Growth in Width Following Pharyngeal Flap Surgery

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An assessment of serial postero-anterior cephalometric radiographs of 17 cleft palate patients who had undergone pharyngeal flap surgery to improve hypernasal speech; no significant effect on growth in width of dental arches or facial skeleton was found.

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Pharyngeal flap surgery is used to partially close the velopharyngeal port and recruit pharyngeal muscle for soft palate elevation in order to improve hypernasal speech caused by velopharyngeal incompetence[1] (Fig. 1).

In a study reported earlier,[2] serial lateral cephalometric radiographs were evaluated in a sample of 17 cleft palate patients who had undergone this pharyngeal flap surgical procedure. The findings suggested an alteration in facial growth pattern following the pharyngeal flap surgery. The nature of this change appeared to be in the direction of a more vertical component of growth in the lower face.

When compared to matched controls, this sample demonstrated a significant decrease in the angle of the facial axis, increase in Frankfort/mandibular plane angle, and more rapid incremental gains in lower anterior face heights. In general, the similarity of these findings to those described in cases described as having

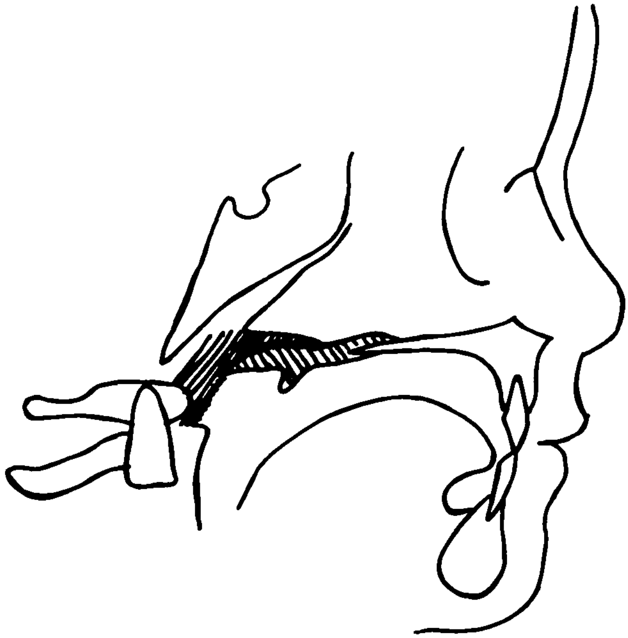

Fig. 1 Diagram of pharyngeal flap procedure. Tissue from the pharyngeal wall //// is shifted to the palate.

nasorespiratory obstruction[3,4,5] suggested the possibility that the pharyngeal flap may have affected subsequent growth through an induced change in respiratory function.

Another study of growth following flap surgery[6] addressed the possibility of a tethering effect of the flap on anterior maxillary growth. However, a mode of action mediated through neuromuscular adaptation to changes in respiratory function was not considered. The likelihood of such a chain of events in experimental animals has already been documented.[7,8] In addition, some of the dento-osseous changes following these induced neuromuscular adaptations[9,10] resemble those described in human studies by Linder-Aronson.[3-5]

Cleft palate patients have been shown to have increased nasal resistance as measured by pressure/flow techniques,[11] presumably a result of numerous nasal cavity deformities associated with clefting.[12] Similar methods of air-flow measurement have shown an increase in nasal resistance following pharyngeal flap surgery.[3] However, no meaningful relationship between craniofacial morphology and mode of respiration has been found using such methods.[14-16]

Although no physiological airflow recordings were available for the sample under investigation here, the initial results from lateral cephalometric radiographs[2] and the findings mentioned above prompted this extension of the original investigation. Since some of the skeletodental characteristics usually associated with mouth breathing occur in the width dimension, it was felt that evaluation of postero-anterior (P-A) radiographs of this sample would be justified.

The purpose of this study was to evaluate growth changes in dentofacial width following pharyngeal flap surgery in cleft patients. Those deviations most likely to be a consequence of the pharyngeal flap itself were to be identified through comparison with matched cleft controls not having undergone this surgery, and through careful documentation of any presurgical growth differences.

Materials and Methods

The sample of 17 patients selected from the longitudinal growth study of the H. K. Cooper Clinic (formerly Lancaster Cleft Palate Clinic) for the previous investigation[2] was also used in this study. These patients all had undergone superiorly-based pharyngeal flap surgery between the ages of 5 and 7 years (mean age 6.2 years).

The sample was evenly divided between cleft palate only (9) and unilateral cleft lip and cleft palate (8). The CPO group consisted of 2 females and 7 males, the UCLP group 5 females and 3 males.

TABLE 1

	Technique	*Approximate Age at Surgery*
Lip Repair (for UCLP)	Triangular Flap	10 weeks
Hard Palate Repair	Vomer Flap	11 months
Soft Palate Repair	Midline Closure or lengthening	16 months

All had yearly P-A radiographic data available between ages 3-5 (preflap growth) and 7-10 years (post-flap growth). The distribution of the sample by age and cleft type is shown in Table 1. The same surgeon performed all procedures. Although there were minor variations from patient to patient in the primary lip and palate repair protocol, the basic plan of primary surgery is shown in Table 1.

A matched control group was also selected from the growth study, chosen on the basis of availability of complete yearly records. They were matched with the flap group according to sex, cleft type, mandibular growth direction (facial axis) at 3-5 year age period, and absolute anterior cranial base size. These patients did not undergo pharyngeal flap surgery during the time period studied.

All efforts were to control for the myriad of surgical and nonsurgical variables converging on cleft patients prior to the pharyngeal flap procedure. Thus, any growth difference between groups before flap surgery was minimized, and remaining differences could be factored out as due to some influence other than the flap if they continued into the post-surgical period.

The data used in this study were derived from serial P-A radiographs taken annually within 2 weeks of the patient's birthday. Tracings of pertinent skeletal and dental landmarks were made independently by two of the authors (M.G.M. and S.G.) and checked by the other (R.E.L.). Differences not due to obvious errors in identification of structures were averaged.

Preliminary width measurements were based on the five bilateral points shown in Fig. 2. Linear measurements were made between those bilateral

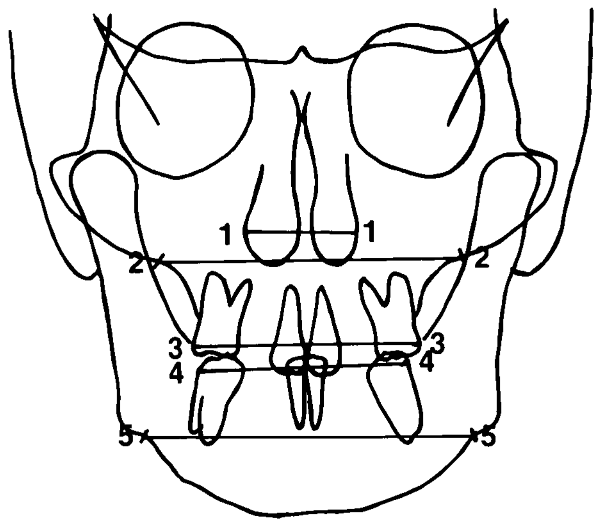

Fig. 2 Landmarks used for measurements of width
1. Lateral nasal walls—the most lateral points on the concavities of the lateral nasal walls.
2. Maxillae—intersections of concavities of buccal surfaces of maxillary alveolar ridges with the convexities of the zygomaticomaxillary buttresses
3. Maxillary molars—greatest convexities on the buccal surfaces of the most lateral fully-erupted upper molars
4. Mandibular molars—greatest convexities on the buccal crown surfaces of the most lateral fully-erupted lower molars
5. Antegonial notches—the greatest concavities

TABLE 2
Descriptive Statistics by Age (Years)

		3		4		5	
		$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Nasal Cavity Width	C	22.55	2.77	23.46	3.14	23.93	2.96
	F	22.88	2.76	23.01	2.52	23.83	2.36
Maxillary Width	C	61.05	3.22	62.51	3.75	63.31	4.16
	F	60.74	4.37	61.99	4.10	63.03	3.20
Upper Molar Width	C	43.62	2.55	44.54	2.19	44.97	2.24
	F	44.83	3.75	45.06	4.30	46.01	3.80
Lower Molar Width	C	44.24	2.17	44.52	2.58	45.05	3.59
	F	43.53	2.75	43.75	2.94	44.22	3.13
Mandibular Width	C	68.11	2.64	69.47	2.85	71.24	2.78
	F	65.09	3.39	67.56	3.43	69.65	3.44

points to the nearest 0.1mm and averaged where discrepant.

Means for each measurement with age, sex and cleft type pooled were plotted to demonstrate longitudinal growth changes in the pre-surgery (3-5 years) and the post-surgery (7-10 years) stages. Analysis of covariance between least squares curvilinear regression lines[17] allowed for examination of differences between regression lines representing presurgical and postsurgical incremental growth changes over time.

A separate analysis was also carried out for each cleft type, because there are known differences in growth between different types of clefts.[18]

Results

Means and standard deviations for the pooled data are shown in Table 2. The same means are plotted graphically in Figs. 3-7 to illustrate the longitudinal nature of the changes. Table 3 is a list of the statistically significant differences in regression lines, based on analysis of covariance. Included in this table are not only the significant findings for the pooled data, but also the sites of significance according to cleft type.

Of greatest interest here are those variables which demonstrate a change in the level of significant difference before and after surgery. These results indicate no significant change in dentoalveolar width measurements. The upper molar width in the flap group was actually greater than in the matched controls, both presurgically and throughout the postsurgical period. This can affect any influence of the flap surgery on subsequent dentoalveolar width growth.

Likewise, mandibular width at the antegonial notch does not appear to be affected by the flap procedure. Although significant differences between the flap group and controls were found after surgery, a similar difference existed before surgery. This difference, which appears to be related mostly to the unilateral cleft, would seem to be the result of some factor other than the flap surgery.

Maxillary and nasal widths show more interesting changes. Growth in nasal width, which demonstrated no significant differences with samples pooled, appears to be the product of two equal and opposite changes within different cleft types. Examination of

TABLE 2—Continued
Descriptive Statistics by Age (Years)

		7		8		9		10	
		$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Nasal Cavity	C	24.81	3.25	25.27	2.90	25.60	3.05	26.01	2.73
Width	F	24.49	2.22	24.81	2.52	25.51	2.81	26.33	3.11
Maxillary	C	65.91	3.67	68.18	3.39	69.88	3.64	70.91	3.95
Width	F	68.22	4.01	69.71	3.51	71.18	3.87	71.79	2.85
Upper Molar	C	49.98	3.75	51.69	3.52	52.45	3.32	52.72	3.26
Width	F	50.61	4.30	53.10	3.48	53.35	3.78	53.98	3.93
Lower Molar	C	51.81	3.38	53.02	2.58	53.94	3.41	54.21	3.06
Width	F	51.95	3.72	53.49	3.16	53.34	3.03	53.30	3.05
Mandibular	C	75.32	3.63	77.34	4.07	78.62	4.03	80.10	3.55
Width	F	73.82	3.55	75.32	3.43	76.91	3.95	78.89	4.34

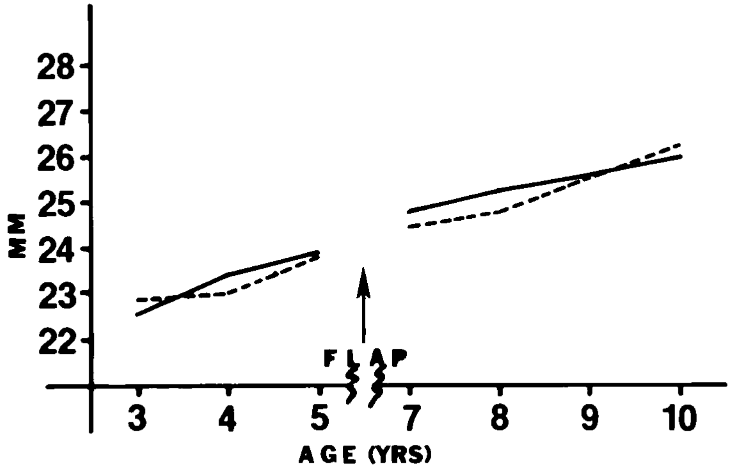

Fig. 3 Mean width of nasal cavity
Solid line—control group
Broken line—pharyngeal flap group

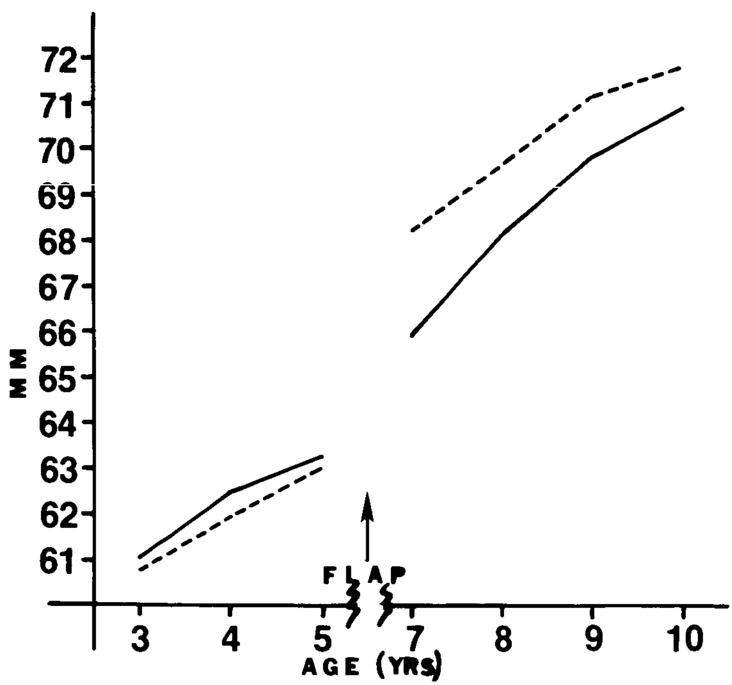

Fig. 4 Mean maxillary width
Solid line—control group
Broken line—pharyngeal flap group

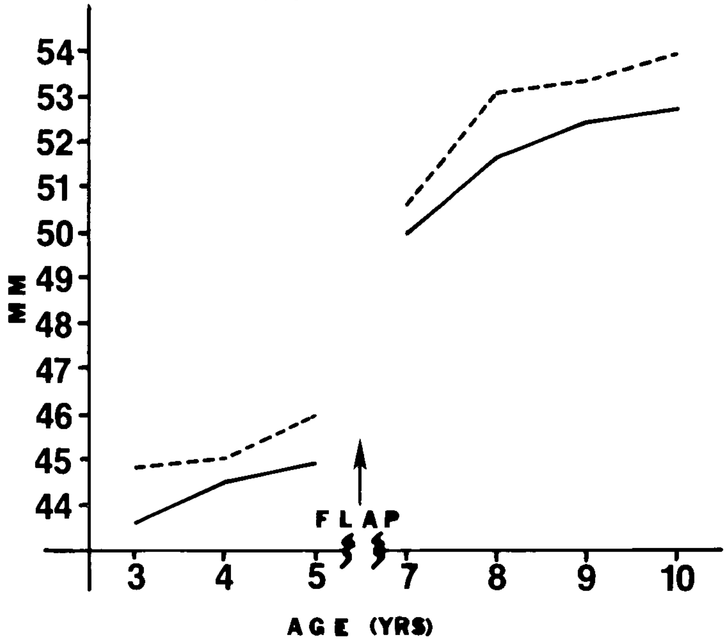

Fig. 5 Upper molar width
Solid line—control group
Broken line—pharyngeal flap group

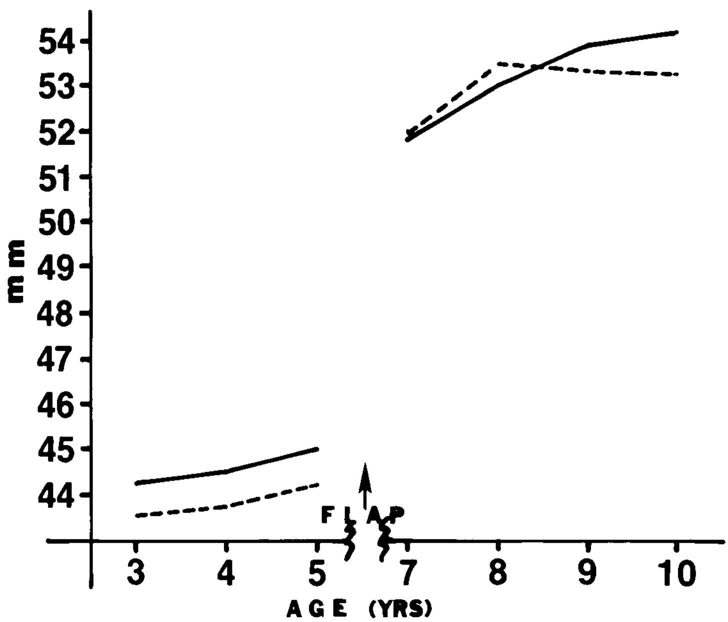

Fig. 6 Lower molar width
Solid line—control group
Broken line—pharyngeal flap group

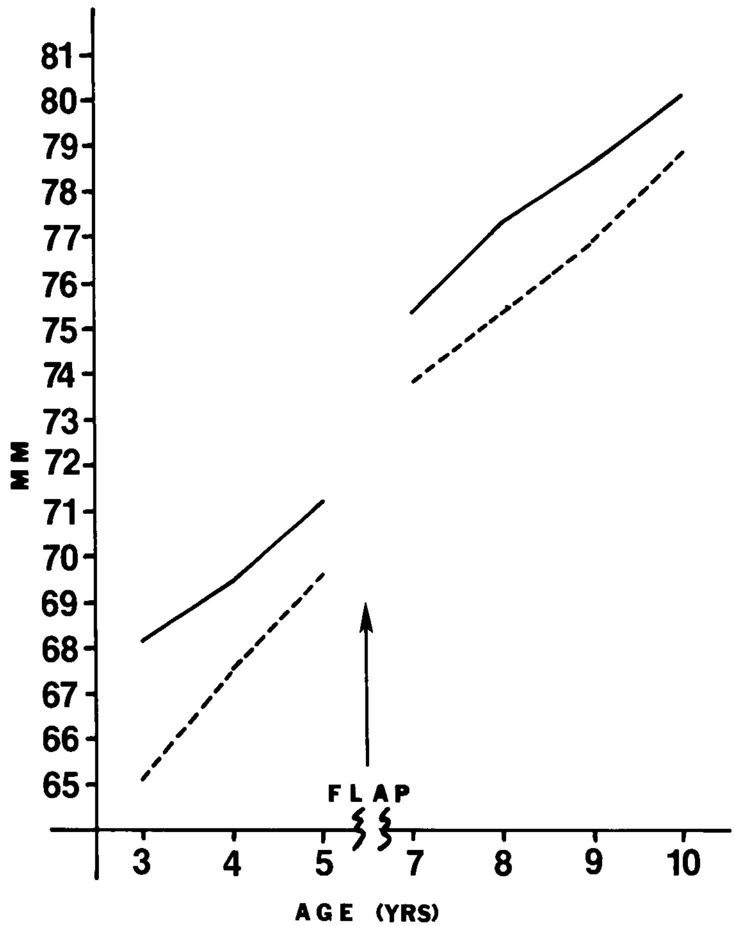

Fig. 7 Mandibular width
Solid line—control group
Broken line—pharyngeal flap group

Table 3 shows that those with a cleft palate only (CPO) became significantly narrower in nasal cavity width in the post-flap period, while the opposite was true in cases of unilateral cleft lip and palate (UCLP).

A partial explanation for this finding may be found in the graphs of the means for the different cleft types (Fig. 8), where the significant differences found following flap surgery seem to be merely extensions of trends already present in the presurgical state. Neither change seems to be related to the flap surgery.

Maxillary width is the dimension which appears to be most likely related to the flap surgery. In the post-flap period those patients who underwent the surgery showed significantly larger increases in maxillary width than the controls. Further analysis of Table 3 shows that the cleft palate only group contributed most to this difference. Unilateral cleft lip and palate did not show such a change.

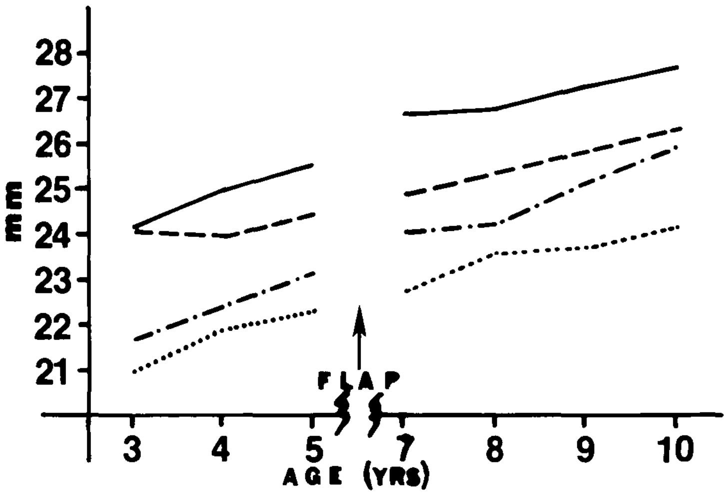

Fig. 8 Mean nasal cavity width by cleft type
Solid line—cleft palate only control group
Broken line—cleft palate only pharyngeal flap group
Dotted line—unilateral cleft lip and palate control group
Dashed-dotted line—unilateral cleft lip and palate flap group

Discussion

The above findings are in marked contrast to the very interesting and occasionally very significant changes found on lateral radiographs of the same sample.[1] The P-A radiograph did not demonstrate any dramatic changes in rate or amount of growth in width. With the possible exception of maxillary width, the pharyngeal flap seemed to be unrelated to any of the width dimensions measured, and there the effect was more growth rather than less.

While growth curves of maxillary width did show a significant difference between the flap group and controls after surgery, the direction of change was opposite that hypothesized for of nasorespiratory obstruction. The decreased arch widths described by Linder-Aronson[3-5] as characteristic of his sample of mouth breathers were

TABLE 3

	Pooled		*CPO*		*UCLP*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Nasal Width				*C > F		*F > C
Maxillary Width		*F > C		*F > C		
Upper Molar Width						
Lower Molar Width						
Mandibular Width	*C > F	*C > F			*C > F	*C > F

$p < .05$

not found in this sample following pharyngeal flap surgery. Upper molar and maxillary width maintained or actually increased their excess over the controls (Figs. 4, 5).

The explanation for this trend is not readily apparent. If the flap did produce an increase in nasal resistance, the expected effects on width did not occur.

The significant differences found in mandibular width following surgery were obviously present before surgery, and can in no way be connected to the pharyngeal flap. This finding illustrates the usefulness of good longitudinal growth data prior to an experimental event to factor out possible differences not related to that event.

Findings on nasal width differences between cleft types, while showing no obvious net significant relationship to the pharyngeal flap, do point out the possible importance of grouping by cleft type in evaluating data such as these. If the airway is in fact a mediating factor in producing growth changes following pharyngeal flap surgery, it may be possible that the preexisting level of nasal resistance may affect the degree to which any resistance added by a pharyngeal flap may influence growth.

Warren *et al*[11] have shown that nasal resistance tends to be greater in clefts involving both lip and palate, presumably due to a greater incidence of nasal cavity deformities and collapse. The present data would tend to support such a contention, at least in relation to nasal cavity width. If true, it is possible that cases with pre-existing nasal obstruction (UCLP) would be less affected by any additional resistance imposed by a pharyngeal flap. This reasoning is now being pursued in the lateral radiographic data.

Finally, it is necessary to place the preceding conjectures in perspective with several words of caution regarding the data reported here.

First, from a technical point of view, tracing error and variability were much greater in the P-A cephalometry than with lateral radiographs.

It must also be reiterated that any statements regarding increased airway resistance following pharyngeal flap surgery *in this sample* are purely inferences drawn from other studies of airflow in flap patients. Physiological recordings of pressure/flow in this sample group were not available, so any relationships between the surgery and subsequent growth change can be labeled only as a temporal sequencing from these data alone. No causal connections can be made.

It is hoped that these data and those presented in the previous paper can add to our body of knowledge regarding this very complex and controversial question. Further investigations using a prospective longitudinal design to simultaneously gather cephalometric and pressure/flow data may provide more complete answers.

Summary

The data reported in this investigation can be summarized in the following statements:

- Pharyngeal flap surgery in this sample of 17 cleft patients did not appear to produce or be related to any dramatic alterations in growth in width of the jaws or dental arches following the surgery.
- The only significant finding was related to an *increase* in basal maxillary width following flap surgery, a result opposite that described as typical of nasorespiratory obstruction.

- In general, the more interesting and significant relationships found between pharyngeal flap surgery and dentofacial growth in studies in the vertical and sagittal planes were not found in this evaluation of growth in width.
- Nasal cavity width changes with growth could not be related to the flap, but point out the possible usefulness of evaluating data such as these grouped according to cleft type.

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