoustic laryngeal deviations occurred quite frequently in our cleft palate population, and that at times they confused decisions of rehabilitative procedures. Therefore, we took a random sample from our clinic of subjects with oral-facial malformations, affecting palatal function, and rated only the laryngeal voice quality to determine the prevalence of perceived acoustic deviations.

Further, we felt it important to see 1) if the condition of velo-pharyngeal closure as seen by X-ray seemed to relate to the laryngeal voice quality, and 2) if physical findings on indirect laryngoscopy related to the laryngeal voice quality.

Procedure

Subjects. The speech of 102 subjects with various palatal involvements was recorded. Every subject over six years of age and under twenty years

TABLE 1. Reported prevalence of voice disorders other than hypernasality in cleft and non-cleft palate speakers

Author(s)	*# of subjs.*	*Age Range*	*% of incidence*	
			Cleft Palate	*Non-cleft Palate*
Brooks & Shelton (1963)	76	6½–12	10	
Takagi *et al.* (1965)	1061		0.6	
Baynes (1966)	1021	1st, 3rd, 6th grades		7.1
Blanton (Milisen, 1952)	2240	Freshmen Univ. Studs.		4.5
Mid-Century White House Conf. (1952)	2,000,000	5–21		2.0
Mills & Streit (Milisen, 1952)	4685	Elem. School		1.5
Morley (Milisen, 1952)	33,339	Univ. Studs.		0.58
Morris (Milisen, 1952)	178	High School		2.8
Pronovost (Milisen, 1952)	87,288			0.5
Senturia & Wilson (McWilliams, *et al.*, 1969)	32,500			6.0
White House Conf. (Milisen, 1592)	10,033			1.0

TABLE 2. Laryngeal portion of the voice rating scale.* Characteristics of a speaker's voice quality were assigned the appropriate number classification as described below. For example, a subject with vocal cord nodules, probably small in size, was often given a rating of +2/−2. This meant in function the vocal cords do not approximate thus giving the voice a breathy quality (−2); yet, at times, there was over compensation of the vocal cords and tight approximation was attained giving the voice a tense quality (+2). If vocal cord nodules are large in size then the rating would probably be −2 to −3 only, showing the inability of the cords to reach approximation.

	Aphonia	Whisper	Breathy	Pitch High +3 +2 1 −2 −3 Low	Tense	Spastic closure of vocal cords	
vocal cords open	−4	−3	−2		+2	+3	vocal cords closed

LARYNGEAL CAVITY

* Scale used at The Jewish Hospital of St. Louis as suggested by Isaac Brackett, Chairman of the Department of Speech Pathology and Audiology, Southern Illinois University.

of age with a palatal defect[1] was recorded until a total of 102 subjects was obtained.

The types of palatal involvement included 18 bilateral cleft lip and palate, 28 unilateral cleft lip and palate, 22 clefts of the hard and soft palate, 9 isolated clefts of the soft palate, 15 subjects with congenital palatal incompetence, 6 submucous clefts, one subject with oral facial digital syndrome, one bilateral lip and unilateral cleft palate, and two unilateral lip and bilateral palate (Table 3).

The age range was from 6 years, 5 months to 19 years, 4 months, with a median age of 12 years, 6 months and a mean age of 12 years, 7 months (SD—3 years and 9 months). There were 48 females and 54 males in the total sample.

Method of recording. A Roberts tape recorded equipped with an Electro-Voice Dynamic microphone, Model 664, was used to record the speech of each subject. All recordings were made in a sound treated room with the patient approximately twelve inches directly in front of the microphone. Each subject was asked to read a standard passage (when a child was not able to read he was asked to recite a nursery rhyme), count to 20, and sustain an /ɑ/ for as long as possible on one breath. A practice session on all procedures was allowed prior to recording so that the subject would

[1] Seen at the Center for Craniofacial Anomalies on their pre-scheduled annual visit.

TABLE 3. Summary of voice ratings by palatal groupings

Palatal Groupings	*No. of Abnormal Laryngeal Voice Qualities*	*No. of Normal Laryngeal Voice Qualities*
Bilateral lip and palate	8	10
Unilateral lip and palate	9	19
Cleft of hard and soft palate	5	17
Isolated cleft of soft palate	3	6
Congenital palatal incompetence	5	10
Submucous cleft	3	3
OFD Syndrome	0	1
Bilateral lip and unilateral palate	0	1
Unilateral lip and bilateral palate	2	0

be familiar with the material and the most natural speech could be recorded.

Judges. Three speech pathologists evaluated the recording of each subject according to a laryngeal voice quality rating scale (Table 2). The judges were familiar with this scale and had been using it to rate subjects in an independent three year longitudinal study of voice disorders in school age children.[2] The ratings were assigned while playing the recordings on a Tandberg, series 12, four track tape recorder in a free field setting.

Judge reliability. Each judge made two separate and independent ratings on the first 60 subjects recorded. The only information about the subjects available to the judges was age and sex. Nothing was known about the anatomical and/or physiological condition of the subject.

The judge's ratings were considered to be in agreement if each judge identified the same vocal quality. For example, if two judges identified a voice as tense (+2) and breathy (−2), they were in agreement. However, if one judge identified only tension (+2) in the voice and made no mention of breathiness (−2), he would not be in agreement with the other judge. One judge rating a voice as normal but having characteristics of either breathiness (−2) or tension (+2) would be considered in agreement with another judge who simply rated a voice breathy (−2) or tense (+2), provided the ratings were in the same category. A judge rating a voice as breathy (−2) going toward a whisper (−3) would be in agreement with a judge rating the voice breathy (−2)—the same would be true for tension. Using such criteria inter-judge reliability was at 90% agreement (0.05 level of confidence) and intra-judge reliability at the 0.05 level of confidence was at 85% agreement.

Subject's rating. A single rating was then assigned to each subject by the judges listening together and agreeing on one rating. This aided in

[2] Unpublished, in progress at The Jewish Hospital of St. Louis under grant #OEG-3-6-061314-0928 from the United States Office of Education, Bureau of Handicapped Children and Youth.

TABLE 4. Summary of voice ratings and cephalometric x-rays

Voice Rating	*Closure on /u/*		*Closure on /s/*		*Flap*	*Prosthesis*
	yes	*no*	*yes*	*no*		
Normal	43	14	29	24	9	3
Abnormal	26	2	19	9	5	2

TABLE 5. Summary of voice ratings

Voice Rating	*No. of Subjects*
Normal	67
−2	10
−2 → −3	2
2	8
−2/+2	15

statistical analysis and in the reporting of the data. In only two cases were the judges unable to agree on a single rating (Table 6).

Laryngeal Examinations. Indirect laryngeal examinations, without anesthesia, were performed by the same otolaryngologist on 45 of the subjects. Five subject's true vocal cords could not be adequately viewed. Laryngeal examinations and speech ratings were done independently. Laryngeal findings are summarized in Table 6.

Cephalometric X-rays. All subjects had standardized cephalometric x-rays taken in the standard Frankfort horizontal plane with the subject in occlusion and during the phonation of /u/ and /s/.

Results

In this investigation 34% of the total sample had laryngeal voice quality ratings that indicated some deviation from normal (Table 5). There were significantly more males with voice deviations than females (0.05 level of confidence). Although statistical analysis was attempted to determine the significance of voice disorders in each type of palatal grouping, the confidence intervals were too large to be of significance because of the small size of groupings.

No significant difference was found when correlating velo-pharyngeal closure on the cephalometric x-ray of /s/ and normal voice rating (Table 4). The null hypothesis was that the population correlation coefficient is 0. The data did not reject this null hypothesis at the 0.05 level of significance ($p \leqslant 0.05$).

Although it would have been helpful to make some statistical inferences between voice ratings and the pathologic condition found on indirect lar-

TABLE 6. Composite of Tables 3, 4, and 5 with correlated laryngeal examination results

Palatal Groupings	*Recording #*	*Cephalometric closure on*		*Laryngeal Voice Rating*	*ENT Description*
		u	*s*		
Bilateral lip and palate	3	yes	yes	1	Slight inflammation of false cords—TVC normal
	27	no	no	1	
	34	flap	flap	−2/+2	
	40	yes	yes	1	
	44	yes	yes	1	
	51	no	no	1	
	60	no	yes	1	Normal
	62	yes	yes	−2/+2	TVC slightly injected—recent URI[3]
	64	yes	yes	−2 (var.-slight)	Normal
	75	no	yes	1	
	78	yes	yes	−2 → −3	Post nasal drip—poor oral hygiene—total dryness of skin—probably in larynx too—TVC in constant inflamation
	79	yes	yes	−2/+2	
	80	prosthesis		−2	
	92	yes	yes	1 → −2	Normal
	102	yes	yes	−2	Bilateral nodules—moderate
	103	no	no	1	Normal
	104	no	yes	1	
Unilateral lip and palate	1	yes	yes	1	Normal
	2	flap	flap	1	Could not view
	7	flap	flap	1	
	9	prosthesis		1	
	10	no	yes	1	
	12	yes	yes	*−2/+2	Anterior TVC not viewed—TVC a little "boggy"
	15	yes	yes	1	Normal
	20	no	yes	+2/−2 (var)	Normal
	22	yes	yes	1	
	25	no	no	1	Normal
	29	yes	yes	1	
	32	yes	yes	−2/+2*	TVC slightly injected—postnasal drip
	33	flap	flap	1	
	47	no	yes	1	
	48	yes	yes	−2/+2	Pieces of saliva act like nodules—can cough off and voice changes
	49	yes	yes	+2 (slight)	
	53	no	yes	1	

TABLE 6—*Continued*

Palatal Groupings	*Recording #*	*Cephalometric closure on*		*Laryngeal Voice Rating*	*ENT Description*
		u	*s*		
	55	yes	yes	1	
	56	flap	flap	+2 (var)	
	66	flap	flap	+2	Could not view
	67	yes	yes	−2/+2 (slight)	Bilateral pinpoint nodules
	72	no	no	−2	Vocal cord nodules
	85	no	yes	1	
	91	yes	yes	1	
	95	flap	flap	1	
	97	yes	yes	1	Normal
	101	no	yes	1	
	105			1	
Cleft of hard and soft palate	8	yes	yes	1	Normal
	17	prosthesis		1	
	35	no	no	−2 → −3	Subglottal stenosis, limited motion of left cord
	36	no	yes	1	
	37	yes	yes	1	
	42	no	yes	−2/+2	TVC close only at anterior 1/3
	43	yes	yes	1	Could not view ant. 1/3—TVC moved well, good color
	45	prosthesis		1	Normal
	50	yes	yes	1	
	52	yes	yes	−2/+2 (var)	Bilateral nodules
	58		yes	1	Normal
	63	no	yes	1	
	70	prosthesis		−2/+2	TVC slightly thickened—good color
	73	yes	yes	1	
	74	flap	flap	1	
	83	flap	flap	1	
	84	no	no	1	
	90	yes	yes	1	
	94	flap	flap	1	Could not view
	100	yes	yes	1	
	107	yes	no	1	
	108	yes	yes	1 → −2	Larynx skewed to right—TVC normal
Isolated cleft of soft palate	11	yes	yes	−2	On occasion did not close at VP[2]
	16	yes	yes	1	
	26	no	yes	1	
	31	yes	yes	+2	
	38	no	yes	1	
	39	yes	yes	1	

TABLE 6—*Continued*

Palatal Groupings	*Recording #*	*Cephalometric closure on*		*Laryngeal Voice Rating*	*ENT Description*
		u	*s*		
	41	yes	yes	1	Mucus both cords—color, shape, motion good
	59	no	yes	1	
	(69)	yes	yes	1—+2 (var)	
Congenital palatal incompetence	6	no	no	1	Normal
	18	flap	flap	+2	Possible slight thickening of TVC—did not close at VP
	21	yes	yes	+2	VP do not meet—TVC thick but smooth—anterior ⅓ meet on inspiration
	23	yes	yes	1	
	24	flap	flap	1	
	28	yes	yes	1	
	46	yes	yes	−2 (slight)	
	57	no	yes	−2/+2	Pinpoint nodules
	61	yes	yes	1	
	68	no	no	1	Normal
	77	no	yes	1	Normal
	81	yes	yes	1	
	89			−2/+2	TVC slightly injected
	96	yes	yes	1	
	98	no	yes	1	
Submucous cleft	4	no	no	1	Normal
	13			+2 (slight)	
	19	flap	flap	+2/−2	Anterior TVC's not viewed—allergist = perennial bronchial asthma
	54	yes	yes	1	
	82	no	yes	1	
	93	no	yes	−2	
OFD Syndrome	87	flap	flap	1	
Bilateral lip and unilateral palate	5	yes	yes	1	
Unilateral lip and lateral palate	(71)	yes	yes	1—+2/−2 (slight)	Normal
	88	no	yes	−2	

[1] TVC = True vocal cords.
[2] VP = Vocal process.
[3] URI = Upper respiratory infection.
( ) judges could not agree on single rating.

yngoscopy, this was not possible because our total sample did not receive an otolaryngological evaluation.

Of the 35 subjects demonstrating laryngeal voice deviations, 24 were selected for indirect laryngoscopy. Eighteen of the 24 examined, exhibited laryngeal abnormalities (Table 6). Since the entire sample was not similarly surveyed, it is clear that we probably preselected all suspect cases for indirect laryngeal examination. However, it should be recognized that the total sample was selected at random. Thus, in failing to administer a laryngeal examination to everyone, our error is on the side of underreporting rather than of overemphasis.

Discussion and Conclusions

Out of the 102 subjects with palatal defects, 34 percent exhibited laryngeal voice disorders as determined by standardized listening procedures tested for reliability. As was mentioned previously these voice disorders were often associated with laryngeal pathology. It is our opinion that acoustically perceived laryngeal deviations may influence the judgement of nasal quality. Thus, sensitive and appropriate listener descriptions of voice quality are necessary and may result in improved habilitative treatment.

In one documented case, all speech pathologists rated a subject's voice as a $+2/-2$ (often associated with vocal cord nodules) but on indirect laryngoscopy no pathology was noted. Three months later another laryngeal examination revealed bilateral vocal cord nodules. Often, as in this case, the voice quality may be a predictor of potential pathology. Moses (*18*) states:

> Any change within the larynx will affect its function: but, also, any change in function will eventually produce some change of the organ. Too often the laryngologist clings to the old dichotomy between organic and functional concepts in laryngeal and vocal pathology. Understandably, he would like to restrict his work to a field in which he feels secure, that of visible, organic pathology. Visual diagnosis with the larynx mirror has practically over-shadowed vocal acoustic diagnosis.

At this point it is interesting to note that in every case where laryngeal pathology was noted the speech pathologists had recorded an abnormal voice rating. A rating of breathiness (-2) or whisper (-3) seemed most closely related to documented laryngeal pathology.

Although compensatory movements may account for some of the laryngeal deviations in speakers with palatal difficulties, many causes must be considered: chronic respiratory-tract infections (*11, 20*), infection of the adenoids (*14, 19*), vocal abuse (*9*) and allergies (*3, 20*).

We feel that one of the successes of our study was based on the laryngeal rating scale which was used (Table 2). This scale is quite descriptive and it is easily understood when taught to those who are unfamiliar with

it. It has allowed us to be more consistent and uniform when referring to laryngeal voice quality deviations.

Summary

In an unselected sample of subjects with palatal defects or dysfunction, 35 of 102, or 34 percent showed listener perceived deviations associated with laryngeal sound generation. The subjects ranged in age from 6 years 5 months to 19 years 4 months. There were 48 females and 54 males; signigicantly more laryngeal voice quality deviations were detected among males. No significant correlation was found between velo-pharyngeal closure on /s/ as shown on cephalometric x-rays and laryngeal voice ratings.

The results of this study suggest a high incidence of perceived laryngeal acoustic deviations, often associated with laryngeal pathology, among speakers with palatal defects. Consideration must be given to such data in planning habilitative procedures with palatally handicapped speakers.

The use of the laryngeal voice quality rating scale developed by Isaac Brackett provided a basis for the establishment of consistent and uniform laryngeal voice quality descriptions.

reprints: *(Mrs.) Carol Rea Marks, M.A.*
Center for Craniofacial Anomalies
University of Illinois Medical Center
P. O. Box 6998
Chicago, Illinois 60680

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