

Application of a Quantitative Method for Arch Form Evaluation in Complete Unilateral Cleft Lip and Palate

PAUL W. STÖCKLI, D.M.D., M.S.

Zürich, Switzerland

Arch form has become one of the major considerations in the treatment of the infant with a complete cleft lip and palate. The controversies regarding early orthopedic procedures, early bone grafting and many operative techniques originated mainly from aspects related to alignment of the segments of the upper jaw. However, only few methods are available for analyzing arch form in cleft lip and palate infants. Isolated measurements of the intertuberosity width and measurements of the posterior and/or alveolar cleft width (6, 8, 11) do not portray arch form. Descriptive criteria like "approximation without contact", "approximation with contact", and "overlap" (8) are too vague for comparative assessments. Evaluation of occlusion (5, 8, 9, 10) does not reveal the reaction of the upper arch during the early stages.

In an analysis of the changes following presurgical orthopedic treatment, Huddart (4) presented a method which is applicable to the unoperated upper arch in infants with cleft lip and palate. For broader application, however, the method reveals two major inadequacies: (1) it is limited to studies before palatal closure, since one of the reference structures is the nasal septum, and (2) it does not describe the configuration of the alveolar cleft.

Because of the lack of a simple, but specific method for arch form evaluation in complete unilateral cleft lip and palate cases, an attempt was made to design a measurement system which would be suitable especially for longitudinal and comparative studies. It was of primary concern that the measurement system express, in numerical terms, the spatial relationship of the two maxillary segments in the frontal and sagittal planes, particularly in the region of the alveolar cleft.

The measurement system was tested in a comparative study as a means of establishing its scope.

Dr. Stöckli is affiliated with the University of Zurich, Zurich, Switzerland.

This work was conducted at Northwestern University Dental School, in partial fulfillment of the requirements for the degree of Master of Science.

Presented in part at the 2nd International Symposium on Early Treatment of Cleft Lip and Palate, Chicago, April 19-20, 1969.

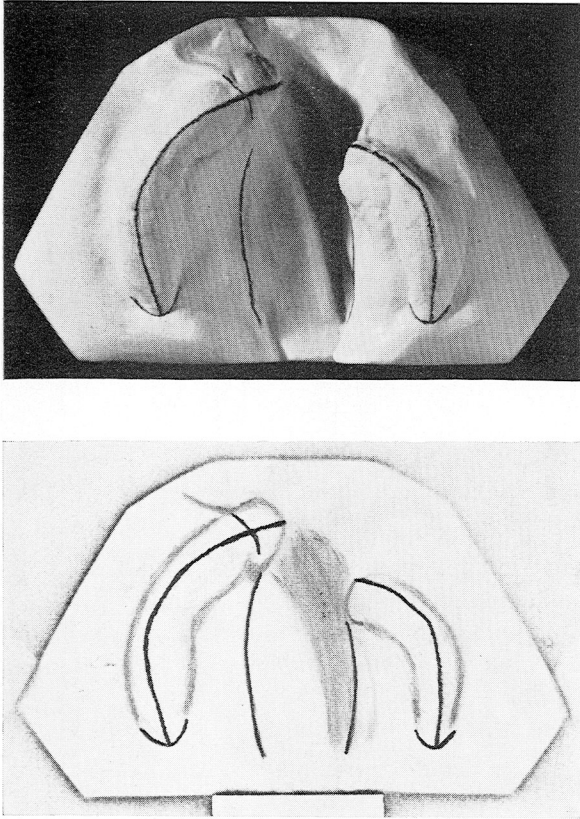


FIGURE 1. *Top*: Model of complete unilateral cleft lip and palate case. Crests of alveolar ridges, medial borders of palatal shelves, tuberosities, incisive papilla and attachment of labial frenum marked with pencil. *Bottom*: Two-dimensional reproduction of plaster cast shown above, obtained by using a Rank Xerox 914 copier machine.

Method for Arch Form Evaluation

The palatal plaster casts included in this study were obtained from alginate impressions. Each cast was duplicated to permit the specific preparation necessary for this type of evaluation. Because interest was focused primarily on arch form, irrespective of the position of the teeth, all teeth of later stages of development present on casts were cut to the height of the alveolar ridge. The crests of the alveolar ridges and the margins of the cleft were marked with pencil. In the greater segment an additional line was drawn from the labial frenum to the incisive papilla. The posterior limits of the alveolar ridges were determined according to the method of Sillman (12) by marking the gingival grooves on the buccal and lingual aspects to facilitate assessment of the tuberosity points (Figure 1).

The marked models were converted into a two-dimensional system by means of a photographic procedure. Accurate reproduction was achieved with a Rank Xerox 914 machine (Figure 1). A constant relation of the models to the camera was obtained by centering them in a frame which

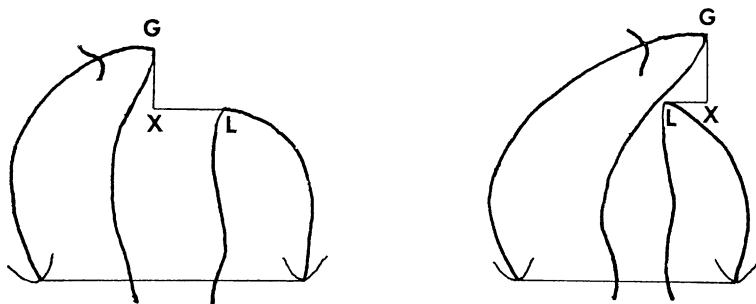


FIGURE 3. Relation of the anterior endpoints of the crest of the alveolar ridges of the greater (point G) and of the lesser segment (point L). *Left*: "Open" configuration, Positive L-X reading. *Right*: "Overlapping" configuration, Negative L-X reading.

the alveolar ridges are in an ideal end to end relation, G L X and Y are located at the same point.

From these points, the following measurements were carried out (Figure 2):

Transverse measurements of the upper arch:

T-T' Intertuberosity width or posterior width of the upper arch.

M-M' Middle width of the upper arch.

t-t' Width of the cleft width at the tuberosities or posterior cleft width.

Antero-posterior measurements of the upper arch:

I-TT' Sagittal length of the upper arch as determined by the length of the perpendicular from the base line (T-T') to the interincisal point (I).

Total length, however, might well be greater in some instances as G is positioned anterior to I. This is often the case before lip closure has been performed.

L-TT' Sagittal length of the lesser segment as determined by the length of the perpendicular from the base line (T-T') to point L.

Transverse and antero-posterior measurements in the region of the alveolar cleft:

L-Y Transverse anterior width of the cleft* or transverse width of the alveolar cleft.

L-X Transverse relation of the lesser to the greater segment.

In an "open" situation the reading is positive, in an "overlapping" situation the reading is negative (Figure 3).

G-X Antero-posterior relation of the lesser to the greater segment.

Since, in the present samples, the alveolar border of the lesser segment (L) was never positioned anterior to the alveolar border of the greater segment (G) all readings were positive.

Measurements were carried out with a caliper gauge reading to 0.1 mm. Each measurement was taken twice. The average of the two readings was then resolved to 0.5 mm.

* "Transverse" is added for the distinction from the commonly used "anterior width of the cleft" which is defined as the shortest distance between the cleft segments at the level of the alveolar borders. According to the labeling described above, this would be the distance between G and L. In the present investigation, however, this G-L measurement was omitted for reasons discussed later.

Subjects

Longitudinal series of maxillary models of 18 patients with complete unilateral cleft lip and plate were studied. The records derived from two sources, each with a different treatment approach.

One group of cases was obtained from the H. K. Cooper Institute of the Lancaster Cleft Palate Clinic, and consisted of 8 patients. Surgically, all these patients had been treated by a three step procedure: (1) lip closure, (2) vomer flap and repair of the hard palate (closure of the anterior palate), and (3) closure of the posterior palate. The advantages of performing the closure of the hard palate as a separate operation subsequent to lip closure were indicated by Harding (3). No early orthopedic, orthodontic, or bone grafting procedures had been undertaken in any of the cases in this group. All operations were performed by the same surgeon. A triangular flap procedure was used for lip closure. The hard palate was repaired in basically the same manner in all cases. The vomer flap procedure performed simultaneously with the repair of the hard palate, varied in cases #105 and #108, where a bilateral vomer flap was carried out. Posterior palatal closure, a median suture procedure, was the same in all cases.

Since three purely surgical interventions were applied to these patients, the group was labeled "PSI".

The other group of cases was made available by the cleft lip and palate team of the Children's Memorial Hospital in Chicago. In the 10 patients in this group, an orthopedic appliance without any expansion device had been inserted at, or immediately before, lip closure. The anterior third of the greater segment remained uncovered by the appliance to allow for the molding effect which usually follows lip closure. After better alignment had been achieved, generally 7-8 months later, a bone graft of rib was inserted as an onlay graft over the alveolar defect. The palatal appliance was worn for approximately another six months after the graft procedure, or until the third operative step, closure of the palate, was performed. The design of the appliance used, the general procedure, and the sequence of events have been published by Rosenstein and Jacobson (11), and Monroe et al. (7). Two surgeons belonging to the same team, and following the same basic surgical procedures, performed all operations in this group. Usually, the rotation advancement approach was carried out for lip closure. In case #508 and #509 the lip was closed according to technique of Wang, and in case #506 according to the technique of Cronin—Brauer. The bone grafting procedure and the palate closure (modification of von Langenbeck) were basically the same in all cases.

This group of cases, which were treated with the combination of early orthopedic procedures and bone grafting, was labeled "EOG".

The sex of the patients and the side of the alveolar cleft are represented in Table 1.

The maxillary models of both groups were selected by criteria relating to the greatest congruence in timing. The "PSI" group was represented by 36 models and the "EOG" group by 45 models, which were organized according to the following scheme:

record a: Before lip closure.

record b: In the period between lip closure and anterior palate closure in the

TABLE 1. Sex of patients and side of cleft.

<i>case #</i>	<i>sex</i>	<i>side of alv. cleft</i>	<i>case #</i>	<i>sex</i>	<i>side of alv. cleft</i>
a) "PSI" group			b) "EOG" group		
101	m	r	501	m	r
102	f	r	502	m	l
103	m	l	503	f	l
104	f	l	504	m	l
105	m	r	505	m	l
106	f	l	506	f	r
107	m	l	507	m	l
108	f	r	508	m	l
			509	m	l
			510	m	l

"PSI" group, and between lip closure and bone grafting in the "EOG" group.

record c: In the period between anterior palate closure and posterior palate closure in the "PSI" group, and between bone grafting and palate closure in the "EOG" group.

record d: Shortly after completion of palatal closure.

record e: Late (on the average 15 months) after completion of palatal closure.

The timing of operations and records in relation to the age of the patients is presented in Table 2. The following abbreviations for the operations are used:

L: Lip closure.

A: Anterior palate closure ("PSI" group).

G: Bone grafting ("EOG" group).

P: Palate closure; in the "PSI" group, this represents posterior palate closure.

The mean value and range of the eight initial (a-records) measurements for each group are recorded in Table 3.

Findings

Alveolar cleft configuration (L-X/G-X)

In the graphic representation of the alveolar cleft configuration, the antero-posterior relation of the greater to the lesser segment is symbolized by the vertical line G-X. The horizontal line L-X expresses the transverse relation. In an "open" situation of the cleft (positive L-X reading), the line is drawn to the right, in an "overlapping" situation (negative L-X reading) the line is drawn to the left (see Figure 3). For reasons of clarity, all cases are presented as left sided clefts.

"PSI" GROUP (TABLE 4)

Initial records (col. a) demonstrated an antero-posterior discrepancy (G-X) between 6 and 8 mm except in one case which showed an ideal end to end relationship (0.0/0.0 reading). Transversely (L-X), a discrepancy of over 10 mm was present in one case, of 5 to 10 mm in three cases and of less than 5 mm in four cases.

TABLE 2. Age of patients at time of operations and records (months).

<i>case #</i>	<i>a</i>	<i>L</i>	<i>b</i>	<i>A</i>	<i>c</i>	<i>P</i>	<i>d</i>	<i>e</i>
a) "PSI" group								
101	1	3½	5	6	9	10	12	—
102	2½	3½	5½	6	9	10	12	—
103	2	3	4	11	14	16	17	24
104	2	3	5	12	14	16	18	24
105	1	2	7	12	—	16	—	25
106	2	3	6	12	15	16	19	25
107	2	3	5	11	13	16	17	36
108	1	4	5	12	15	18	20	36
<i>case #</i>	<i>a</i>	<i>L</i>	<i>b</i>	<i>G</i>	<i>c</i>	<i>P</i>	<i>d</i>	<i>e</i>
b) "EOG" group								
501	½	½	5	7	8	13	17	—
502	6	6	11	11	12	20	22	—
503	1	1	7	10	12	13	—	26
504	1	1	4	5	—	14	—	26
505	3	5	6	8	12	14	19	27
506	½	½	4	6	8	9	12	29
507	½	½	2	4	9	10	11	32
508	1	1	4	7	9	13	14	34
509	½	½	8	12	15	17	19	37
510	½	½	5	8	10	14	16	39

Following lip closure (col. b), five of the eight cases exhibited an "overlapping" relationship (negative L-X reading), two cases still showed a positive L-X reading, and one case assumed an end to end relationship. The initially ideal relationship did not prevent slight collapse in case #105. In all cases except in case #105, the initial antero-posterior discrepancy (G-X) decreased. In two cases (#101 and #108), however, the G-X reading still amounted to 5 mm.

Following closure of the anterior palate (col. c), all cases exhibited a negative L-X reading. The anterior part of the greater segment overlapped the lesser segment more than in the records after lip closure in all cases but one. The antero-posterior distance G-X increased or stayed the same in six of the seven cases recorded.

Following closure of the posterior palate (col. d), the antero-posterior and transverse relationship did not change significantly.

Late records (col. e) revealed an alveolar cleft configuration ranging from an ideal end to end relationship to an "overlapping" situation of a -6 mm L-X reading. The G-X readings were, in general, smaller than in the previous records.

Comparison between the *initial* (col. a) and *late* (col. e) records suggested that there is no strict correlation between the alveolar cleft configuration before lip closure and at a later stage of development. The ideal end to end relationship in the late record of case #106 was related to an initial configuration which was also found to a high degree of similarity in other cases. However, the alveolar cleft configuration of case #103, which initially was very similar to case #106, resulted in a collapsed situation of a -3 mm L-X reading with a 3 mm antero-posterior deviation. It should be noted in the comparison between the initial and late

TABLE 3. Mean values and ranges of initial measurements of arch form (mm).

<i>measurement</i>	<i>"PSI" group</i>		<i>"EOG" group</i>	
	<i>mean</i>	<i>range</i>	<i>mean</i>	<i>range</i>
L-X	+4.5	0.0-(+10.5)	+8.0	(+4.0)-(+12.5)
G-X	6.0	0.0-8.0	7.0	3.5-14.0
L-Y	7.0	0.0-12.5	11.5	7.0-17.5
T-T'	31.5	28.5-34.0	34.5	31.0-40.0
M-M'	34.0	31.5-36.5	35.5	31.0-38.0
I-TT'	27.5	22.5-33.5	26.0	22.0-30.0
L-TT'	21.5	16.5-23.5	20.5	18.0-23.5
t-t'	11.0	8.0-13.5	12.5	10.5-17.5

records that the case with the widest initial cleft of this group (#108; L-X: 10.5 mm) exhibited the severest collapse in the late records (L-X: -6 mm).

"EOG" GROUP (TABLE 5)

Initial records (col. a) showed that the alveolar cleft configuration of these cases varied significantly more when compared with the "PSI" group; in general the cleft was wider in the "EOG" group. In three cases the L-X reading was over 10 mm, in six cases between 5-10 mm and in only one case below 5 mm. The antero-posterior discrepancy (G-X) ranged from 3.5 to 14 mm.

Following lip closure (col. b), none of the cases exhibited an overlapping relation. Two cases (#504 and #508) showed an end to end relationship and in two cases (#501 and #506) an antero-posterior deviation only (1 mm or less) was found. All other records demonstrated an "open" relationship.

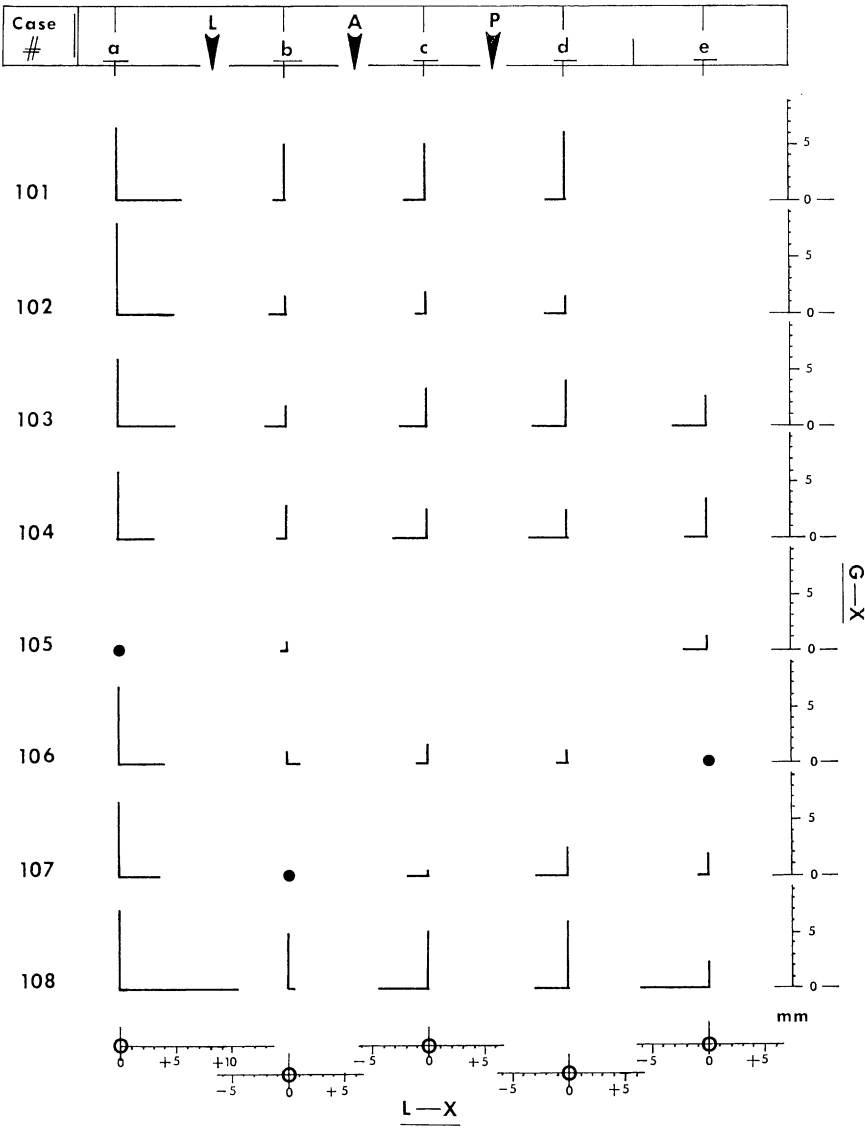
Following bone grafting (col. c), two additional cases (#506 and #510) assumed an end to end relationship. Case #502 still exhibited an "open" situation, the grafting having been performed in spite of the separation of the two segments. Four cases showed "overlapping", the upper limit being no more than -1.5 mm. In one of these four cases (#503), however, the antero-posterior discrepancy reached almost 5 mm.

Following closure of the palate (col. d), two of the three cases with an end to end relationship in the records following bone grafting maintained this configuration. All other cases demonstrated slight increase in the "overlapping" relationship.

Late records (col. e) revealed in two cases an end to end relationship (#508 and #510), and in two cases (#506 and #509) an alveolar cleft configuration which was very close to an ideal relationship. In the remaining four cases, collapse amounted to no more than 2 mm. The highest G-X reading of 2.5 mm was found in case #503.

There appeared to be no correlation between the alveolar cleft configuration

TABLE 4. "PSI" group: Alveolar cleft configuration ($\pm L-X/G-X$).



before lip closure and the alveolar cleft configuration at a later stage of development.

At the time of the investigation, intraoral radiographs had been taken of the alveolar cleft area. The time lapse between bone grafting and the latest intraoral films averaged 19 months, with a range of 10 to 31 months. In all ten cases a bony bridge was exhibited.

Transverse width of the alveolar cleft (L-Y, Table 6)

"PSI" GROUP

Initial records (col. a) revealed that the L-Y distance ranged in seven cases

TABLE 5. "EOG" group: Alveolar cleft configuration ($\pm L-X/G-X$).

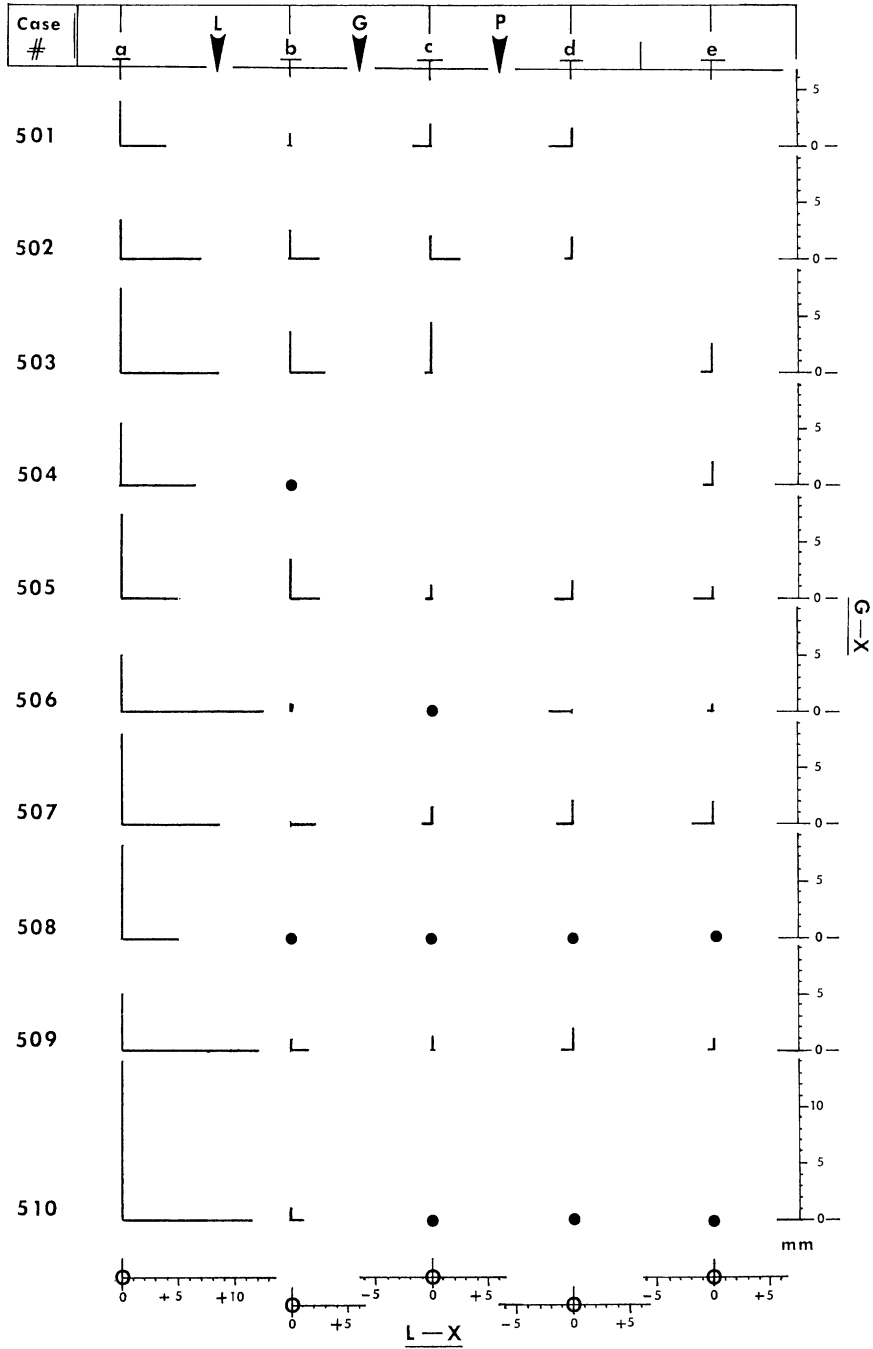


TABLE 6. "PSI" and "EOG" group: Transverse width of alveolar cleft (L-Y) in mm.

<i>case #</i>	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>
a) "PSI" group				
101	9.0	1.0	0.0	0.0
102	8.0	0.0	0.0	0.0
103	7.5	0.0	0.0	0.0
104	6.5	0.0	0.0	0.0
105	0.0	0.0	—	0.0*
106	5.5	1.0	0.0	0.0
107	7.0	0.0	0.0	0.0
108	12.5	3.5	0.0	0.0
b) "EOG" group				
501	7.0	0.0	0.0	0.0
502	12.0	9.0	5.0	0.0
503	11.5	6.5	3.5	0.0*
504	8.0	0.0	—	0.0*
505	7.0	5.0	0.0	0.0
506	15.0	0.0	0.0	0.0
507	12.0	2.0	0.0	0.0
508	10.5	0.0	0.0	0.0
509	15.0	2.0	1.5	0.0
510	17.5	1.5	0.0	0.0

* late (e-) records.

from 5.5 to 12.5 mm. One case of this group (#105) showed a 0.0 L-Y reading before lip closure.

Following lip closure (col. b), five of the eight cases exhibited anterior contact between the two segments.

Following closure of the anterior palate (col. c), all cases demonstrated contact.

"EOG" GROUP

Initial L-Y readings (col. a) ranged from 7.0 to 17.5 mm.

Following lip closure (col. b), only four of the ten cases exhibited anterior contact between the segments.

Following bone grafting (col. c), no contact was present in three cases.

Following closure of the palate (col. d), however, all cases manifested a 0.0 L-Y reading.

Transverse arch measurements (M-M' and T-T')

"PSI" GROUP (TABLE 7)

Initial records (col. a) revealed that the middle width (M-M') exceeded the posterior width (T-T') in six of the eight cases, the M-M' reading being 1.5 to 5.5 mm higher than the T-T' reading. One case (#101) exhibited equal M-M' and T-T' readings and in one case (#105) the posterior width was greater.

Following lip closure (col. b), five of the eight cases showed simultaneous decrease in the middle and posterior width, the largest decrease being 4 mm in the M-M' measurements of cases #103 and #108. The remaining cases demonstrated only slight or no changes in the transverse arch measurements (#105, #106 and #107). With respect to the alveolar cleft configuration of these cases (see Table 4), an end to end relationship was exhibited by case #105 before lip closure and by case #107 after lip closure. In case #106, the interrelation between the trans-

verse dimensions of the arch and the alveolar cleft configuration was not that obvious; however, there was still an "open" relationship present in spite of the fact that lip closure had been performed 3 months previous to the b- record.

Following closure of the anterior palate (col. c), the posterior width remained almost unchanged except in case #103, which demonstrated a considerable increase of 4.5 mm. In the middle width, no change or slight increase was exhibited by five cases. Two cases, #104 and #108 showed a decrease of 2 to 3 mm in the M-M' distance. This marked medial approximation of the two segments was reflected by corresponding changes in the alveolar cleft configuration (see Table 4).

Following closure of the posterior palate (col. d), five of the seven cases exhibited a decrease in posterior width. Unlike the simultaneous decrease in the middle and posterior width which predominated subsequent to lip closure, decrease of the T-T' width accompanied by decrease of the M-M' width could be found in only one case (#101) following posterior palatal closure. In all other instances, a decrease in posterior width was associated with an unchanged or with an increased M-M' distance.

Comparison between the *initial* (col. a) and *late* (col. e) models of the six recorded cases revealed a greater posterior width in the late records of four cases, whereas the measurements in two cases were less than the initial readings. The same observation could be made in relation to the middle width though not necessarily in the same cases.

"EOG" GROUP (TABLE 8)

Initial records (col. a) of this group showed that the middle width exceeded the posterior width in eight of ten cases, the M-M' readings being 0.5 to 3.0 mm higher than the T-T' readings. In the two cases with the reverse relation, the posterior width did not exceed the middle width by more than 2.5 mm.

Following lip closure (col. b), only two of the ten cases showed a simultaneous decrease in the middle and posterior width (#506 and #507). In the remaining eight cases an increase of the middle width was observed which was associated with an increase of the posterior width in six cases, and with an unchanged or very slightly decreased posterior width in two cases. Case #504 and #508 showed very high increases of 7.5 and 6.0 mm in the T-T' measurement and of 5.5 mm in the M-M' measurement.

Following bone grafting (col. c), an even distribution of increase and decrease in the M-M' as well as in the T-T' measurements was observed. In general, the changes did not exceed the limit of 2 mm.

Following closure of the palate (col. d), wide variation of the changes in the transverse dimensions was found in this group. Of the eight available records, three showed a decrease, four an increase and one no change in the posterior width. In the middle width, a smaller M-M' reading was found in five cases and a higher reading in three cases.

Comparison between the eight *initial* (col. a) and *late* (col. e) records revealed a higher posterior width in the late records of all cases. The late M-M' readings were greater than the initial values in six cases. In the two remaining cases, #506 and #507, the initial middle width had not been reached in the late records; one of these, case #507, exhibited a reading which was 5 mm less than the initial reading. This was the case with the most unfavorable L-X reading in the late records of the "EOG" group (see Table 5).

Antero-posterior arch measurements (I-TT' and L-TT')

"PSI" GROUP (TABLE 9)

From the *initial* (col. a) to the *late* (col. e) records a steady increase of both the sagittal length of the arch and the sagittal length of the lesser segment could

TABLE 7. "PSI" group: Middle (M-M') and posterior (T-T') arch width.

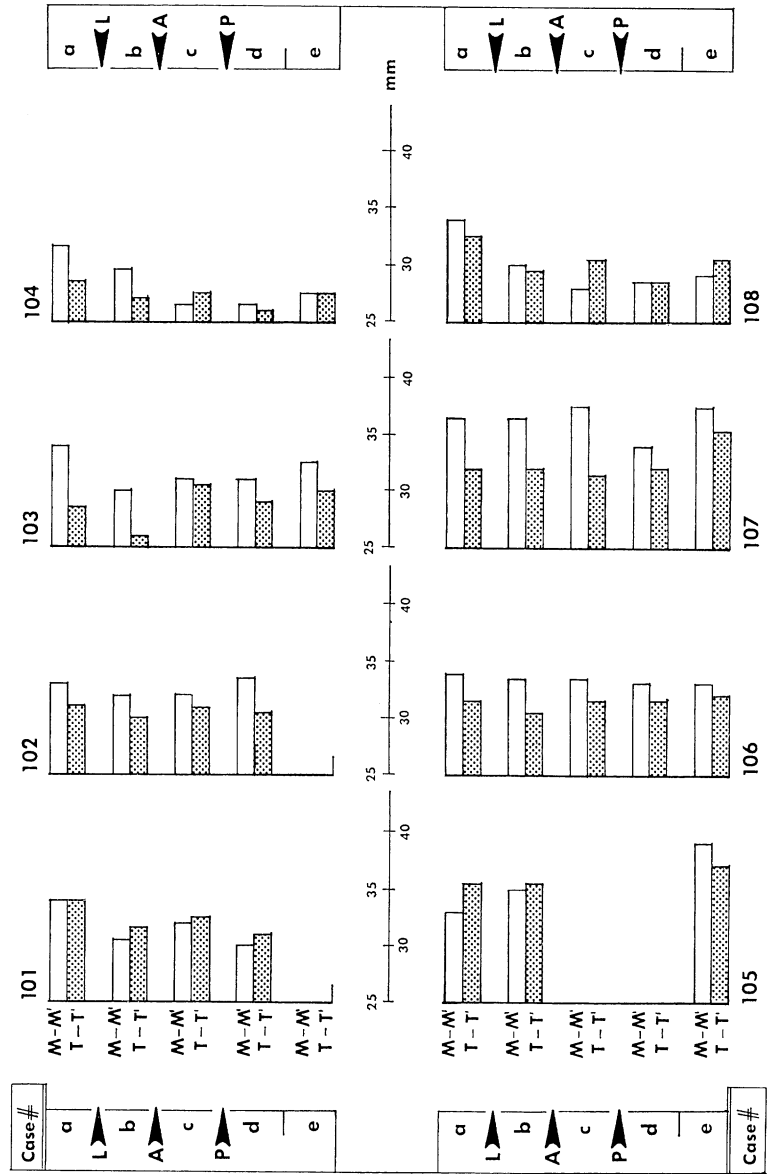


TABLE 8. "EOG" group: Middle (M-M') and posterior (T-T') arch width.

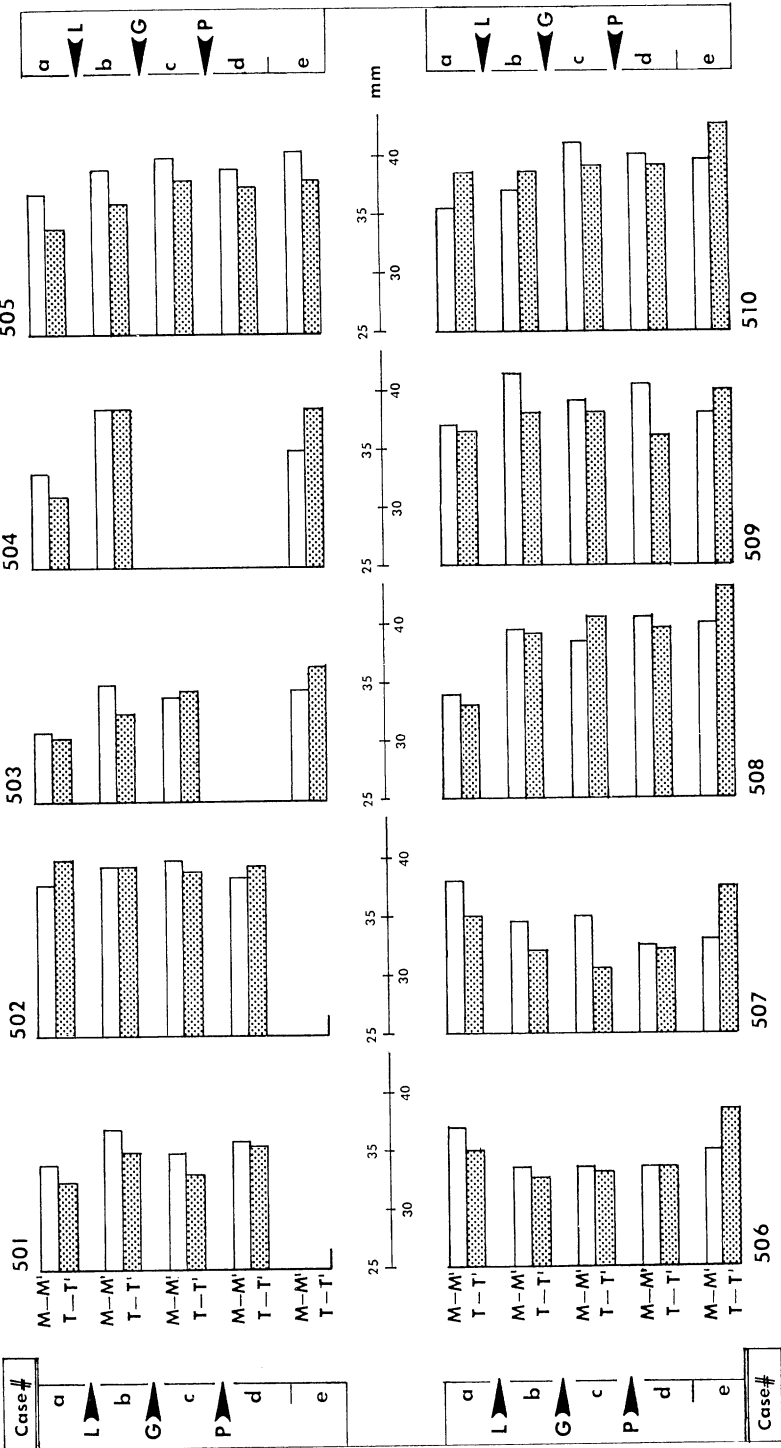
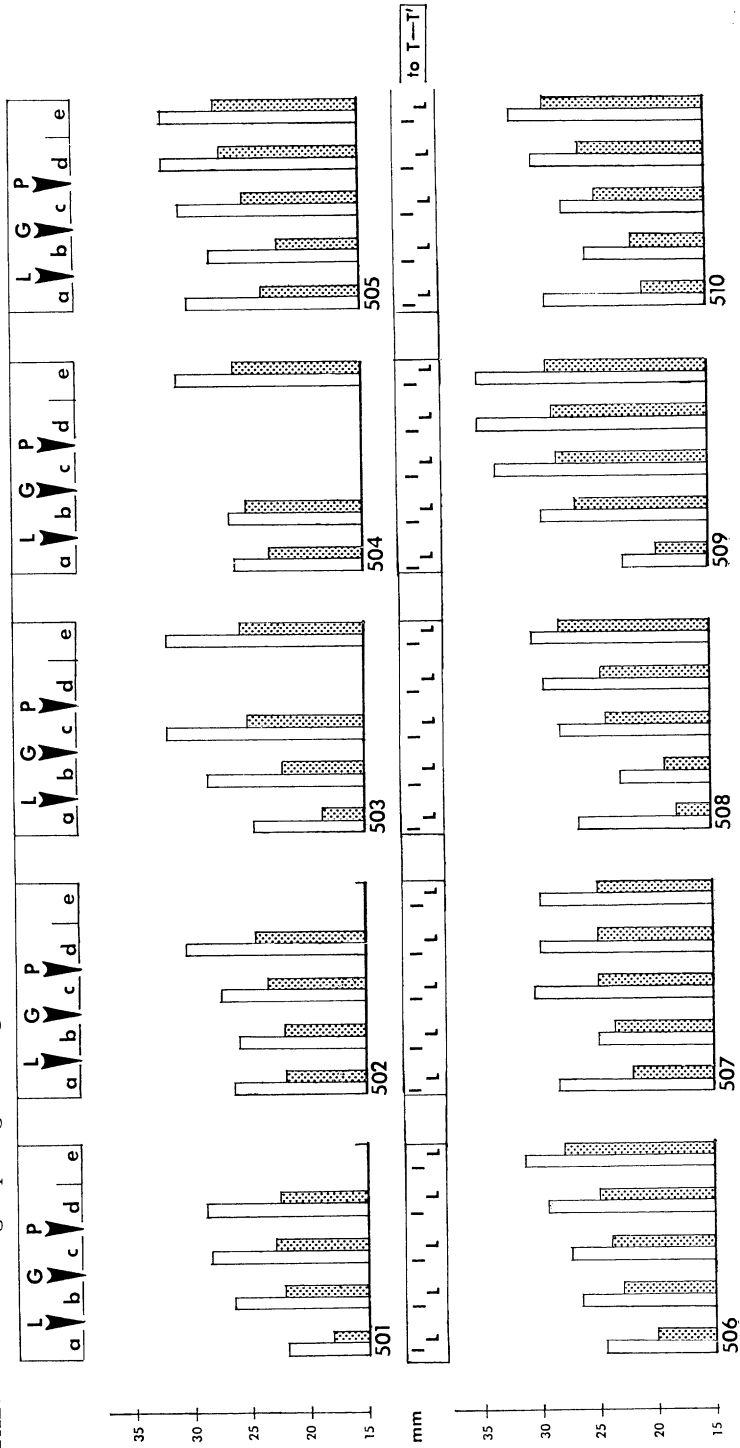


TABLE 10. "EOG" group: Sagittal length of the arch (I-TT') and of the lesser segment (L-TT').



be observed. This increase was temporarily interrupted in three cases at the time of posterior palatal closure (#103, #104 and #107).

Cases showing a continuous approximation of the L-TT' distance to the I-TT' distance from the initial to the late records, exhibited the best relationship of the segments in the region of the alveolar cleft (see Table 4). Case #106 demonstrated this pattern very clearly: the initial difference between the L-TT' and I-TT' measurement amounted to 5.5 mm and was reduced to half at the time the late records were taken. At the alveolar cleft, this case finally assumed an ideal end to end relationship. On the other hand, the I-TT'/L-TT' difference increased significantly in cases #104 and #108 from the initial to the late records; both cases manifested in the late records the greatest deviations in the region of the alveolar cleft.

"EOG" GROUP (TABLE 10)

The same interrelation as described for the previous group, was observed. The approximation after lip closure, related to a shortening of the I-TT' distance or to a relatively greater increase of the L-TT' distance, or to a combination of both, was maintained in case #506, #508 and #510 to the late records. On the other hand, the small I-TT'/L-TT' difference of case #504 and #507 in the records following lip closure was not preserved. Thus, the alveolar cleft configuration after lip closure altered from ideal or good to unfavorable (see Table 5).

Posterior cleft width (measurement t-t', Table 11)

In the *"PSI" group* the posterior cleft width was not evaluated in the records following anterior palatal closure, because in some cases the repair of the hard palate extended up or very close to the points t and t'. The extent of narrowing of the posterior cleft width subsequent to lip closure was not strictly correlated with the changes of the intertuberosity width (see Table 7). For example, cases with unaltered T-T' readings from the initial to the records following lip closure exhibited notable decreases in the t-t' distance (#105 and #107).

TABLE 11. "PSI" and "EOG" group: Posterior cleft width (t-t') in mm.

case #	record a	diff. record a to b	diff. record a to c
a) "PSI" group			
101	11.5	-6.5	
102	8.0	-4.0	
103	10.0	-2.5	
104	8.5	-3.5	
105	13.0	-4.0	
106	13.0	-2.0	
107	9.5	-3.5	
108	13.5	-4.0	
b) "EOG" group			
501	11.5	-2.5	-4.5
502	12.0	0.0	0.0
503	10.5	-5.5	-7.5
504	11.0	-0.5	—
505	11.5	-3.5	-2.5
506	12.5	-5.5	-6.0
507	12.0	-3.0	-5.5
508	12.0	-1.0	-1.0
509	17.5	-3.5	-5.5
510	15.0	-3.5	-4.5

In the "EOG" group, the $t-t'$ distance narrowed less than in the "PSI" group. The reduction of the posterior cleft width was more pronounced from the initial records to those following lip closure, than from the records following lip closure to those following bone grafting. No correlation between the changes of the $T-T'$ and $t-t'$ dimensions could be detected.

Discussion and Conclusions

The present measuring system was designed in relation to three anatomical landmarks (interincisal point and the bilateral tuberosity points) which were most reliably identified in casts of complete unilateral cleft lip and palate cases. The intertuberosity line ($T-T'$) was chosen as a base line and represented the posterior width of the arch. To record the width of the arch more anteriorly, the distance from the base line ($T-T'$) to the interincisal point (I) was bisected and a line parallel to the base line was constructed ($M-M'$). By relating the transverse line $M-M'$ to the antero-posterior dimension of the arch, the measurement of the middle width could be assessed accurately irrespective of arch form. Furthermore, the influence of growth or segmental movement on locating a measurement in this region could be reduced.

With the combined representation of the posterior ($T-T'$) and middle ($M-M'$) arch width, the type of transverse movement of the two segments could be exhibited. Simultaneous increase or decrease of both readings represented movement of the entire segments, whereas an independent change of either one of the two measurements represented rotational movement of one or both segments. For detailed analysis of changes in position of one or the other segment or both, a midline would have to be constructed in relation to facial structures which are not affected by changes in the upper jaw.

The topographical location of the two transverse measurements of the maxillary arch should be noted. The dimension of the posterior width ($T-T'$) is partly influenced by the inclination of the pterygoid plates (14), whereas the dimensions of the middle width ($M-M'$) is strongly affected by the size and shape of the inferior nasal concha (1).

By definition, the antero-posterior measurements along perpendiculars from the base line ($T-T'$) to point I in the greater segment and to point L in the lesser segment, were not strictly representative of the actual length of the segments themselves. Curvilinear measurements would have indicated growth changes in the length of the two segments far better. However, these measurements would not have given any information pertinent to the position of the anterior limit of the greater and of the lesser segment in space. One must realize, therefore, that alterations of the distances $I-TT'$ and $L-TT'$ do not necessarily represent growth changes, although they are affected by them. These measurements also may be changed by movement of the segments alone; for example, a severe inward rotation of the lesser segment will shorten the distance $L-TT'$ in spite of

the fact that the same segment may have grown slightly in length during the same period.

For the quantitative description of the alveolar cleft configuration, the relationship of the anterior borders of the two segments was assessed in the transverse and sagittal planes (L-X and G-X), and the transverse distance between the two segments (L-Y) was measured. A measurement of the commonly used "anterior width of the cleft" (2, 4, 8), which would be the distance G-L according to the labeling described previously, was rejected because it does not indicate the spatial relationship of the two segments. The line G-L is only related to two points, and these points can be located in any number of positions while maintaining the same distance.

The combination of the three readings L-Y, G-X and $\pm$ L-X renders comprehensive quantitative information about the spatial relationship of the two segments in the region of the alveolar cleft. Although the exact millimetric value of each measurement may not be of ultimate interest, the range of values for each measurement may serve as a basis for the establishment of a more refined grouping when large numbers of cases are evaluated. Thus, the broad classification of the alveolar cleft configuration into "approximation with/without contact" and "overlap", as suggested by Pruzansky and Aduss (8), could be elaborated further and more precisely.

This investigation was not undertaken with the intention of arriving at a qualitative assessment of various treatment procedures. The two samples served merely as a medium for evaluating the adequacy and potential of a method designed for comparative and longitudinal studies of maxillary arch form in unilateral cleft lip and palate cases. The ability to graphically represent the measurements permits one to visualize, at a glance, all of the different measurements of a particular case at any stage, and to better understand all of the various changes in the dimensions of the arch and the configuration of the alveolar cleft throughout development. A great number of correlations can be discovered when all measurements of the same case are compared. Although the different dimensions undoubtedly influence one another, one fact becomes very clear when all cases of the present study are reviewed: arch form in the early stages of development does not give a reliable clue as to what further changes, in direction and magnitude, can be expected. Wide variation among cases exists not only in the initial arch form, but also when the patterns of reaction to various treatment procedures and during the various stages of development are analyzed. A profound understanding of this variance would require a comprehensive evaluation of the many factors which influence arch form. Not one of the many morphologic and functional factors is taken into consideration in this study, and any interpretation or conclusion regarding the cases presented must be made with a complete awareness of this fact.

Summary

A new method has been designed for quantitative evaluation of arch form in infants with complete unilateral cleft lip and palate. The applicability of the method was demonstrated in a comparative longitudinal study of two groups of cases. Each group was exposed to a different approach to treatment; one group was treated by surgical interventions only, and in the other group early orthopedics in combination with bone grafting was applied. The scope of the new measurement system was discussed.

Acknowledgments: The author wishes to extend his appreciation to S. W. Rosenstein, D.D.S., M.S.D., and B. N. Jacobson, D.D.S., M.S., Children's Memorial Hospital Chicago, and M. Mazaheri, D.D.S., M.Sc., H. K. Cooper Institute of the Lancaster Cleft Palate Clinic, for their generosity in making their records available for this study. I also wish to express my sincere appreciation to R. M. Cole, Ph.D., whose help was invaluable.

References

1. ADUSS, H. and PRUZANSKY, S., The nasal cavity in complete unilateral cleft lip and palate. *Arch. Otolaryng.*, 85: 53-61, 1967.
2. ADUSS, H., and PRUZANSKY, S., Width of cleft at level of the tuberosities in complete unilateral cleft lip and palate. *Plast. Reconstr. Surg.*, 41: 113-123, 1968.
3. HARDING, R. L., Recent advances in cleft lip and palate habilitation. *J. Oral Surg., Anes. & Hosp. D. Serv.*, 21: 462-468, 1963.
4. HUDDART, A. G., An analysis of maxillary changes following presurgical dental orthopaedic treatment in unilateral cleft lip and palate cases. *Europ. Orthodont. Soc. Rep. Congr.* 43: 299-314, 1967.
5. KLING, A., Evaluation of results with reference to the bite. In *Early Treatment of Cleft Lip and Palate*, pp. 193-197, edited by R. Hotz. Hans Huber, Berne, 1964.
6. MAZAHERI, M., HARDING, R. L. and NANDA, S., The effect of surgery on maxillary growth and cleft width. *Plast. Reconstr. Surg.*, 40: 22-30, 1967.
7. MONROE, C. W., GRIFFITH, B. H., ROSENSTEIN, S. W., and JACOBSON, B. N., The correction and preservation of arch form in complete clefts of the palate and alveolar ridge. *Plast. Reconstr. Surg.* 41: 108-112, 1968.
8. PRUZANSKY, S., and ADUSS, H., Arch form in the deciduous occlusion in complete unilateral clefts. *Cleft Palate J.*, 1: 411-418, 1964.
9. PRUZANSKY, S., and ADUSS, H., Prevalence of arch collapse and malocclusion in complete unilateral cleft lip and palate. *Europ. Orthodont. Soc. Rep. Congr.*, 43: 365-382, 1967.
10. ROBERTSON, N. R. E., and JOLLEYS, A., Effects of early bone grafting in complete cleft of lip and palate. *Plast. Reconstr. Surg.* 42: 414-421, 1968.
11. ROSENSTEIN, S. W. and JACOBSON, B. N., Early maxillary orthopedics: a sequence of events. *Cleft Palate J.* 4: 197-204, 1967.
12. SILLMAN, J. H., Serial study of good occlusion from birth to 12 years of age. *Amer. J. Orthodont.* 37: 481-507, 1951.
13. STÖCKLI, P. W., A method for evaluation of maxillary arch form in complete unilateral cleft lip and palate cases. Master's thesis, Chicago: Northwestern University Dental School, 1969. pp. 23-24.
14. SUBTELNY, J. D., Width of the nasopharynx and related anatomic structures in normal and unoperated cleft palate children. *Amer. J. Orthodont.*, 41: 889-909, 1955.