The Effect of Surgery on Maxillary Growth and Cleft Width

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The repair of the cleft lip physiologically restores the continuity of the upper lip musculature which is continuous with the circumoral musculature extending posteriorly to the basilar part of the occipital bone. After lip surgery, a notable reduction in the width of palatal cleft has been observed. This observation has been previously mentioned in 1954 by Slaughter and Pruzansky,[1] and in 1955 by Pruzansky;[2] however, no quantitative analysis has been reported.

The reduction in width of the cleft could be the result of the following factors: (1) the restoration of the muscle continuity and the scar tissue formed due to the lip surgery; (2) the buccinator muscle complex exerting a molding action which probably brings into equilibrium the internal and external muscle forces on the partially detached maxillary segment, thus repositioning the two halves of maxilla; (3) the reduction of the palatal cleft width because of the growth and possible downward displacement of palatal shelves.

The present investigation was undertaken to make a discrete analysis of the effect of muscle activity and tissue growth on the narrowing of the palatal cleft after lip surgery.

Material and Method

The present investigation utilized a collection of serial cephalometric roentgenograms and dental casts from 12 children with complete unilateral cleft lip and palate and 12 children with cleft of the hard and soft palate. The sex ratio was equally distributed in both groups (table 1). All of the individuals participated in a longitudinal growth study at the Lancaster Cleft Palate Clinic, Lancaster, Pennsylvania. The age ranged from 23 days to 2 years, 4 months.

Only posteroanterior cephalometric x-rays and dental casts, recorded at comparable ages, were utilized. A minimum of four roentgenograms and dental casts were available for each subject as follows: (1) prior to lip surgery (mean age 1 month, 26 days); (2) after lip surgery (mean age 3 months, 2 days); (3) anterior palatal closure by a vomer flap (mean age 1 year, 1 month); (4) soft palate closure (mean age 1 year, 5 months).

Linear measurements were recorded from the radiographs and the dental cast series with a fine-pointed caliper, measured to the nearest 0.5 mm.

Radiographic Measurements: Bimaxillary Width

The linear dimension of the midface was measured on the serial roentgenograms, in *norma frontalis,* (fig. 1) between the two radiographic landmarks called maxillare, defined as the point of the maximum concavity on the contour of the maxilla between the first molar and malare. This dimension was chosen to represent the maximum bimaxillary width of the maxilla and to assay growth changes in width in order to determine the effect of lip surgery on this dimension of the face.

Measurements of Dental Casts

Bituberosity dimension (*line A to D*). This distance, earlier defined in 1964 by Sillman,[5] was located by a line drawn on the crest of the gum pad to its most posterior limit and another line drawn on the posterior limit

Supported by Public Health Service Grant D-2172-2, National Institutes of Dental Research, United States Public Health Service.

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TABLE 1
Distribution of sex, cleft type and observations

Type of Case	Male			Female		
	No. of cases	Dental casts	Cephalometric x-rays	No. of cases	Dental casts	Cephalometric x-rays
Individuals with unilateral clefts	6	24	24	6	24	24
Individuals with hard and soft palate clefts	6	12	12	6	12	12

of the dental arches; the point of intersection of these two lines was located and measured on both sides of the arches.

Cleft width (line B to C). The maximum width of the cleft was determined on the *line A to D by the line segment B to C* (figs. 2 through 9).

Palatal shelf size (line A to B and line C to D). The cleft and noncleft segments of palatal shelf were measured along the *line A to D*. The measurement was made to determine the actual increase in size of palatal shelves which might be a contributing factor in decreasing the size of palatal cleft (figs. 2 through 9).

To determine the reliability of measurements, they were made on two separate occasions. Measuring error was determined by computing the mean absolute difference between the two sets of measurements. The magnitude of the error of measurement between the paired measurements on the data indicated a high degree of reliability for measurements on the radiograph and dental casts.

The resultant data were then subjected to descriptive statistical analyses which included a comparison of the sample means by Student's *t*-test.

Results

Tables 2 and 3 give the means and standard deviations for the bituberosity width, cleft width and bimaxillary width for the subjects with unilateral cleft lip and palate and for subjects with clefts of the hard and soft palate.

Bituberosity Cast Measurements

Cleft palate group. The linear bituberosity dimension of the casts prior to palatal surgery ranged from 26 mm. to 32.5 mm., with a mean of 29.3 and standard deviation of 1.75. The bituberosity measurement after palatal surgery varied from 27 mm. to 34 mm., with a mean of 30.3 and standard deviation of 2.10. The mean group bituberosity measurements before and after palate surgery were compared, using a *t*-test, but no significant difference was found at 0.05 level of probability (*t*-value 1.31 with 22 degrees of freedom). However, using a paired difference tests the average difference was found to be significantly different from zero at the 0.05 level of probability (*t*-value 2.406 with 11 D.F.).

The ordinary *t*-test required independence of the observation in the two samples being compared (among other things). Examination of the data and the design of the experiment indicated that this was not true. Hence, a paired difference test, which did not require independent samples, was more applicable; therefore, the results of the paired difference test were more meaningful.

Unilateral cleft lip and palate group. The bituberosity width before lip surgery ranged from 27 mm. to 36 mm., with a mean of 30.5 and standard deviation of 2.65. The same measurement after lip surgery varied from 28 mm. to 37 mm., with a mean of 30.3 and standard deviation of 2.99. The comparison

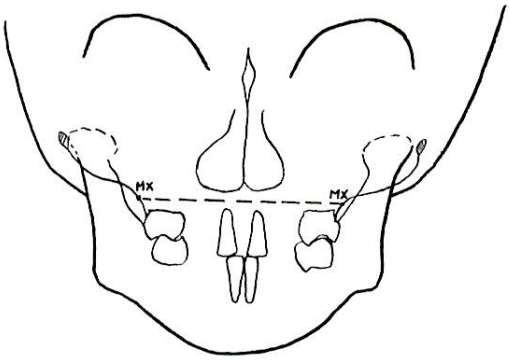

FIG. 1. Bimaxillary width was recorded by measuring between the reference points maxillare (*Mx*) on the postero-anterior tracings of a cephalometric radiograph.

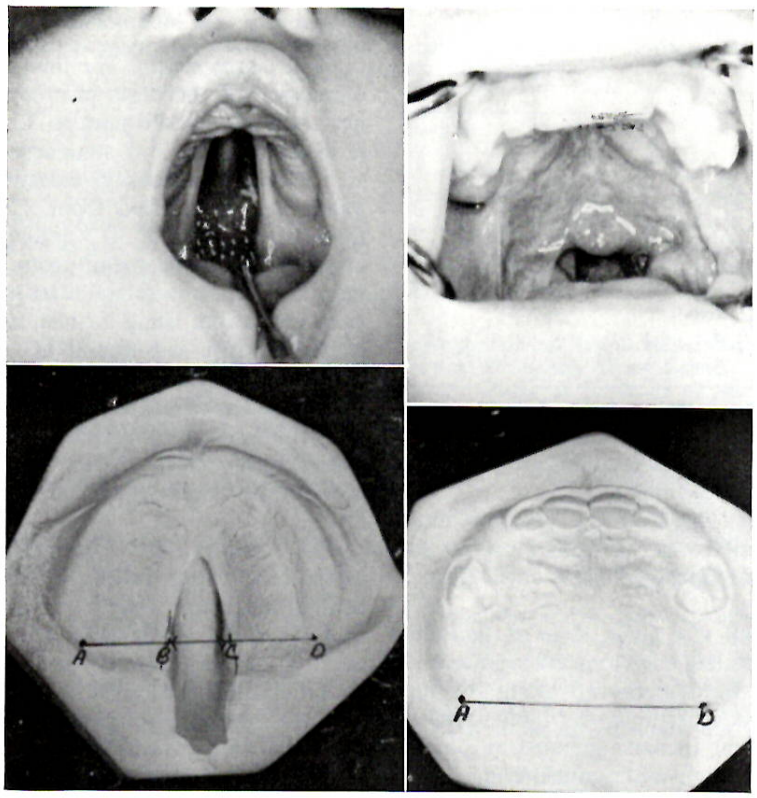

FIG. 2. Case 1. A female with cleft of the soft and two-thirds of the hard palate at age 4½ months: *A* to *D*, 30 mm.; *B* to *C*, 11 mm. Reference points and dimensions in the maxillary dental cast: *A* to *D*, bituberosity width; *B* to *C*, cleft width; *A* to *B* and *C* to *D*, palatal shelves.

FIG. 3. Case 1. After palatal surgery, age 1 year and 10 months: *A* to *D*, 33 mm.

of the mean values using the *t*-test revealed no significant difference at 0.05 level of probability (*t*-value 0.16 with 16 D.F.). The paired difference test supported the *t*-test results.

Comparison of cleft palate and unilateral cleft lip and palate group. The mean of bituberosity values of the cleft palate group was compared to the mean value of the cleft lip and palate group before and after lip surgery, using standard *t*-test and paired difference test. No significant differences were found among these comparisons.

Comparison of cleft groups to normal. The bituberosity mean values of both cleft groups were compared to Sillman's normal group at the age levels birth to 1 year, 2 years and 3 years. Both cleft groups manifested significant differences from the normative data at all age levels. The normals had a greater bituberosity width. This would indicate a definite impediment in the growth of all cleft groups.

Cleft Width

The width of the cleft at the level of the tuberosity in the cleft lip and palate group before lip surgery ranged from 8 mm. to 14 mm., with a mean of 10.1 mm. and standard deviation of 2.34. The same measurement after lip repair varied from 3 mm. to 10 mm., with a mean of 5.5 mm. and standard deviation of 2.26. The comparison of these two measurements resulted in *t*-value of 7.54 with 8 D.F., which indicated significant difference in the mean.

The cleft width in the cleft palate group varied from 4 mm. to 11 mm., with a mean of 6.8 mm. and standard deviation of 2.04. The cleft width in the cleft palate group was

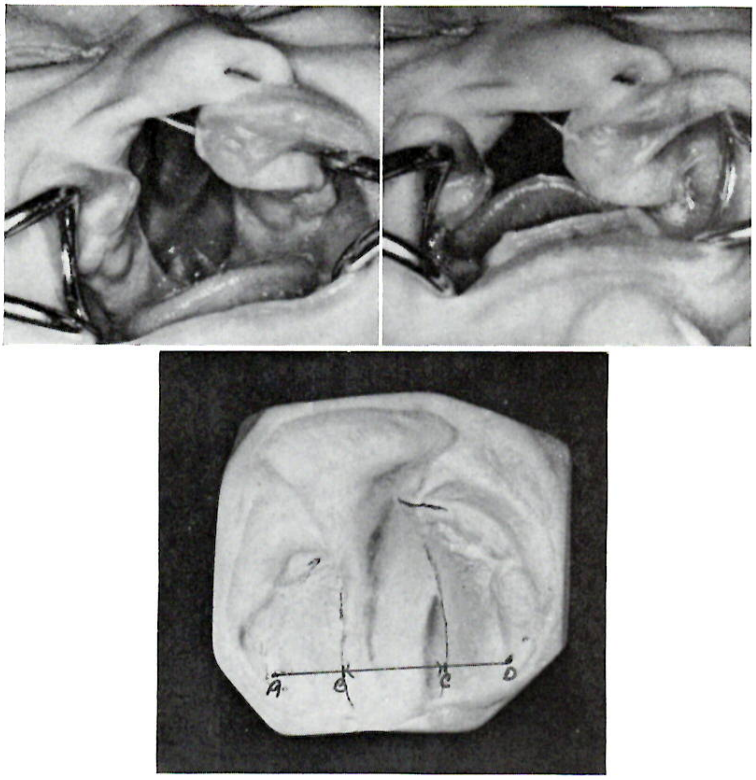

FIG. 4. Case 2. A female patient with complete unilateral cleft of the lip and palate at age 1 month: *A* to *D*, 34 mm.; *B* to *C*, 14 mm.; *A* to *B*, 11 mm.; *C* to *D*, 13 mm.

compared to the cleft width of the cleft lip and palate group before lip surgery using a *t*-test and paired difference tests; and a highly significant difference was found (*t*-value 10.76 with 19 D.F.). After lip closure, the cleft width mean values were compared between the two groups and were found to be insignificant at the 0.5 probability level (*t*-value 1.41 width 19 D.F.).

It was evident from the statistical analysis that after lip repair the cleft width in the cleft lip and palate group was considerably reduced when compared to cleft palate subjects. Moreover, prior to lip surgery the initial cleft was wider when compared to the cleft palate subjects.

Maxillary Width

Cleft palate group. The frontal cephalometric film linear measurement of the bimaxillary width in cleft palate subject prior to palatal surgery ranged from 38 mm. to 54 mm., with the mean of 46.1 mm. and standard deviation of 4.43. After palatal surgery the same measurement varied from 43 mm. to 58 mm., with mean of 48.6 mm. and standard deviation of 5.34. The mean bimaxillary widths before and after palatal surgery were compared using a *t*-test and were found to be insignificant at any reasonable level (*t*-value 1.04 with 27 D.F.). This analysis would indicate that surgery did not have a disturbing growth effect on the bimaxillary width, even though the palate surgery was done at an average age of 1 year, 2 months and 18 days. This is contrary to previous reports.

Cleft lip and palate group. The bimaxillary width in the cleft lip and cleft palate group prior to lip surgery ranged from 38 mm. to 54 mm., with a mean of 45.0 mm. and standard deviation of 4.59. After lip repair this measurement varied from 38 mm. to 55 mm., with a mean of 44.4 mm. and standard devia-

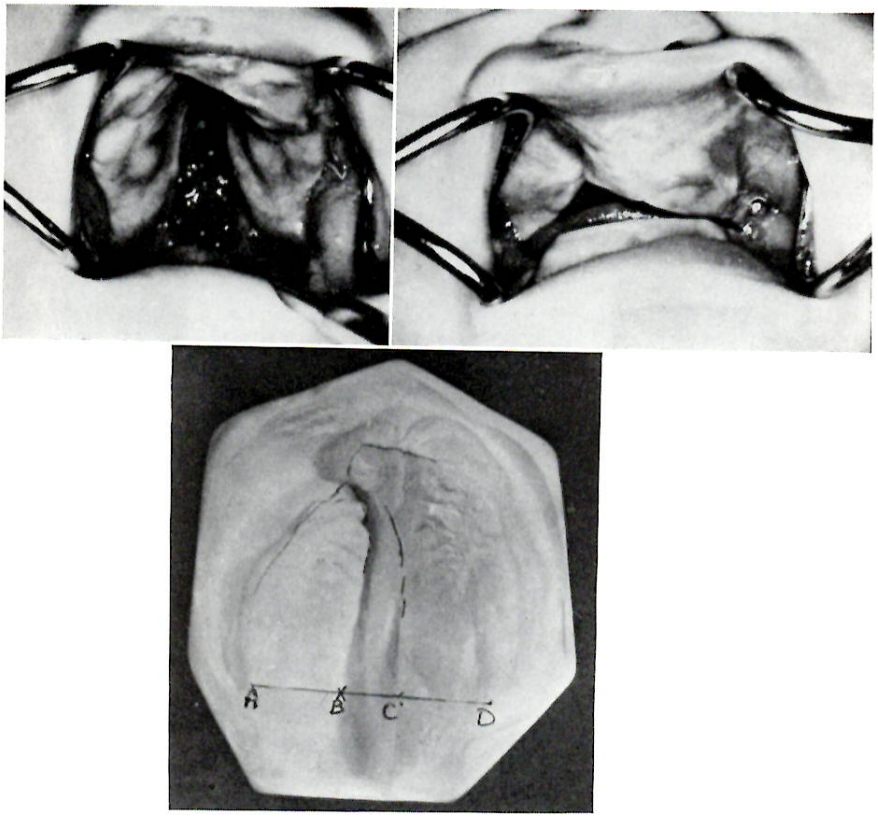

FIG. 5. Case 2. Intraoral view and dental cast after lip closure. Muscle molding and growth of the palatal shelves have contributed to the considerable reduction in the width of the cleft both in the alveolar and palatal areas at age 5½ months: *A* to *D*, 30 mm.; *B* to *C*, 8.5 mm.; *A* to *B*, 12 mm.; *C* to *D*, 14 mm.

tion of 4.87. Subsequent to complete palate repair, this dimension ranged from 44 mm. to 52 mm., with a mean of 48.1 mm. and standard deviation of 1.28.

To evaluate the effect of lip surgery on the bimaxillary width in unilateral cleft lip and palate subjects, a *t*-test was used to compare the dimensional values of this variable before and after lip repair. No significant differences were found. This finding validates the previous assertion that surgery has no effect on either bimaxillary width or bituberosity width. A comparison between the dimensions after lip and after palate surgery showed a significant difference in the mean values using a *t*-test (*t*-value 2.13 with 18 D.F.). This finding suggests that palatal surgery did not have disturbing growth effect on these children when performed at a mean age of 1 year, 4 months and 6 days. Again these findings are in great contrast to the previous reports.

Between group comparison. There was no significant difference between the following variables when using a *t*-test: (1) bimaxillary width in cleft palate subjects before surgery and cleft lip and palate group before lip repair (*t*-value 0.68 with 23 D.F.); (2) no significant difference between the bimaxillary width of cleft palate subject before palate repair and cleft lip and palate group after lip repair (*t*-value 1.70 with 25 D.F.); (3) no significant difference between the bimaxillary width of cleft palate subject after palate repair and the cleft lip and palate group after lip and palate repair (*t*-value 0.103 with 20 D.F.). These analyses reveal that the maxillary width growth in both cleft palate and cleft lip and palate followed the same gen-

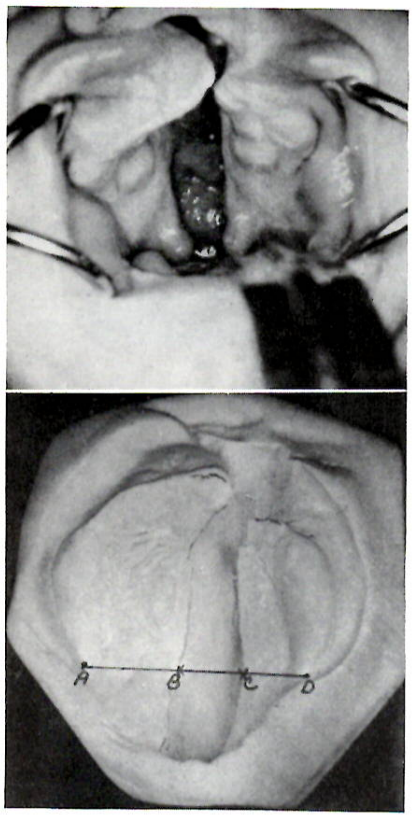

FIG. 6. Case 3. A male with complete unilateral lip and palate, age 2 months; *A* to *D*, 32.5 mm.; *B* to *C*, 11.5 mm.; *A* to *B*, 14.5 mm.; *C* to *D*, 13 mm.

eral pattern, before and after the various surgical techniques.

Palatal shelf. The palatal shelves were measured on each side of the cleft to evaluate the growth of the two palatal shelves, in order to determine whether decrease in palatal cleft size was due to lip repair, palatal shelf growth or both.

The mean palatal shelf measurements in unilateral cleft of lip and palate before lip surgery, *i.e., line A to B, line C to D,* were similar (13 mm.). However, after the lip surgery, the average width of both palatal shelves increased from 13.00 mm. to 14.3 mm. on the cleft side and from 13.00 mm. to 15.2 mm. on the noncleft side. This demonstrated that the palatal shelf on the side of cleft showed less growth when compared to the non-cleft palatal shelf. The increase in amount of growth on the cleft and noncleft side of the palatal shelf might clear up some of our thoughts on why the palatal cleft narrows after lip surgery. The muscle molding does play an important part; however, the growth of the palatal shelf should be considered as a contributing part in narrowing the palatal cleft.

Summary

The results of the present investigation indicated that the reduction of palatal cleft size after lip repair involved two mechanisms:

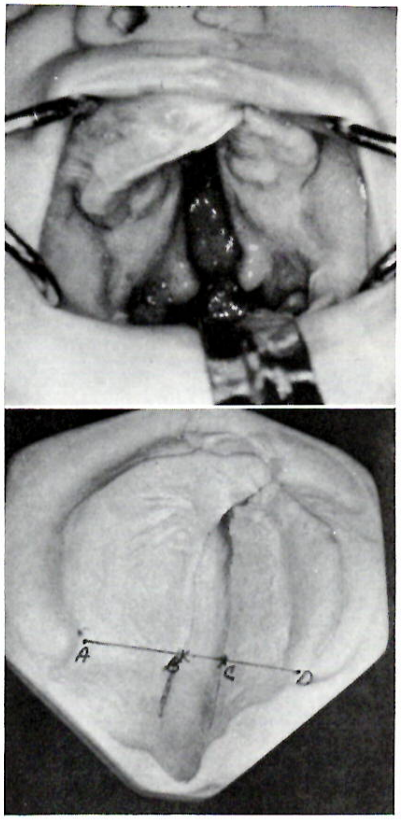

FIG. 7. Case 3. After lip repair, age 6 months and 10 days, note the changes in the maxillary segment relationship and the arch form before and after lip repair, even though no type of orthopedic appliance was utilized. *A* to *D*, 32 mm.; *B* to *C*, 7 mm. The restoration of extraoral muscular balance and the growth of the palatal shelves have caused significant reduction in the palatal cleft of this patient. Measurement *A* to *B* increased by 2 mm., while *C* to *D* increased by 1.5 mm. in the period of 4 months.

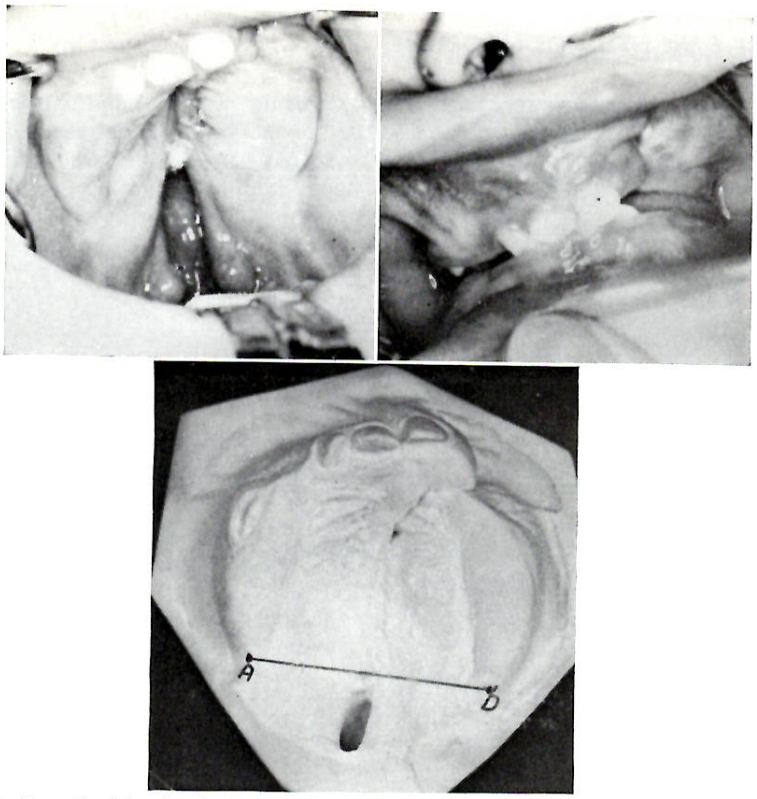

FIG. 8. Case 3. After hard palate repair, age 1 year and 2 months, *A* to *D* measured 32 mm.

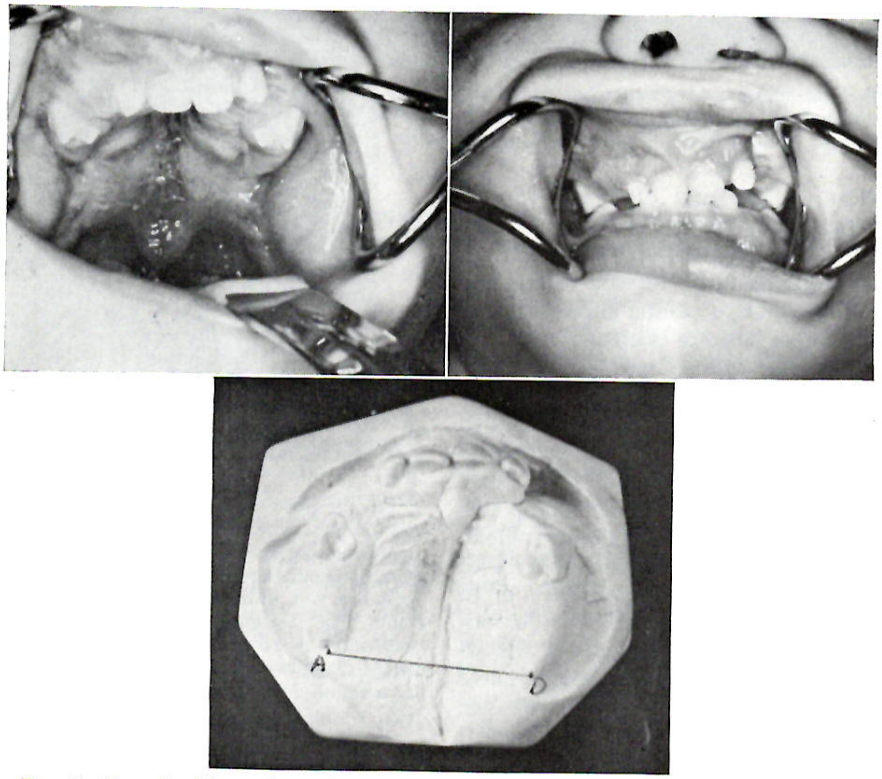

FIG. 9. Case 3. After soft and hard palate repair, age 1 year and 6 months, *A* to *D* measured 33 mm.

(1) the establishment of an intact circumoral muscular complex; and (2) growth of the palatal shelves. The establishment of normal muscle force activity against the periphery of the dental arches manifested itself in a molding action which resulted in a subsequent decrease in the width of the cleft. The measurement of the bituberosity width, as well as bimaxillary width, before and after lip surgery, gave no indication of any significant increase in this dimension. Since the palatal shelves on the cleft and noncleft segments increased in size within the same period, it seemed logical to assume that the palatal shelves grow medially, as the bituberosity and

TABLE 2

Mean and standard deviation for bituberosity, cleft and bimaxillary measurements for 12 clefts of soft and hard palate

	Cast Measurements			Frontal X-ray	
	Bituberosity, *line A to D*		Cleft, *line B to C*	Bimaxillary width	
	Before palatal surgery	After palatal surgery		Before palatal surgery	After palatal surgery
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Mean	29.3	30.3	6.8	46.1	48.6
Standard deviation	1.75	2.10	2.04	4.43	5.34

TABLE 3

Mean and standard deviation for bituberosity, cleft and bimaxillary measurements for 12 unilateral cleft lip palate subjects

	Cast Measurements				Frontal X-ray		
	Bituberosity, *line A to D*		Cleft, *line B to C*		Bimaxillary width		
	Before lip surgery	After lip surgery	Before lip surgery	After lip surgery	Before lip surgery	After lip surgery	After palate surgery
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	30.5	30.3	10.1	5.5	45.0	44.4	48.1
Standard deviation	2.65	2.99	2.34	2.26	4.59	4.87	1.28

TABLE 4

Results of the t-test determinations of the differences between measures for the unilateral cleft lip and palate and cleft of hard and soft palate subjects

Type of Case	Comparisons	Differences of the Mean	*t*	*P**	Degree of Freedom
Unilateral cleft lip and palate	Bituberosity width before and after lip surgery	0.2	0.16		16
	Cleft size before and after lip surgery†	4.5	7.54	<0.001	8
	Bimaxillary width before lip and after lip surgery	0.6	0.59	>0.10	22
	Bimaxillary width before and after lip and palatal surgery	2.2	2.13	0.025	18
Cleft of soft and hard palate	Bituberosity before and after palatal surgery†	1.0	2.40	0.018	11
	Bimaxillary width before and after palatal surgery	2.4	1.04	0.012	27

* *P* is a probability of a larger *t* when in fact there is no difference between means.

† Paired difference *t*-test was used as opposed to the standard *t*-test.

TABLE 5

Results of t-test determinations of the differences between unilateral cleft lip and palate and cleft of hard and soft palate subjects

Comparisons	Differences of the Mean	*t*	*P*	D.F.
Bituberosity width before surgery	0.2	1.3	>0.10	19
Cleft size prior to any surgery	3.1	10.8	<0.001	19
Bimaxillary width before surgery	1.2	0.7	>0.10	23
Cleft size after lip surgery and prior to any surgery in cleft of hard and soft palate	1.3	1.4	0.09	19

bimaxillary width dimensions showed no significant change. The data strongly indicated that muscle molding does play an important role in the narrowing of the palatal cleft; however, the growth of the palatal shelves also contributed to the decrease in the width of the cleft.

The data indicated that lip and palatal surgery of the type performed did not have a disturbing growth effect on the bimaxillary and bituberosity width, even though the surgery was done prior to age 18 months.

The bituberosity mean values of both cleft groups were compared to Sillman's normal group at the age levels birth to 1 year, 2 years and 3 years. Both cleft groups manifested significant differences from the normative data at all age levels. The normals had a greater bituberosity width. This would indicate a definite impediment in the growth of all cleft groups.

Acknowledgments. We greatly acknowledge the assistance of Dr. Joseph Meier, Professor of Mathematics, Millersville State College, and Dr. Harry Canter, Assistant Professor of Mathematics, Millersville State College and Clinic Biometricians, for carrying out the statistical analysis in this paper.

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REFERENCES

1. Slaughter, W. B., and Pruzansky, S.: The rationale for velar closure as a primary procedure in the repair of cleft palate defects. Plast. & Reconstruct. Surg., *13:* 341–357, 1954.
2. Pruzansky, S.: Factors determining arch form in clefts of the lip and palate, Am. J. Orthodontics, *41:* 827–851, 1955.
3. Watson, E. H., and Lowrey, G. H.: *Growth and development of children.* p. 336. Ed. 4. Year Book Publishers, Inc., Chicago, 1962.
4. Sassoune, V.: The face in five dimensions. p. 13B. School of Dentistry Publication, West Virginia University, Morgantown, 1962.
5. Sillman, J. H.: Dimensional changes of the dental arches: Longitudinal study from birth to 25 years, Am. J. Orthodontics, *50:* 824–842, 1964.