Cranial Base Angle, Amount of Palatal Tissue, and Nasopharyngeal Depth in Individuals with Clefts

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Individuals with cleft lip and palate have been compared to individuals without cleft lip and palate in a number of investigations (*3, 7, 8*). Research has been concerned with the aspects of growth, occlusion, speech, hearing, and psychological factors associated with such variables. These studies have also investigated differences and similarities among various nasopharyngeal structures.

Ricketts (*9–11*) studied the range of variation of the cranial base angle and pharyngeal depth in 20 normal subjects and four noncleft subjects with 'cleft-palate-type speech.' In the four noncleft subjects, the cranial base angle and nasopharyngeal depth were greater than in the normal group. Ricketts concluded that the cleft palate population might exhibit similar cranial base abnormalities. Other authors (*2, 3, 7, 8*) have reported no differences in cranial base angle or nasopharyngeal depth among individuals with unoperated cleft palates, operated cleft palates, and normals.

An investigation by Brader (*2*) was undertaken to establish diagnostic criteria in the surgical and prosthetic treatment of cleft palate individuals. His working hypotheses were as follows:

1. Cleft palate subjects differ significantly from control subjects with respect to:

a) Greater variation in angularity of cranial base is exhibited in cleft palate individuals.

b) Size of aperture of nasopharynx in the anteroposterior and vertical dimensions is relatively greater in cleft palate individuals.

c) Adenoid tissue comprises a relatively small percentage of nasopharyngeal area in cleft palate individuals.

2. Variations in morphology of the cranial base and associated pharyngeal structures of cleft lip and palate individuals reside at the extreme ranges of variations found in the control group.

3. Range of morphological variations in the cranial base and associated pharyngeal structures found in the cleft group may be expressed quanti-

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tatively in such a manner that the cleft palate individual may be subjected to analysis. These findings may constitute criteria upon which to base palatal surgery or prosthesis.

The first two hypotheses were not supported by Brader's data. The third hypothesis was supported by his findings and he suggested that hypothesis be employed as a criteria for treatment. In his words, '... some expression of the collective pattern of structural variations provides a frame of reference for comparison of any cleft palate individual.' The disproportion of structures, deficiencies of structures, or malposition of parts may provide criteria for management.

The primary purposes of the present study were to investigate the angle of the cranial base and the position of maxilla in relation to the cranial base, the depth of nasopharynx, and the amount of palatal tissue and movement in cleft palate population. More specifically, the investigation proposed to test the following hypotheses: a) cleft palate individuals without velopharyngeal closure have a more obtuse cranial base angle and a different position of maxilla than individuals with velopharyngeal closure; b) the length of the soft palate and movement of palatal tissue are related to the degree of velopharyngeal closure, and c) cranial base angle, position of the maxilla, velar length, velar movement, and velopharyngeal closure bear significant relationships to each other.

Procedure

SUBJECTS. The subjects for this study consisted of 67 Caucasian cleft lip and palate individuals. The group consisted of 15 complete bilateral cleft lip and palate patients, 28 complete unilateral cleft lip and palate patients, and 24 palate-only patients. No restrictions were made concerning the type of surgical management used to achieve velopharyngeal closure or the age at which surgery was performed. According to Spriestersbach, Moll, and Morris (*12*), for data which are most meaningful, pertinent subgroups in the cleft population should be recognized in the design of research. Since all the clefts for the present study were grouped without respect to type of cleft, an examination was made to see if there were any significant differences between the subgroups. Simple randomized analyses of variance indicated that no significant differences existed in complete unilateral cleft lip and palate, complete bilateral cleft lip and palate, and cleft palate only.

The subjects ranged in age from 12 years to 16 years. Björk (*1*) and Stramrud (*13*) concluded from longitudinal studies that the cranial base angle, on the average, remains unchanged from three years to adulthood. King (*6*) found little change in depth of nasopharynx after 12 years of age. In view of the findings in these experiments, the cranial base angle measurement and nasopharyngeal depth used in the present study were considered to be relatively stable for the age range that was used.

X-RAY PROCEDURE. Lateral cephalic roentgenograms of 67 cleft individuals were obtained from the research files in the Department of

Otolaryngology and Maxillofacial Surgery at the University of Iowa. The roentgenographic equipment used to obtain these films had been described in detail previously (*5*). The equipment included a generator with a line compensator capable of delivering 130 kv, an electric timer, a rotating anode with a one-millimeter focal spot, and a Potter-Bucky diaphragm with a 12:1 grid. Stability of the equipment was achieved by heavy mountings to the floor. The distance of the focal spot to the film was fixed at 182.88 cm. A modification of the self-centering Higley head positioner (*4*) was mounted independent of a modified dental chair.

FILM ANALYSIS. The landmarks were located and traced on acetate tracing paper. The angular measurements were obtained with a steel protractor to within one-half a degree. A Boley gauge was used for the linear measurements. These measurements were made to within .1 of a millimeter.

The following cephalometric landmarks were located (Figure 1). a) Nasion (N): the anterior point of the juncture. b) Sella (S): the center of sella turcica as determined by inspection. c) APOC: the most anterior point on the occipital condyles, as used by Engman (*8*). In this study, APOC was used as posterior mark of the cranial base. d) Pmf: a point on the posterior surface of the left maxilla at the intersection of the palatal plane. e) Palatal Plane: parallel to the nasal floor.

The following angular measurements were made. a) N-S-APOC: angularity of cranial base. b) N-S-Pmf: the anteroposterior position of pterygomaxillary fissure, used to determine the anteroposition of the maxilla. c) APOC-S-Pmf: degree of interspace between APOC and Pmf, taken to indicate bony depth of nasopharynx. d) S-APOC-Pmf: relative

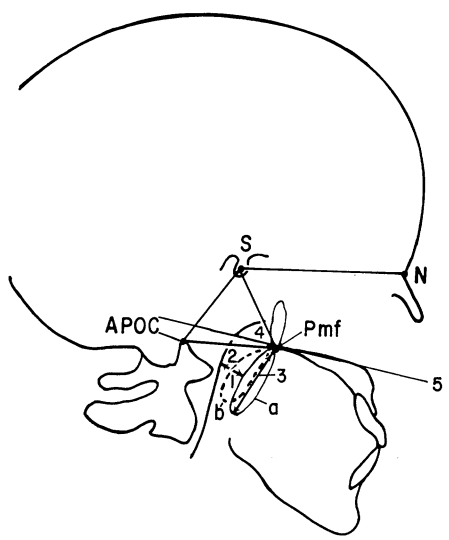

FIGURE 1. The following cephalometric landmarks were located: Naison (N), Sella (S), APOC, Pmf, and palatal plane (shown as ※5). The following angular measurements were made: N-S-APOC, N-S-Pmf, APOC-S-Pmf, and S-APOC-Pmf. The following linear measurements were made: extent of palatal movement (※1), v-p opening (※2), palatal length (※3), and nasopharyngeal depth (※4).

TABLE 1. Standard error of measurement obtained from 24 films which were traced twice and measured twice by the author. The first four measurements are in degrees.

Statistic	*SE*
N-S-APOC	1.026
N-S-Pmf	1.00
APOC-S-Pmf	1.536
S-APOC-Pmf	2.1201
Pharyngeal depth	.7596
Palatal length	.94
Palatal movement	.123
V-p opening	.105

superoinferior position of pterygomaxillary fissure, used to determine the superoinferior position of the maxilla.

The following linear measurements were made. a) Pmf to posterior-pharyngeal wall measured on palatal plane, used to determine pharyngeal depth. b) Length of palate at rest. c) Amount of movement during /u/ or /s/. d) Velopharyngeal opening (V-p opening) remaining during movement.

The landmarks on 24 films were located and traced twice to determine the investigator's measurement-remeasurement reliability. Standard errors of measurement and means, ranges, and standard deviations for each of the eight measures are presented in Tables 1 and 2. For linear measurement based on landmarks judged as reliable, Björk (*1*) found standard errors of measurement ranging from .3 to 1.4 millimeters. The largest standard error of the measurement (.94), for a linear measurement, in the present study falls within this range.

Results

The data obtained in this study were analyzed by successive multiple correlation procedures. The dependent variable was velopharyngeal open-

TABLE 2. Means, ranges, and standard deviations (SD) for each of the eight measures.

Measure	*Mean*	*Range*	*SD*
N-S-APOC	129.51	114–141.5	5.98
N-S-Pmf	72.38	63.5–83	4.60
APOC-S-Pmf	57.10	45.5–70	5.35
S-APOC-Pmf	61.87	51.3–70.5	5.94
Pharyngeal depth	22.72	1–31.5	4.88
Palatal length	27.99	9–42.9	7.08
Palatal movement	5.38	0–17.4	4.61
V-p opening	7.31	0–25.5	5.43

TABLE 3. Beta weights of the various independent variables and multiple correlation coefficients derived from the analysis. Those beta weights which are asterisked are significant at the 5% level.

Independent variable	*Analysis 1*	*Analysis 2*	*Analysis 3*	*Analysis 4*
N-S-APOC	0	0	0	0
N-S-Pmf	1.111	0.792	0	0
APOC-S-Pmf	0.3689	0	0	0
S-APOC-Pmf	0.939	2.676	2.989	0
Pharyngeal depth	10.515*	13.899*	14.666*	11.812*
Palatal length	8.306*	8.036*	7.933*	8.583*
Palatal movement	35.928*	35.947*	39.767*	36.359*

ing. There were a total of seven independent variables. A 7040 IBM computer was used for all analyses.

ANALYSIS NUMBER 1. In the first multiple regression analysis, all seven independent variables were included. A multiple correlation coefficient, R, of .725 was obtained. This analysis yielded the correlations of the dependent variable with each independent variable. Inspection of Table 3 reveals that three variables were statistically significant: pharyngeal depth, palatal length, palatal movement. Examination of beta values indicated that cranial base angle was not significantly related to velopharyngeal opening. This finding corroborated research reported by Engman, Spriestersbach, and Moll (*3*).

ANALYSIS NUMBER 2. The third independent variable was eliminated (APOC-S-Pmf) for the second analysis. Pharyngeal depth, palatal length, and palatal movement were again significantly related to the dependent variable, velopharyngeal opening.

ANALYSIS NUMBER 3. The third analysis indicated that Variable 4 (S-APOC-Pmf) was not significantly related to the dependent variable. By eliminating the four angle measurements, the correlation was reduced only from .72 to .70. Thus, the present study suggests that, of the variables studied, those significantly related to velopharyngeal opening were nasopharyngeal depth, palatal length, and palatal movement.

An intercorrelation matrix for all variables was computed (Table 4) and the N-S-APOC angle was found to be significantly related to all other angle measures. As the cranial base angle increased, the maxilla was positioned further forward. The bony depth of the nasopharynx increased, as suggested by the positive relationship between N-S-APOC and N-S-Pmf, and N-S-APOC and N-S-Pmf. Further, as the cranial base angle increased, the maxilla did not descend as far from the cranium as it did with a smaller cranial base angle. This is suggested by the negative relationship between N-S-APOC and S-APOC-Pmf. The matrix also revealed negative relationships between N-S-Pmf and APOC-S-Pmf and between APOC-S-Pmf and S-APOC-Pmf. This would suggest that as the

TABLE 4. Intercorrelation matrix for eight variables. Coefficients which are asterisked are significant at the 5% level.

	Measure						
	2	*3*	*4*	*5*	*6*	*7*	*8*
N-S-APOC	.48*	.69*	−.47*	.17	.15	.07	.12
N-S-Pmf		−.30*	−.05	.06	−.005	−.18	.21
APOC-S-Pmf			−.46*	.13	.17	.22	−.03
S-APOC-Pmf				.27*	.07	−.12	−.01
Pharyngeal depth					.005	.01	.30*
Palatal length						.13	−.33*
Palatal movement							−.58*
V-p opening (dependent variable)							

maxilla is positioned farther forward, the bony depth of the nasopharynx increases and as the depth increases the maxilla is closer to the cranial base.

The only angle measurement which is related to the linear measurements is the posterior position of the maxilla (S-APOC-Pmf). As would be expected, as this angle increases, so does the soft tissue distance.

In the linear measurements, palatal movement was correlated with velopharyngeal opening, that is, as palatal movement increased, velopharyngeal opening decreased ($p < .01$). It is of special interest that cranial base angle does not appear to be related to velopharyngeal opening, palatal movement, palatal length, or pharyngeal depth. The only angular measurement in this study which had any relationship with palatal tissue (soft tissue, not bone) was the posterior position of the maxilla (S-APOC-Pmf) and soft tissue depth of measurement ($p < .05$). It should be noted in Table 4 that correlations of angular measurements were clustered together and the linear measurements were clustered together, but there was no significant correlation between the two.

Discussion

Cranial base angle, bony depth of nasopharynx, and position of maxilla do not appear to be related to amount of velopharyngeal opening. The variables showing a significant relationship with velopharyngeal opening were nasopharyngeal depth, total palatal length, and palatal movement. In this study approximately 50% of the variation in velopharyngeal closure was isolated. The need for further research designed to discover additional criteria which relate to velopharyngeal closure, in an attempt to predict outcome of management procedures, is indicated by the present study.

Summary

The subjects for this study consisted of 67 Caucasian cleft palate individuals. The age range was from 12 to 16 years. The data were analyzed

by successive multiple correlation procedures. The dependent variable was velopharyngeal opening. From results of this study the following conclusions were obtained: a) Cranial base angle has no relationship to velopharyngeal opening. b) Position of posterior surface of maxilla has no relationship to velopharyngeal opening. c) No significant relationship was seen between the linear and the angular measurements. d) The important variables related to velopharyngeal opening, in this study, were pharyngeal depth, palatal length, and palatal movement.

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