Dr. Long

Facial growth following pharyngeal flap surgery: Skeletal assessment on serial lateral cephalometric radiographs

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The purpose of this study was to evaluate the effect of pharyngeal flap surgery on subsequent facial growth in patients with cleft lip and/or palate. Pharyngeal flap surgery is used in such patients to partially obliterate the velopharyngeal port, reducing hypernasal speech. Thirty-four patients (18 with cleft palate only, 16 with unilateral cleft lip and palate) were selected from the longitudinal growth study of the H. K. Cooper Clinic. Seventeen of these (9 with cleft palate only, 8 with unilateral cleft lip and palate) underwent pharyngeal flap surgery between the ages of 5 and 7 years. The other seventeen patients did not undergo pharyngeal flap surgery and served as a control group for this study. Serial lateral cephalometric radiographs were traced and digitized (ages 3 to 5, preflap; ages 7-10, postflap). Fourteen skeletodental measurements (six angular, six linear, two derived) were taken to determine whether pharyngeal flap surgery may be related to subsequent facial growth changes. The data from the 17 flap patients were compared with control data taken from the other seventeen patients. The groups were matched for sex, cleft type, and similarity of presurgical mandibular growth direction (facial axis angle). Results obtained demonstrate several significant areas of change following flap surgery, including a decrease in facial axis angle, an increase in Frankfort-mandibular plane angle, an increase in incremental gains in lower anterior face height, and increased retroclination of upper and lower incisors in the flap group as compared to their matched controls.

Key words: Cleft palate, pharyngeal flap, cephalometric radiographs, longitudinal growth, airway

The factors contributing to the development of postoperative dentofacial deformities and malocclusion in the cleft palate patient are complex and incompletely understood. Past emphasis on anatomic tissue deficiencies and distortions resulting from the cleft itself, as well as oversimplified descriptions of scar effects following surgery, no longer adequately explain the changes and variability of subsequent dentofacial growth and development. Physiologic factors, such as altered oropharyngeal muscle function resulting from the cleft itself or subsequent surgical procedures, offer additional explanations.

One elective surgical procedure, the pharyngeal flap, is performed to improve the quality of speech in the hypernasal cleft palate patient through a reduction in velopharyngeal port size.[1] A secondary effect of this reduction is a simultaneous increase in nasal airway resistance,[2] thus raising the possibility of compensatory alterations in oropharyngeal muscle function. These, in turn, may contribute to the dentofacial growth changes seen in the cleft palate population.

Clinical interest in a possible relationship between nasorespiratory function and dentofacial growth was stimulated by the studies of Linder-Aronson.[3-5] Patients classified clinically as chronic mouth breathers were shown to have several significant deviations in dentofacial skeletal morphology, including increased gonial angles, mandibular plane angles, and lower facial heights, as well as incisor retroclination and decreased molar widths.

Experimental data are also available demonstrating altered orofacial muscle activity secondary to induced nasal obstruction in young rhesus monkeys.[6-8] Subsequent alterations in craniofacial skeletal morphology

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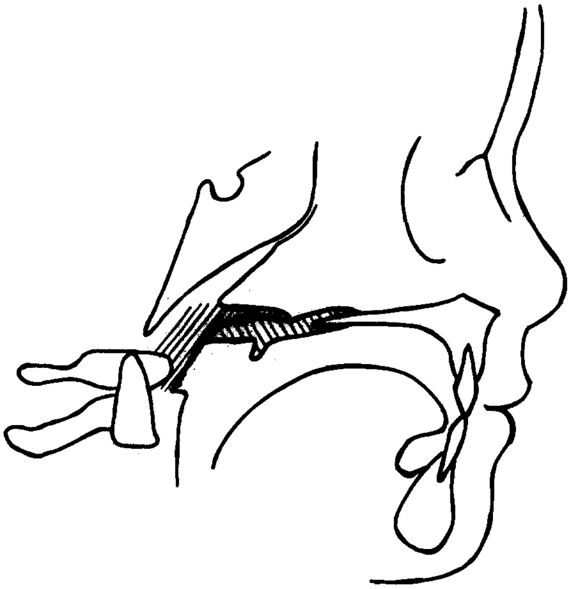

Fig. 1. Line diagram of pharyngeal flap surgical procedure.

Table I. Sample

		Flap	*Control*	*Total*
Cleft palate only	Male	2	2	4
	Female	7	7	14
Unilateral cleft lip and palate	Male	5	5	10
	Female	3	3	6
Total		17	17	34

Table II. List of measurements

1. *Facial axis angle:* Angle between nasion-basion plane and foramen rotundum-gnathion plane
2. *Frankfort-mandibular plane angle (FMA):* Angle between Frankfort horizontal (anatomical porion-infraorbitale) and mandibular plane (menton-inferiormost point posterior to antegonial notch)
3. *Gonial angle:* Angle between ramal plane (articulare-posteriormost point on ramus) and mandibular plane
4. *Upper anterior face height (UAFH):* Distance between nasion and anterior nasal spine
5. *Lower anterior face height (LAFH):* Distance between anterior nasal spine and menton
6. *Face heights ratio:* Ratio UAFH/LAFH
7. *Point A to nasion perpendicular (A-NP):* Perpendicular distance from point A to plane perpendicular to Frankfort horizontal through nasion
8. *Pogonion to nasion perpendicular (Pog-NP):* Perpendicular distance from pogonion to plane perpendicular to Frankfort horizontal through nasion
9. *Maxillary length (Max L):* Distance between condylion and point A
10. *Mandibular length (Mand L):* Distance between condylion and gnathion
11. *Maxillomandibular differential (Diff.):* Mandibular length minus maxillary length
12. *Lower incisor-mandibular plane angle (IMPA):* Angle between mandibular plane and plane formed by long axis of lower incisor
13. *Upper incisor-nasion perpendicular (UINP):* Angle formed between mandibular plane and plane formed by long axis of upper incisor
14. *Interincisal angle:* Angle formed between lines of long axes of upper and lower incisors

were also documented,[7, 9] although it should be mentioned that both neuromuscular and skeletal changes in these studies showed a wide range of response, only some of which resembled the clinical research findings of Linder-Aronson.

On the other hand, studies utilizing physiologic measures of airflow have consistently failed to establish any correlation between mode of respiration and craniofacial morphology.[10-12] Additionally, there seems to be little relationship between clinical assessment of breathing mode and actual nasal and oral airflow patterns.[12] However, these data suffer from the shortcomings of evaluating static morphology rather than dynamic growth change.

The pharyngeal flap procedure, usually performed secondarily in midchildhood, represents a discrete chronologic event that has been shown to increase airway resistance.[2] Subtelny and Nieto[13] measured maxillary growth in cleft patients following this procedure and were able to demonstrate a retardation of forward development, suspected to be due to a "tethering" effect. However, a lack of "preflap" growth data in their study weakens the argument for causality.

The purpose of the present study was to identify deviations from prepharyngeal flap dentofacial growth patterns that occur in cleft palate patients following pharyngeal flap surgery. This study was carried out through comparison with growth in matched cleft palate patients who had not been subjected to the pharyngeal flap surgery.

MATERIALS AND METHODS

The sample used in this investigation was drawn from the longitudinal growth study of the H. K. Cooper Clinic (formerly Lancaster Cleft Palate Clinic). Data available in this growth study include lateral cephalometric radiographs taken yearly from the ages of 1 to 10 years. Of the 174 patients included in the Cooper Clinic growth study, 50 had superiorly based pharyngeal flaps performed secondarily for treatment of velopharyngeal insufficiency. This procedure is depicted in Fig. 1. All flap procedures were performed by the same surgeon.

Table III. Descriptive statistics by age—Presurgical

Measurements		Age (yr) 3 $\bar{X}$	3 SD	4 $\bar{X}$	4 SD	5 $\bar{X}$	5 SD
Facial axis angle	C	88.46	3.23	88.16	2.70	88.61	2.91
(degrees)	F	89.55	4.18	89.56	4.69	88.86	4.18
FMA (degrees)	C	29.34	5.47	29.39	4.99	29.10	4.93
	F	29.48	5.59	29.24	6.00	29.39	5.11
Gonial angle (degrees)	C	136.77	5.08	134.55	4.96	134.13	5.43
	F	134.90	5.98	134.06	4.85	132.42	4.70
UAFH (mm)	C	37.70	3.21	39.18	2.31	40.68	1.97
	F	39.15	2.55	40.54	2.84	41.96	2.92
LAFH (mm)	C	54.82	4.68	57.47	4.61	58.40	4.53
	F	52.45	4.19	55.08	3.57	56.87	2.88
FH ratio	C	.689	.955	.684	.044	.699	.045
	F	.751	.082	.737	.050	.739	.049
A-NP (mm)	C	0.12	2.38	0.21	2.75	0.12	2.29
	F	−2.48	3.05	−2.41	3.16	−2.43	2.92
Po-NP (mm)	C	−10.48	5.17	−10.14	4.63	−9.17	4.38
	F	−13.35	4.82	−12.70	5.66	−12.38	5.49
Max L (mm)	C	71.82	4.92	73.92	4.50	75.28	4.76
	F	71.36	4.54	73.95	4.59	75.99	4.94
Mand L (mm)	C	83.78	6.39	87.44	6.07	90.59	6.08
	F	83.93	5.21	87.83	5.37	91.71	5.57
Diff (mm)	C	11.97	3.63	13.52	3.27	15.31	4.01
	F	12.57	2.94	13.87	2.82	15.73	3.85
IMPA (degrees)	C	84.33	7.92	84.10	7.25	81.54	4.56
	F	85.72	4.92	84.08	4.99	82.47	6.47
UINP (degrees)	C	3.51	8.36	3.66	7.72	3.73	10.95
	F	−2.52	9.39	0.75	8.97	−0.80	7.15
Interincisal (degrees)	C	152.82	13.56	152.85	13.59	155.63	15.95
	F	157.33	13.20	155.93	10.80	158.94	9.68

C = Control group.
F = Flap group.

Of the patients with flaps, those who underwent the surgical procedure between the ages of 5 and 7 years were selected for this study. This allowed for a minimum of 3 or 4 years of cephalometric data both preceding and following the surgery. Further, only those cases with no missing data in the age ranges 3 to 5 and 7 to 10 were selected for study. This reduced the sample to that shown in Table I.

The mean age at which pharyngeal flap surgery was performed in this group was 6.2 years. All patients with complete clefts of the lip, alveolus, and palate had undergone primary lip repair by a triangular flap method at approximately 10 weeks of age. Palatal clefts were closed by vomer flap at an average age of 11 months, and soft palate closure was carried out at a mean age of 16 months.

The control group for this study was also chosen from the longitudinal growth study. Similar selection criteria were used for availability of data. The controls were matched to the flap group for cleft type, sex, and, to the extent possible, mandibular growth direction (facial axis angle) and absolute cranial base size (anterior cranial base) at the ages of 3 to 5 years. The former was chosen in an attempt to match subjects with approximately similar mandibular growth directions presurgically. The latter was used in an attempt to control for absolute craniofacial size variation. Although perfect matching would have been ideal, given the limitations of sample size, sex, cleft type, and age, it was practically impossible to find matches for more craniofacial dimensions than those listed. The control group did not undergo pharyngeal flap surgery. The selection criteria distinguishing patients requiring pharyngeal flap surgery from those used in the control group were based on clinical assessments of velopharyngeal competence and speech resonance by a speech pathologist. It was

Table IV. Descriptive statistics by age—Postsurgical

Measurements		Age (yr) 7 $\bar{X}$	7 SD	8 $\bar{X}$	8 SD	9 $\bar{X}$	9 SD	10 $\bar{X}$	10 SD
Facial axis angle (degrees)	C	89.42	3.27	88.57	3.54	88.42	3.75	87.86	4.20
	F	87.59	5.33	86.77	4.69	86.61	4.67	86.05	4.54
FMA (degrees)	C	26.63	4.50	26.92	4.18	26.65	4.62	26.62	4.56
	F	29.99	5.04	29.52	5.62	29.78	4.98	29.46	4.24
Gonial angle (degrees)	C	130.66	6.01	130.60	5.95	130.09	7.05	131.60	6.50
	F	131.10	4.72	130.37	4.10	129.75	3.29	129.06	4.23
UAFH (mm)	C	43.80	2.70	45.63	2.97	46.78	3.06	47.82	2.91
	F	44.97	2.96	46.81	3.25	47.46	2.95	49.00	2.97
LAFH (mm)	C	58.76	5.28	59.79	5.44	60.42	5.81	61.46	5.73
	F	59.09	2.86	60.46	3.20	61.81	3.39	63.22	4.05
FH ratio	C	.750	.061	.767	.058	.778	.059	.782	.059
	F	.762	.044	.775	.055	.769	.048	.777	.061
A-NP (mm)	C	−0.13	2.53	−0.39	2.66	−0.34	2.38	−0.47	3.20
	F	−3.12	3.14	−3.09	3.39	−3.72	3.58	−4.20	3.67
Po-NP (mm)	C	−6.21	4.21	−5.85	4.32	−6.01	4.58	−5.67	4.50
	F	−13.11	6.39	−12.86	6.69	−12.78	6.59	−12.29	6.03
Max L (mm)	C	77.71	3.98	78.08	4.82	80.03	4.79	81.53	4.97
	F	77.13	5.37	78.72	4.55	79.07	4.70	80.10	5.03
Mand L (mm)	C	95.96	5.69	98.14	5.95	100.01	5.59	102.38	6.04
	F	94.94	6.21	97.55	5.93	99.66	5.94	102.63	6.19
Diff (mm)	C	18.25	3.15	20.06	3.42	19.99	3.91	20.85	3.75
	F	17.81	3.76	18.83	3.99	20.59	3.71	22.53	4.62
IMPA (degrees)	C	86.82	7.79	86.87	5.80	87.64	6.22	88.23	5.44
	F	85.98	8.86	86.34	6.01	85.92	6.96	84.41	6.71
UINP (degrees)	C	13.36	10.39	15.09	8.49	16.25	7.85	15.88	7.96
	F	3.12	10.40	5.25	8.89	7.84	6.46	10.92	8.55
Interincisal (degrees)	C	143.18	14.67	141.12	11.53	139.46	10.64	139.24	9.90
	F	150.90	16.01	148.88	11.82	146.46	8.29	145.22	9.06

C = Control group.
F = Flap group.

hoped that any *pre-existing* differences in growth prior to pharyngeal flap surgery could be minimized and that those remaining could be documented so as not to be erroneously attributed to the flap, if they continued into the postsurgical period.

The growth data used in this study were taken from standardized lateral cephalometric radiographs. The precise procedures used in the collection of these data are described elsewhere.[14] Acetate tracings of major hard- and soft-tissue landmarks and structures were made by two research assistants (M. G. M. and S. G.). These were then checked independently by the senior author (R. E. L.). Differences not due to error in landmark identification were resolved through averaging.

Digitization of these tracings was done by a modification of the method used for the longitudinal growth study at the University of Michigan Center for Human Growth and Development. A total of 84 points (54 hard-tissue, 14 internal soft-tissue, 16 soft-tissue profile) were plotted on a Summagraphics digitizing tablet at the University of Michigan Center for Human Growth and Development. A total of 238 lateral cephalometric radiographs (119 flap group, 119 controls) were thus digitized for later analysis.

The skeletodental dimensions chosen for this preliminary analysis are described in Table II. The principal components of this analysis represent a modification of the McNamara analysis.[15] An attempt was also made to negate absolute size variability in this relatively small sample by using primarily angular, proportional, and relative linear measurements.

Means for each group at each age were plotted to

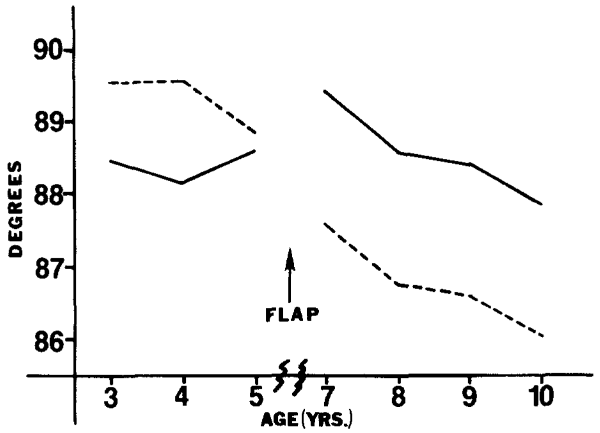

Fig. 2. Facial axis angle. *Solid line* = Control group; *broken line* = flap group.

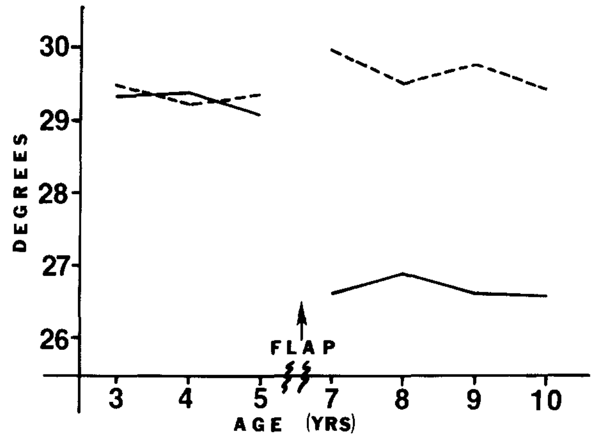

Fig. 3. Frankfort-mandibular plane angle. *Solid line* = Control group; *broken line* = flap group.

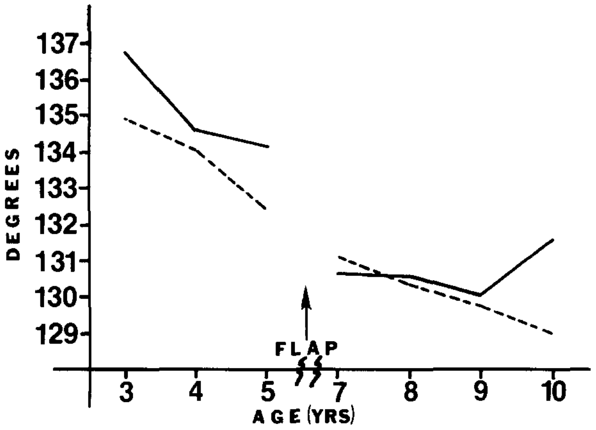

Fig. 4. Gonial angle. *Solid line* = Control group; *broken line* = flap group.

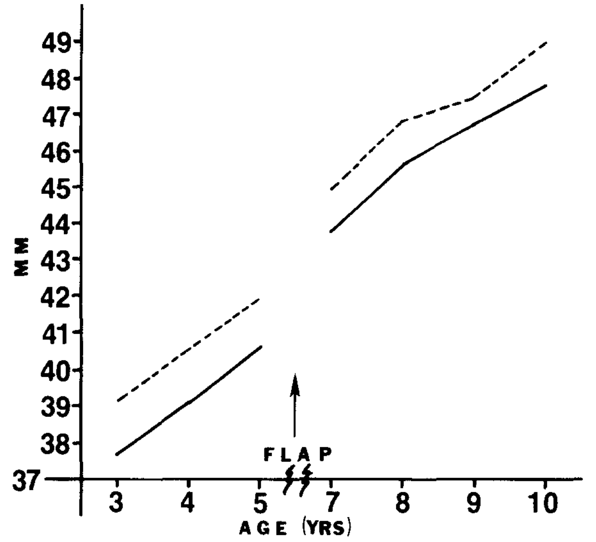

Fig. 5. Upper anterior face height. *Solid line* = Control group; *broken line* = flap group.

illustrate longitudinal growth changes, both before flap surgery (ages 3 to 5) and after flap surgery (ages 7 to 10). Statistical analysis was performed with the Statistical Research Laboratory computer package (MIDAS) at the University of Michigan. Analysis of covariance between least squares regression lines[16] for each group was carried out to check for significant differences between groups and for changes in the relationship between groups from the preflap to the postflap time period.

RESULTS

The descriptive statistics by age (mean and standard deviation) are provided in Tables III and IV (presurgical and postsurgical, respectively). These data are plotted graphically in Figs. 2 to 15 to accentuate the longitudinal growth changes over time. Statistical significance using analysis of covariance (ANCOVA) between regression lines at both preflap and postflap stages is listed in Table V.

Three basic relationships between groups in the pre- and postoperative states evolve from these data. Of greatest interest are those measurements which demonstrate some changes in either appearance or level of significance from the preflap to the postflap condition (facial axis angle, FMA, UAFH, LAFH, FH ratio, Po-NP, UINP, and interincisal angle). For these dimensions, there appears to be at least a temporal relationship between pharyngeal flap surgery and a change in the significance of differences between flap and control groups. While some of these changes suggest the de-

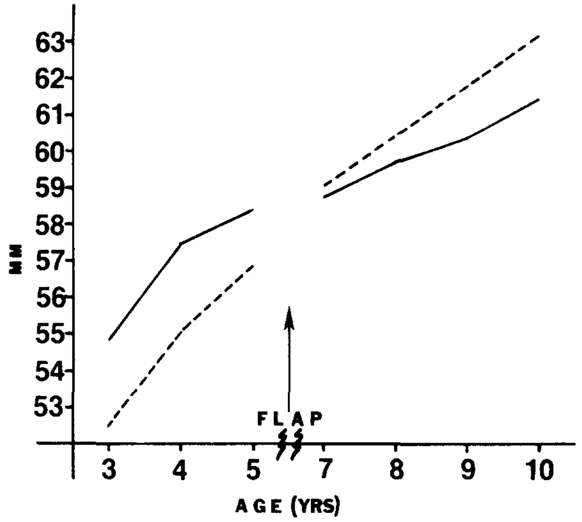

Fig. 6. Lower anterior face height. *Solid line* = Control group; *broken line* = flap group.

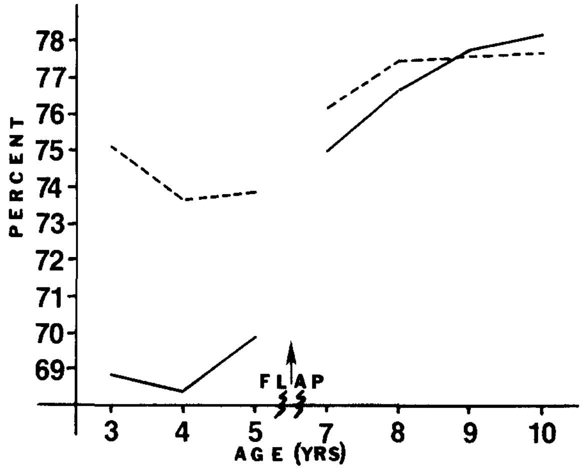

Fig. 7. Face heights ratio. *Solid line* = Control group; *broken line* =; flap group.

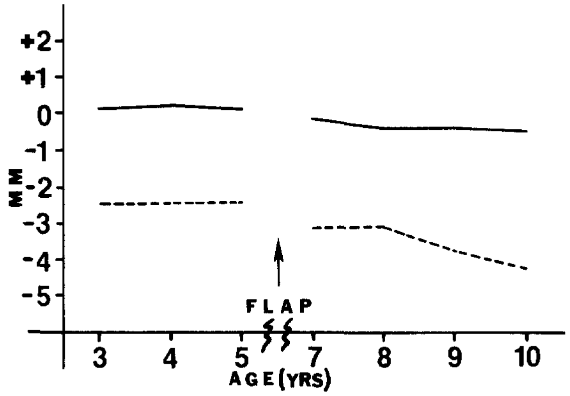

Fig. 8. Point A to nasion perpendicular. *Solid line* = Control group; *broken line* = flap group.

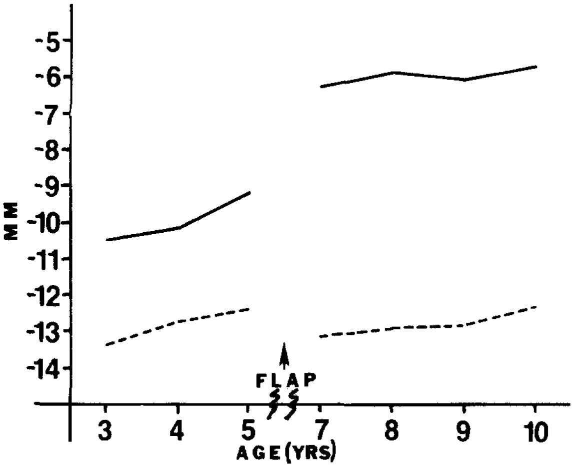

Fig. 9. Pogonion to nasion perpendicular. *Solid line* = Control group; *broken line* = flap group.

velopment of a significant difference postoperatively (facial axis angle, FMA, interincisal angle), others illustrate the elimination of a previously existing significant difference in the preflap age groups (UAFH, LAFH, FH ratio).

A second series of measurements demonstrates no significant difference between groups either pre- or postoperatively (gonial angle, maxillary length, mandibular length, maxillomandibular differential, IMPA). Growth changes in these dimensions, therefore, seem to bear no relationship to pharyngeal flap surgery.

A final characteristic demonstrated by the dimension A-NP was the preflap existence of a significant difference between groups, which persisted at the same level postoperatively. Again, in this situation, no link between growth changes in this dimension and the surgical procedure is evident.

In general, mandibular growth direction appears to have become more vertical in the surgical group following pharyngeal flap surgery. Both facial axis angle and Frankfort-mandibular plane angle illustrate this. In the flap group the former became significantly more acute and the latter more obtuse relative to their matched controls, both indicative of an increased vertical component to the growth direction. However, the gonial angle did not demonstrate a similar "opening" facial rotation.

With regard to facial height, the significant differences seemed to occur in the presurgical state. Here, those patients who were ultimately to have pharyngeal flap surgery were characterized as having greater upper anterior face height and lesser lower anterior face height than their controls. This, in turn, led to a significantly

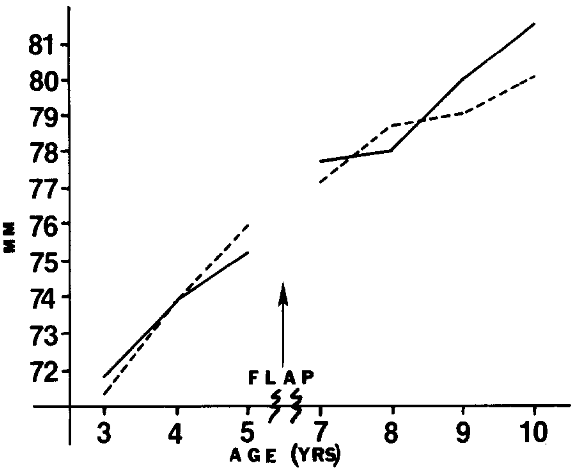

Fig. 10. Maxillary length. *Solid line* = Control group; *broken line* = flap group.

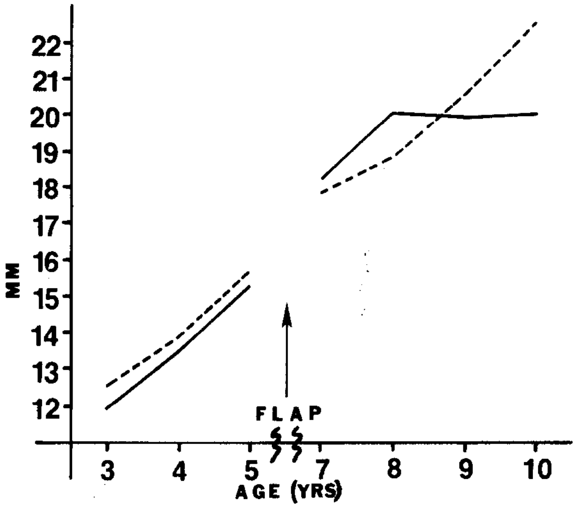

Fig. 12. Maxillomandibular differential *Solid line* = Control group; *broken line* = flap group.

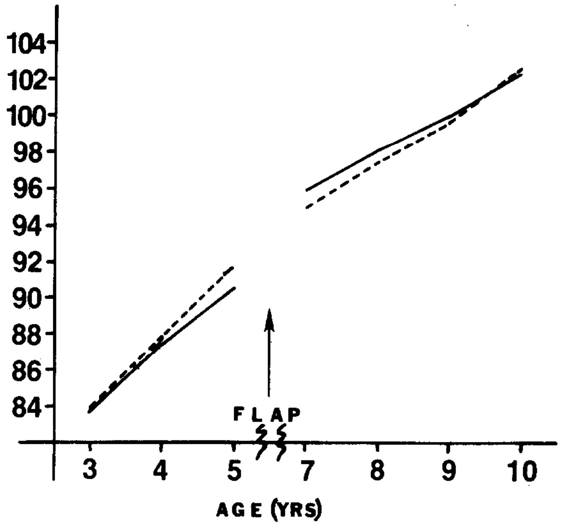

Fig. 11. Mandibular length. *Solid line* = Control group; *broken line* = flap group.

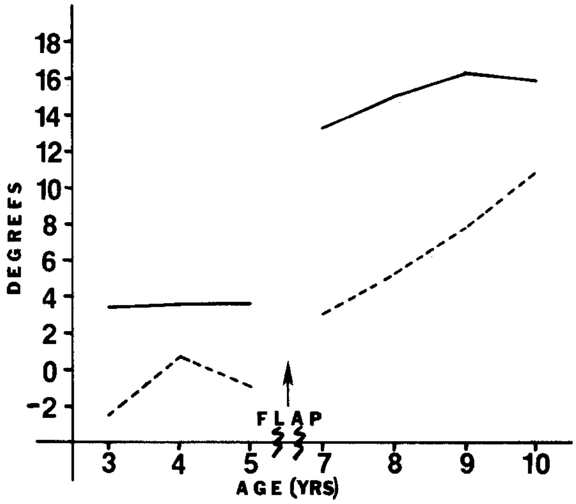

Fig. 13. Upper incisor to nasion perpendicular. *Solid line* = Control group; *broken line* = flap group.

larger facial height ratio (UAFH/LAFH) in the flap group prior to surgery. However, consistent with the previous suggestions of excessive vertical facial growth following flap surgery, the flap group demonstrated a more rapid increase in LAFH postsurgically as compared to the controls. This eliminated the significant differences seen presurgically and actually resulted in the flap group's surpassing the control group (although not to a new level of statistical significance).

Interestingly, although both maxilla and mandible demonstrated similar absolute lengths in both groups (Max L, Mand L, Diff), which were also not influenced by surgery, the patients who were to receive pharyngeal flaps showed definite retrognathia, both pre- and postsurgically. Thus, although the flap group had significantly retrognathic maxillas and mandibles relative to nasion-perpendicular following surgery, the existence of this same condition presurgically reduces the possibility that it had any relationship to the surgery itself. At best, it could be stated that the relative mandibular retrognathia became significantly worse in the flap group following surgery. This, again, would be consistent with a change to a more vertical growth direction.

Dentally, those patients receiving pharyngeal flaps appeared to develop an increased retroclination (interincisal angle) of upper and lower incisors in the time period following surgery. This was accentuated by a

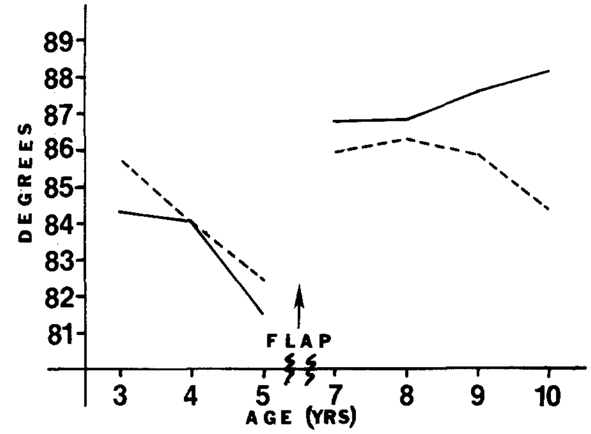

Fig. 14 Lower incisor to mandibular plane angle. *Solid line* = Control group; *broken line* = flap group.

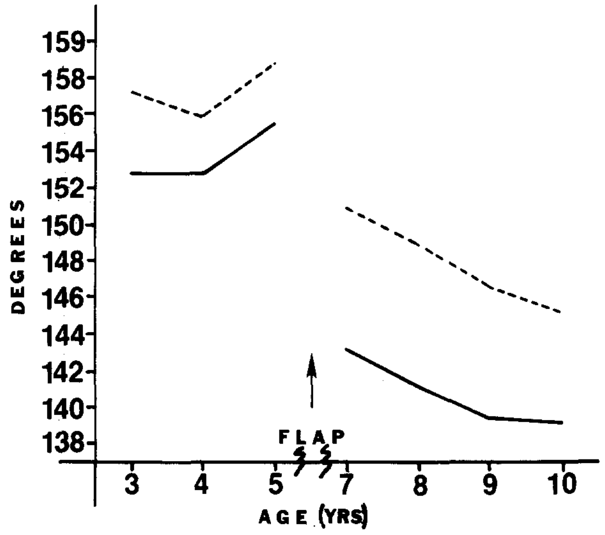

Fig. 15. Interincisal angle. *Solid line* = Control group; *broken line* = flap group.

pre-existing upper incisor retroclination relative to controls, which become more significant after surgery, as well as a lower incisor retroclination postsurgically which approached but did not reach statistical significance ($p = 0.13$).

DISCUSSION

The data presented herein provide information relative to two areas of interest. On the one hand, there is a continuing need to add to the body of knowledge regarding the growth of the cleft palate face and the effects of various surgical procedures on that growth. In a broader sense, it was hoped that this sample might also provide, indirectly, an opportunity to test current hypotheses of respiratory function on facial growth, longitudinally, in human subjects. The principal strength of a serial cephalometric growth study such as this is that it allows for isolation of the surgical event in time. Furthermore, since this event occurred in midchildhood in these patients, the availability of data *before* the surgery allows for adequate documentation of growth characteristics prior to the influence of the pharyngeal flap. This is an especially pertinent point in these cleft palate children, since a myriad of potential growth-modifying influences (type and extent of original deformity, primary lip repair, primary palate repair, etc.) have already converged prior to flap surgery. Thus, if we are to attempt to isolate pharyngeal flap effects on growth, pre-existing growth relationships must be known. Without this, it becomes more difficult to differentiate effects on growth related to the flap surgery from those related more to other factors in the earlier treatment of cleft patients.

Table V. Analysis of covariance

	Presurgical		*Postsurgical*	
Measurements	*Significance*	*Description*	*Significance*	*Description*
Facial axis angle			*	C > F
FMA			**	C < F
Gonial angle				
UAFH	*	C < F		
LAFH	*	C > F		
FH ratio	***	C < F		
A-NP	***	C > F	***	C > F
Po-NP	*	C > F	***	C > F
Maxillary length				
Mandibular length				
Maxillomandibular differential				
IMPA				
UINP	*	C > F	***	C > F
Interincisal angle			**	C < F

* = $p < 0.05$.
** = $p < 0.01$.
*** = $p < 0.001$.

The cleft palate patient presents a number of potential craniofacial growth disturbances. The role of scar tissue as the primary influence in the cleft palate deformity[17, 18] must be re-evaluated. The uniform, three-dimensional growth deficiencies following traumatic surgery and injudicious scarring[19] are seen less frequently. Improved, less traumatic surgery has resulted in less consistent and sometimes near-normal growth findings which cannot be explained in terms of generalized growth inhibition.

Ongoing research at the H. K. Cooper Clinic utilizing longitudinal craniofacial growth data on clefts[14, 20, 21] has demonstrated facial growth patterns that are not characterized by generalized deficiencies. Excess facial heights, increased gonial and mandibular plane angles, retroclined incisors, and decreased arch widths are very obvious trends in this sample. The similarity of these morphologic variations to those described by Linder-Aronson,[3-5] as well as the well-known nasal airway deformities[22] and increased nasal resistance in clefts,[23] suggested a possible partial explanation of the growth changes seen and an opportunity to test the respiratory function hypothesis on this sample. The pharyngeal flap seemed to afford the most testable "experimental" paradigm in this regard.

The results obtained illustrate an apparent relationship between the pharyngeal flap surgical procedure and growth changes in certain skeletodental measurements. In general, the most common characteristic of the post-flap growth period in the operated group is an increase in the vertical component of maxillomandibular development compared to matched controls. The significant decrease in the facial axis angle, the increase in the Frankfort-mandibular plane angle, and the more rapid incremental gains in lower anterior face height all support this conclusion. Interestingly, this "opening" rotation of the lower face appears not to have been a ramocorporal adjustment, inasmuch as the gonial angle did not show significant opening. A condylar rotation could be an alternative explanation, although changes in ramal axis were not measured in this study.

Commensurate with this vertical growth change and opening mandibular rotation was a decrease in anteroposterior mandibular position. Although the mandible, in fact, was significantly retrognathic in the flap group before surgery, the anticipated gains with further growth never occurred. As a result, the flap group became more retrognathic compared to the controls. Although both groups appeared to be growing equally in absolute mandibular length (Mand L), these incremental additions in the flap group seem to have been negated by excessive vertical rotation.

The maxillary retrognathism evident following surgery appears to be similar to that described by Subtelny and Nieto.[13] In this sample, however, it could not be attributed to a "tethering" effect of the surgery, inasmuch as the deficiency existed even before the pharyngeal flap. The significance of this pre-existing difference and those involving face heights remains unclear. However, it does point out the "nonrandom" nature of the selection process for those patients who are to receive pharyngeal flaps. Since a clinical diagnosis of hypernasal speech was the primary criterion originally used in this selection process, it is possible there may, in fact, exist some skeletodental differences which correlate closely to the clinical appearance of hypernasality. Those dimensions cited above may represent just such structural differences, distinguishing cleft patients with hypernasal speech requiring pharyngeal flap surgery from those judged as having acceptable speech. However, this possibility was not specifically addressed in this investigation.

When the data are evaluated in light of current theories of effects of nasorespiratory function on facial growth, certain points must be stressed. First, it is obvious that the growth trends demonstrated follow fairly closely with those described originally by Linder-Aronson (with the exception of the gonial angle). Thus, these data could *not* be used to prove or support the null hypothesis in this case.

Second, there appears to be an association between the flap surgery and the growth changes seen. At most, with the data presented, the nature of this relationship can be stated as a temporal sequencing. A direct casual link between any flap-induced airway changes and the growth changes is *not* possible through these data alone. A drawback of this retrospective study relates to the unavailability of physiologic airway data both before and after the flap. Without these, any cause-and-effect relationship remains tenuous at best. Conclusions, therefore, about cause and effect must be conjectural and rely on the *assumption* that the increased airway resistance found in one sample of pharyngeal flap patients,[2] applied also to this sample. If so, these data would add credibility to the possible existence of a relationship between nasorespiratory function and craniofacial growth. However, the case for direct cause and effect is further complicated by the wide range of individual response in nasal-resistance changes following flap surgery in the literature cited.

Emphasis on future studies using a similar experimental paradigm should focus prospectively on the problem so as to allow for simultaneous longitudinal collection of both cephalometric and physiologic airflow data. In addition, the sample size should be increased and followed over a longer time period to allow for application of a more precise growth curve analysis. The present statistical method was best suited to the constraints of the present study, but its use in a group of repeated, nonindependent measures might have somewhat underestimated sample variability.

Finally, an increase in sample size should allow for a comparison of this nature with the subjects grouped according to cleft type. There exists a very real possibility that milder forms of clefts (palate only) with most normal-appearing nasal airways presurgically may be more adversely affected by pharyngeal flap surgery than more severe clefts (lip, alveolus, and palate) with pre-existing significant airway anomalies. These approaches are now being pursued.

SUMMARY

The results and discussion of this investigation can be summarized as follows:

1. Pharyngeal flap surgery as performed on this sample of cleft palate patients between the ages of 5 and 7 years was followed by differences in growth curves for several dentofacial measurements.

2. These differences were most typically related to an increase in the vertical component of lower facial growth.

3. Several significant morphologic differences following pharyngeal flap surgery were found to be preexisting differences prior to the surgery and, therefore, may be less likely to be attributable solely to the pharyngeal flap itself.

4. Since other studies have demonstrated an increase in airway resistance following pharyngeal flap surgery, it is tempting, although conjectural, to relate the changes described as being secondary to surgically induced airway obstruction. However, a lack of physiologic pre- and post-surgical airflow data on this sample precludes the possibility that such a conclusion can be drawn.

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