Early Maxillary Orthopedics in Relation to Maxillary Cleft Repair by Periosteoplasty

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Part I. Periosteoplasty Procedures in Infancy

Since 1964, our Cleft Palate Center in Uppsala, Sweden has abandoned the procedure of primary bone grafting in cases of clefts involving the maxilla. Instead, we have adopted the periosteoplasty procedure as introduced by Skoog (*9*). The principle of the periosteoplasty procedure involves the establishment of periosteal continuity across the cleft utilizing local flaps from the bordering maxillary segments. As it proved necessary to keep the flaps suitably separated in order to obtain a larger volume of bone by periosteal repair, the technique was further developed for this purpose to include the use of oxidized regenerated cellulose (Surgicel®) to provide a scaffolding for bone formation. This procedure will lead to the formation of cancellous bone within the Surgicel®-hematoma mass, while the fabric itself will be completely absorbed.

Thus, in the repair of complete clefts, Skoog now recommends a two-stage procedure. The first stage represents a periosteal repair and is performed as part of the lip repair at the age of three months. In the second operation, the periosteum covering the new bone is elevated to the desired level where it is maintained by the packing of Surgicel®. This second operation has been performed three to fifteen months following the first operation and is generally carried out in conjunction with some other part of the patient's surgical rehabilitation. These surgical procedures were reported in detail by Skoog (*10*) in 1967.

New bone formation in the cleft area after periosteoplasty in the infant is rapid. Exploration of the alveolar cleft in bilateral cases on the side which was first repaired 3 months previously often reveals well-defined bone structures bridging the cleft. Intraoral roentgenograms taken 11 months postoperatively at the time of cleft palate repair demonstrated a solid bone union between the bony segments (Figure 1).

This operation has been carried out in both unilateral and bilateral complete clefts. The majority of patients was in the three-to-six-months age group. Our group of patients treated with the periosteoplasty procedure now includes 65 well-documented cases. These patients are followed up regularly on a long term basis, so that further comparison may be

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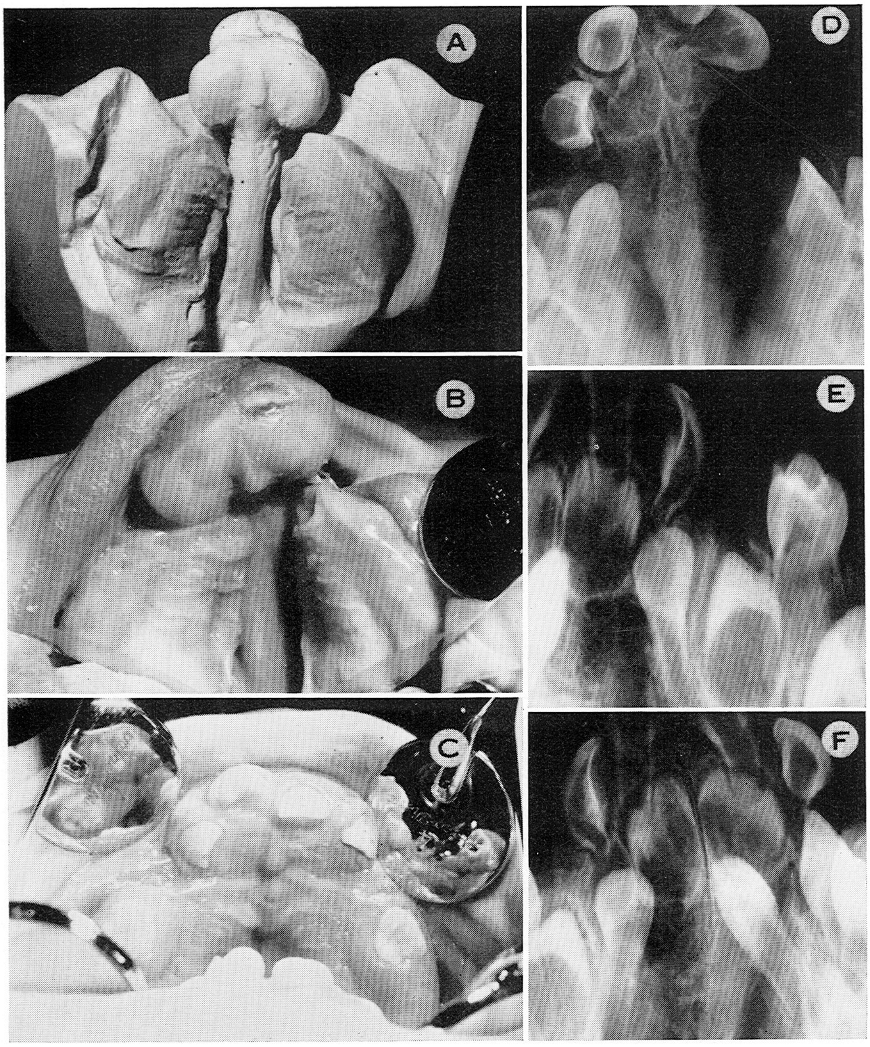

FIGURE 1. Case J.B.—Male patient with complete bilateral clefts. (A) Study model of upper jaw before lip closure and periosteoplasty stage I on the right side at three months of age. (B) At age 6 months, before lip repair and periosteoplasty stage I on the left side and periosteoplasty stage II on the right side. (C) Maxillary arch at age 20 months, 3 months after cleft palate repair. (D) Intraoral roentgenograms of the cleft areas on the left and right side at the age of 6 months. Note deviation of premaxilla to the right and the thin new bone bridge across the right alveolar cleft after lip repair and periosteoplasty stage I on the right side. (E) and (F) Roentgenograms of the right and left alveolar clefts at the age of 20 months, three months after cleft palate closure and periosteoplasty stage II on the left side. Note the amount of well-defined new bone in the former cleft areas.

made with another group of cleft lip and palate patients who has not been treated with the periosteoplasty procedure.

Since the surgical technique in the periosteoplasty was modified in 1966, with the introduction of the two stage procedure, no long term results are as yet available for analysis. However, the results have been very promising to date and to the best of our knowledge there is no clinical evidence of retarded growth of that part of the maxilla which was temporarily denuded of periosteum.

Part II. Presurgical Maxillary Orthopedics

The rapid formation of new bone in the cleft areas after periosteoplasty helps to stabilize the maxillary segments and prevent collapse; preventive maxillary orthopedics with passive appliances to maintain maxillary dimension therefore is not required as a routine in these cases. However, in cases of marked primary collapse of the lateral maxillary segments, presurgical maxillary orthopedic treatment is necessary to accomplish expansion.

The appliance used for this purpose is an acrylic plate coupled with a helical spring or a fan expansion screw. With these types of appliances anterior expansion may be achieved by lateral rotation of the maxillary segments without increasing the width of the palate across the tuberosities (*1*); thus there is no interference with the width of the cleft in the soft palate areas (Figure 2).

Presurgical correction of severe premaxillary protrusion is carried out by the use of an extraoral appliance, in the manner of Collito (*12*), to achieve retropositioning of the premaxillary segment. With this appliance a soft and easily adjustable pressure is applied to the premaxilla (Figure 3C).

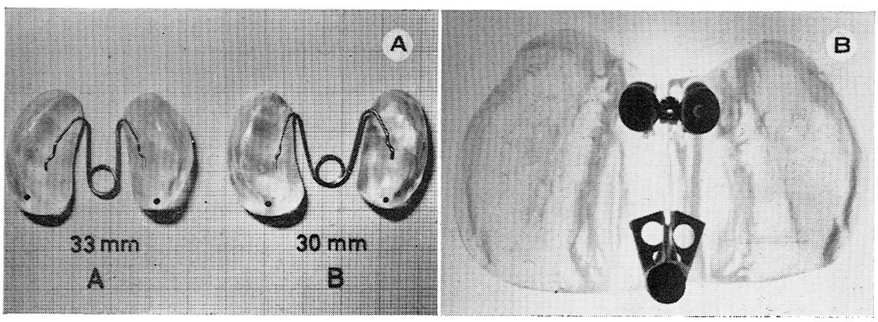

FIGURE 2. Acrylic plates used in preoperative oral orthopedics for anterior expansion and rotation of the maxillary lateral segments without increasing the width of the palate across the tuberosities. (A) Plate with helical spring ø 0.9 mm. A. Passive spring. The distance between the points at the level of tuberosities is 33 mm. B. Spring activated. The anterior halves of the plate separated 10 mm. Yet the distance between the posterior points has decreased to 30 mm. (B) Plate with Dentaurum fan expansion screw.

Several mechanisms have been suggested by which orthopedic backward movement of the premaxilla is accomplished without tilting of the segment; for example, by resorption of bone, by sliding of the premaxilla along the prevomerine suture, or by bending of the nasal septum itself with foreshortening of the premaxilla (*8*). Furthermore, the pressure against the premaxilla is easily transmitted to the rostrum of the sphenoid, resulting in either bone absorption or an actual backward shifting of the vomer on the sphenoid (*3*).

Our experience with the extraoral pressure appliance is that of rapid initial retropositioning of the premaxillary segment. This backward move-

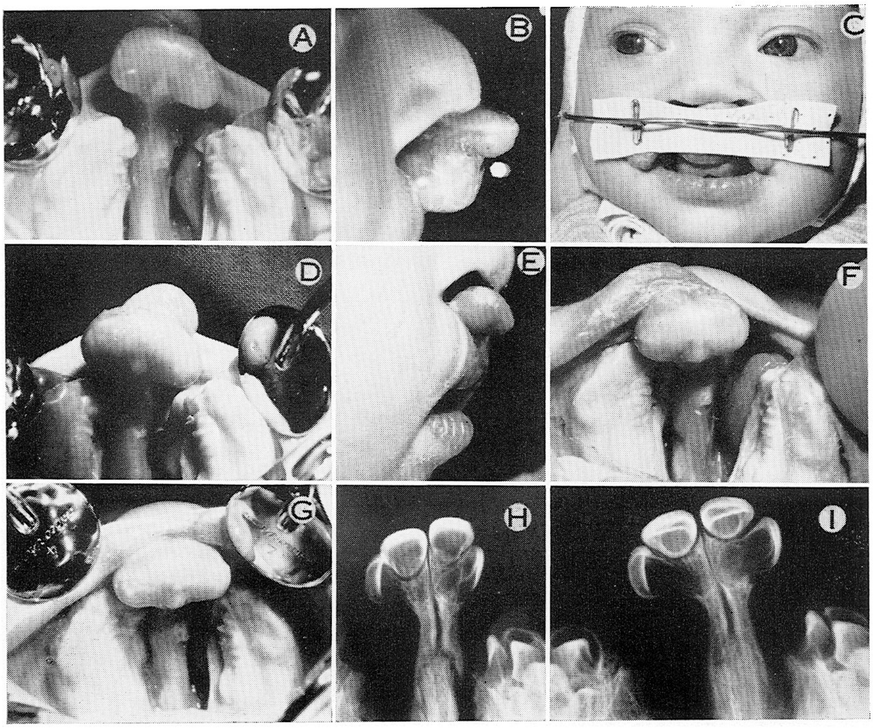

FIGURE 3. Case K.W. (A) and (B) Three months old girl with complete bilateral cleft and markedly protruding premaxilla before insertion of extraoral pressure appliance and intraoral expansion plate. (C) Extraoral pressure appliance, modified after Collito. (D) and (E) Age 4 months. After 4 weeks of preoperative oral orthopedic treatment the lateral maxillary segments had rotated outwards and the premaxilla was considerably retruded. A retention plate was then fitted and the patient ready for lip closure. (F) Age 6 months. After lip repair on the right side the premaxillary segment deviated to the right under the influence of lip pressure. (G) Age 9 months. 3 months after lip closure on the left side the premaxilla had moved into button contact with the lateral segments. Retention plate still worn. The patient now ready for periosteoplasty stage I on both sides. (H) Intraoral roentgenogram before pressure was applied on the premaxilla. Note wide-open prevomerine suture. (I) Intraoral roentgenogram after the use of extraoral pressure appliance for one month. Note narrowing of the prevomerine suture.

ment decreases in speed after some weeks. Roentgenograms of the premaxillary region taken before treatment in cases of complete bilateral clefts with protruded premaxilla often reveal a wide-open prevomerine suture, whereas roentgenograms taken after the use of the extraoral pressure appliance for 3 or 4 weeks in these same cases would show a distinct narrowing of the suture. After lip closure the prevomerine suture would be yet further narrowed (Figure 3H & I). We are anxious not to damage in any way the growth centers in the nasal septum through the use of too great a pressure with the extraoral appliances. Therefore we do not aim at perfect alignment of the segments prior to lip closure and periosteoplasty but instead to have these in acceptable position only. The result obtained by preoperative oral orthopedics in the child shown in Figure 3 demonstrates these principles.

Further moulding of the maxillary arch is thus taken over by pressures exerted by the repaired lip. By restoring continuity of the labial musculature a new environment is created to modify and guide bone growth. The subsequent problem of arch symmetry will be reviewed in due course at the age of 4 or 5.

Part III. Maxillary Orthopedics in the Deciduous Dentition

Indications. In our program, particular stress is laid on the maxillary orthopedic treatment in this period. There are several reasons why this approach has been adopted. First, the stage of dental occlusion may be regarded as an index to jaw development, thus collapse of the lateral maxillary segments may be reflected in the buccal crossbite of the posterior teeth (*6*). Neglect of crossbite with transversed forced bite can result in dysplastic asymmetry of the mandible with growth of the mandible diminishing on the side toward which the mandible is displaced (*2*). Second, there are other growth considerations, which make postponing maxillary orthopedic treatment to the late mixed or permanent, dentition periods undesirable. Third, from the phoniatric point of view, it is of great value to create good anatomical conditions for the speech organs, including the tongue, at an age when basic speech habits are being established rapidly. Fourth, the problems of dental caries are not so acute in the deciduous dentition period, and also the maxillary posterior teeth offer good anchorage for the appliance.

Appliance. For maxillary expansion in cleft palate cases in the deciduous dentition period, I have developed a type of fixed orthopedic appliance, the purpose being to move the lateral segments together with the teeth (Figure 4). When in use, the teeth are locked to the splints and are therefore immobilized. The spring is held in place by vertical tubes and by means of triangular locks in the cuspid and second deciduous molar regions. By activating the spring the lateral segments may be easily rotated or expanded. To reinforce anchorage in unilateral cases, the splint on the

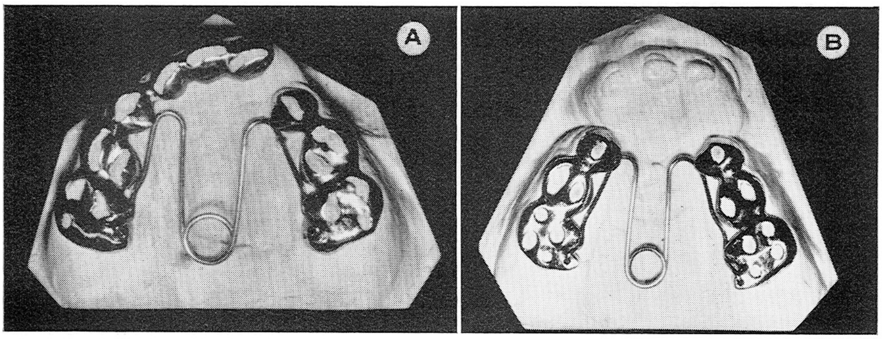

FIGURE 4. Appliance with fixed splints and helical spring θ 0–0.8 mm used for expansion and rotation of the lateral maxillary segments in the deciduous dentition of cleft palate conditions. (A) Appliance for unilateral clefts with reinforced anchorage. (B) Appliance used in bilateral clefts with reciprocal anchorage.

noncleft side is often extended to cover all the teeth in that segment whereas in bilateral cases the anchorage is reciprocal. By means of this appliance, the lateral segments can be brought back to a fairly normal position in a period of 2 or 3 months in the young subjects. After the segments have been adjusted to the correct position, it is necessary to maintain them in this position for about one year by using retention appliances. This is particularly important in overcoming the constricting effect of the repaired lip musculature. A case of complete bilateral clefts with severe collapse and treated in the deciduous dentition period according to these principles is shown in Figure 5.

Patient Material. The expansion appliance was first tried in 1963–64 in a small number of complete cleft patients at the age of 4. The results were encouraging. During the past two years, 11 patients have been treated in the deciduous dentition period according to these principles. No presurgical maxillary orthopedics had been carried out previously in these patients. In 10 of 11 cases, neither periosteoplasty nor bone grafting had been carried out. This group consisted of 7 Veau Class III complete unilateral cases and 3 Veau Class IV complete bilateral cases (Table 1). Mean age at which expansion was started was 5 years, 3 months; ranging from 4 years, 1 month to 6 years, 6 months. These cases are designated as the 10-patient group. The remaining case, J.L., a Veau Class IV complete bilateral patient, was operated upon according to the periosteoplasty procedure at the age of 2 months and 7 months respectively, and maxillary expansion was started at the age of 4½ years.

These cases have been recorded, both before and after maxillary expansion with study models, photographs, panoramic roentgenograms and cephalometric roentgenograms, according to the registration program which has been set up at the Cleft Palate Center in Uppsala for the purpose of adequate documentation on a long term follow-up basis.

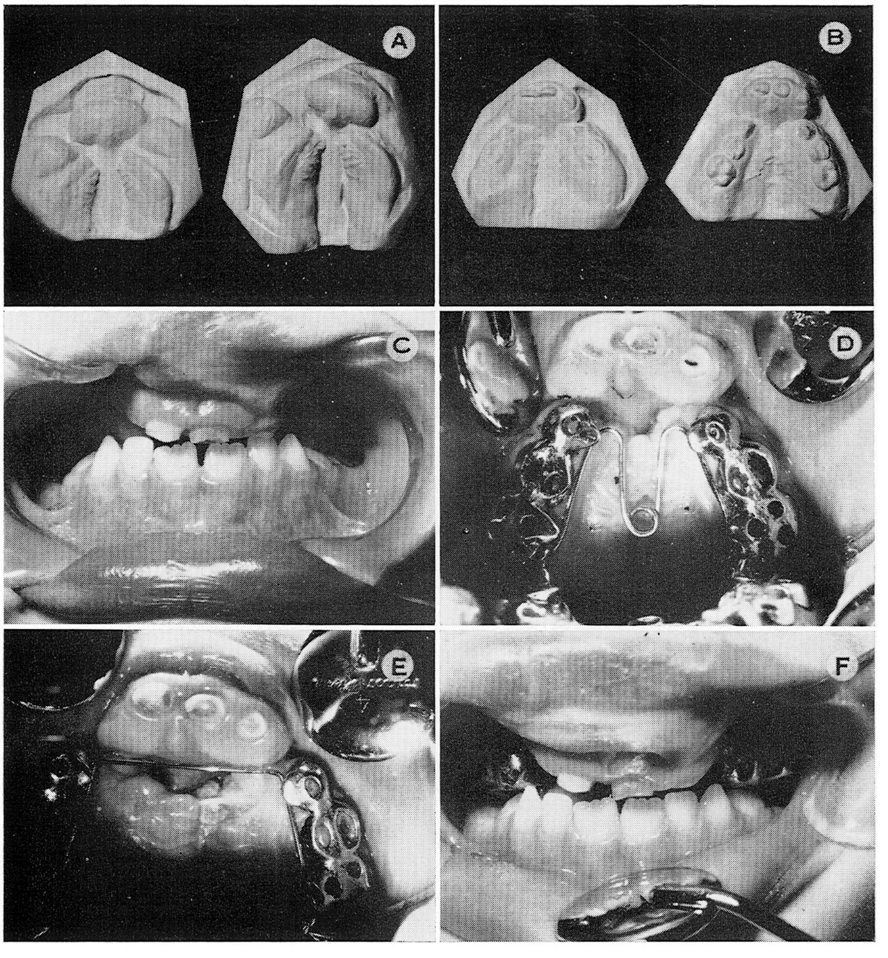

FIGURE 5. Case P.A.M.—Six year old boy with complete bilateral clefts. (A) Study models of upper jaw. *Left:* At age 3 months prior to lip surgery on the left side. *Right:* Three months later at time of surgery on the right side. The premaxilla rotated to the left by lip pressure after closure of the first side. (B) *Left:* Age 26 months. Before surgical repair of the secondary palate. Note lateral width of the premaxilla was much larger than the anterior space between the lateral segments. *Right:* In the deciduous dentition period increased collapse of the maxillary lateral segments. (C) At age 6 years, the maxillary lateral segments were locked behind the premaxillary segment and there was a severe bilateral total crossbite. (D) A fixed expansion appliance with reciprocal anchorage was inserted at the age of 6 years. (E) After 3 months of expansion and rotation the interdental width of the upper deciduous canines and second deciduous molars increased 15.4 mm and 10.9 mm respectively. The spring was then changed for a retention lingual arch which was worn for one year. As the premaxilla moved backward by lip pressure into the new space created between the lateral segments, the lingual arch had to be adjusted at certain intervals. (F) Occlusal view after expansion. Note correction of severe bilateral total crossbite.

TABLE 1. Type of cleft and prevalence of crossbite in the 10-patient group.

cleft type	*unilateral complete crossbite*	*bilateral complete crossbite*	*anterior crossbite*
Veau III	7	0	1
Veau IV	2	1	0

Method of Analysis

1. Study Models. The following measurements of interdental arch width were made on the study models before and after maxillary expansion by the use of a Mauser Calliper with an accuracy of 5/100 mm: a) the distance in mm between the left and right cusp tips of the upper deciduous

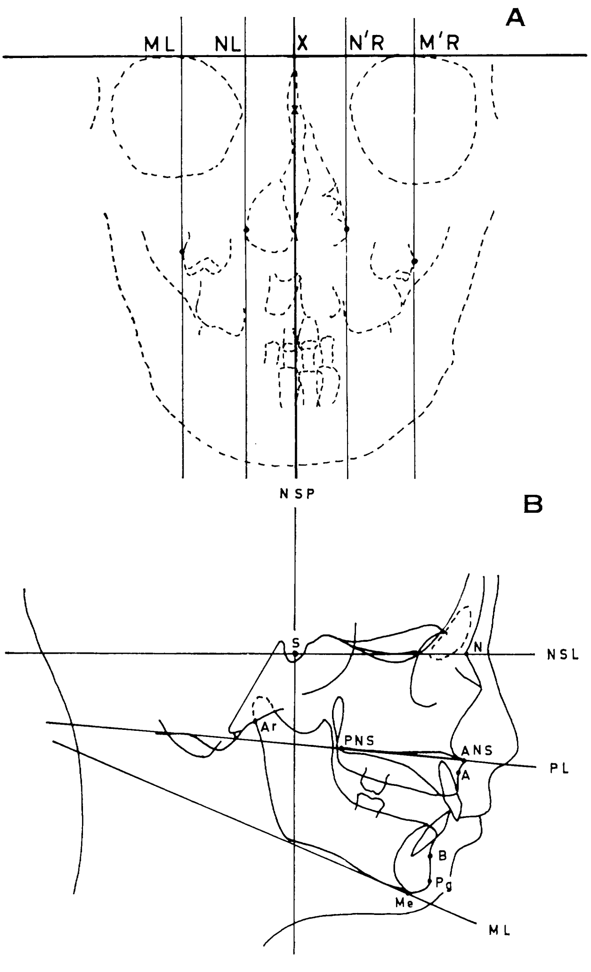

FIGURE 6. Anatomical landmarks and reference lines used in analysis of (A) postero-anterior and (B) lateral cephalometric roentgenograms. See text.

canines, and b) the distance in mm between the left and right mesiolingual cusp tips of the upper deciduous second molars.

All of the casts were obtained from alginate impressions.

2. Cephalometric Roentgenograms. The postero-anterior roentgenograms were analyzed in a manner similar to that described by Harvold (*7*), except that instead of using the zygomatico-frontal sutures as reference points the horizontal reference plane was formed by a line tangential to the superior margins of both orbits (Figure 6A). The vertical reference plane, the x-line, was formed by a line drawn through point X and perpendicular to the horizontal plane; point X being the center of the base of the crista Galli of the ethmoid, as located by inspection. The left and right lateral limits of the nasal cavity (NL, N′R) as well as the most lateral points of the unerupted left and right first permanent molars (ML, M′R) were also determined by inspection. Perpendiculars were then drawn from these points to the horizontal reference plane, and the following distances between the perpendiculars were measured on the horizontal plane, by the use of a Mauser Calliper with an accuracy of 5/100 mm.

a) The linear distance in mm between the left and right lateral walls of the nasal cavity, i.e. NL–N′R.

b) The linear distances in mm between the lateral walls of the nasal cavity to the midline, i.e. NL–X and N′R–X. In each case, the measurements of the width of the nasal cavity were taken to represent the distance between the maxillary components of the nasal cavity (*4*). With these measurements it was considered possible to evaluate the lateral displacement of the maxillary bones following expansion.

c) The linear distance between the buccal surfaces of the unerupted upper left and right first permanent molars, i.e. ML–M′R.

d) The linear distance between the upper left and right unerupted first permanent molars to the midline respectively, i.e. ML–X, M′R–X. These two measurements were taken to represent the position of an area of alveolar segment which were not directly subjected to the forces of the expansion appliance.

For analysis of the lateral cephalometric roentgenograms the following landmarks were used (Figure 6B):

A:	Subspinale	Me:	Menton
ANS:	Anterior Nasal Spine	N:	Nasion
Ar:	Articulare	PNS:	Posterior Nasal Spine
B:	Supramentale	Pg:	Pogonion

Reference planes:

NSL: Nasion—Sella line

ML: Mandibular plane, a line tangential to the lower border of the mandible, passing through Me.

PL: Palatal plane, a line drawn between ANS–PNS.

The following angular measurements were made on the lateral cephalometric roentgenograms:

1. S-N-A; 2. S-N-B; 3. S-N-Pg; 4. A-N-B; 5. NSL/PL; 6. NSL/ML; 7. N-S-Ar.

3. Statistical Analysis. The significance of the differences in linear and angular measurements before and after treatment in the 10-patient group was tested with the analysis of variance. Therefore in the 10-patient group the degrees of freedom for the F-tests were 1 and 9 ($df_1 = 1$ and $df_2 = 9$).

All measurements both in roentgenograms and on study models were repeated 2 times. The method of error for the linear measurements on the study models of maxillary intercuspid width and interdental width between the upper second deciduous molars was 0.08 and 0.04, respectively.

The method of error for the six linear measurements on each posteroanterior roentgenogram was mean 0.04 mm with a range of 0.03–0.07 mm.

The method of error for seven angular measurements on each lateral cephalometric roentgenogram was mean 0.09° ranging from 0.06–0.13°.

Findings

1. Measurements on Study Models. In the 10-patient group the increase in interdental arch width after maxillary expansion as measured between the upper deciduous canines was mean 9.2 ± 2.68 mm ranging from 5.3–15.4 mm. The increased intercuspid width was found to be statistically significant at the 0.005 level. The interdental width between the second deciduous molars in the same patients increased 3.4 – 10.9 mm and the mean was 7.3 ± 2.36 mm. Statistical analysis confirmed that these differences were significant at the 0.005 level (Table 2).

In the case J.L. where primary periosteoplasty was done, the interden-

TABLE 2. Analysis of study models before and after expansion

case	*distances in mm between right and left cusp tips of the upper deciduous canines*			*distances in mm between the right and left mesiolingual cusp tips of the upper second deciduous molars*		
	before expansion	*after expansion*	*increase in arch width*	*before expansion*	*after expansion*	*increase in arch width*
10-patient group (no primary periosteoplasty or bone-grafting)						
Mean (SD)	23.1 (3.02)	32.3 (3.07)	9.2 (2.68)	30.1 (2.13)	37.4 (2.98)	7.3 (2.36)
Range	18.3-30.3	29.0-39.8	5.3–15.4	27.0-33.9	33.8-43.3	3.4–10.9
method of error			0.078			0.035
F-test ($d.f._1 = 1$; $d.f._2 = 9$)			120.9*			106.1*
Case J.L. (primary periosteoplasty)	20.8	31.2	10.4	33.9	38.6	4.7
Case L.M. (noncleft, rapid expansion)	27.6	34.1	6.5	33.1	40.6	7.5

* Stat. signific. at 0.005 level.

TABLE 3. Increase in mm between right and left cusp tips of the upper deciduous canines after expansion. Expansion duration and rate of expansion.

case	*increase in maxillary arch width, mm*	*expansion, duration, months and days*	*expansion rate, mm per month*
10-patient group (no primary periosteoplasty or bonegrafting)			
Mean (SD)	9.2 (2.68)	2m15d	3.7 (0.77)
Range	5.3–15.4	1m24d–3m10d	2.7–5.1
Case J.L. (primary periosteoplasty)	10.4	4m26d	2.1 mm
Case L.M. (noncleft, rapid expansion)	6.5	1m0d	6.5 mm

tal width between the maxillary deciduous canines and upper second deciduous molars increased 10.4 mm and 4.7 mm respectively.

The mean expansion duration in the 10-patient group was 2 months 15 days with a range of 1 month 24 days to 3 months 10 days. In the case J.L. the active expansion took 4 months 26 days.

The increase in width of the maxillary arch in relation to the duration of expansion gives the expansion rate. In the 10-patient group the expansion rate in the region of the upper deciduous canines was mean 3.7 ± 0.8 mm per month and in the case J.L. 2.1 mm per month (Table 3).

2. Analysis of the postero-anterior cephalometric roentgenograms in the 10-patient group revealed that the linear distance between the left and right 1st permanent molars ML-M′R after expansion increased mean 2.4 ± 1.42 mm. The largest increase was 4.4 mm and the smallest was 0.9 mm. Statistical analysis revealed these changes to be significant at the 0.005 level (Table 4). If the distance between the upper 1st permanent molar of each side to midline was measured separately, it would be found that the distance from the upper left 1st permanent molar to midline ML-X was increased mean 1.2 ± 1.01 mm with a range of 0.0–3.4 mm—whereas that from the upper right 1st permanent molar M′R-X was increased mean 1.2 ± 0.97 mm, in a range of 0.0–2.9 mm (Table 4). The increased distance upper left first molar to midline was significant at the 0.025 level and the increase in distance upper right molar to midline was statistically significant at the 0.005 level.

In the case J.L. the increase in linear distance between the left and right 1st permanent molars ML-M′R was 2.7 mm. The distance ML-X increased 0.7 mm, whereas the distance M′R-X increased 2.0 mm.

The linear distances in mm between the left and right lateral walls of nasal cavity NL-N′R before and after expansion are recorded in Table 5. In the 10-patient group the width of the nasal cavity was increased mean 1.5 ± 0.76 mm with a range of 0.8–3.1 mm. The linear distance between the left lateral nasal wall to midline NL-X increased mean 0.7 ± 0.27 mm in a range of 0.1–1.7 mm; the distance between the right lateral nasal wall to midline N′R-X was increased mean 0.8 ± 0.53 mm in a range of 0.0–1.6

TABLE 4. Analysis of postero-anterior cephalometric roentgenograms before and after expansion.

case	*linear distance between the buccal surface of the upper left and right first molars, ML-M'R in mm*			*upper left first molar to midline, ML-X in mm*			*upper right first molar to midline, M'R-X in mm*		
	before expansion	*after expansion*	*increase in width*	*before expansion*	*after expansion*	*increase in width*	*before expansion*	*after expansion*	*increase in width*
10-patient group (no primary periosteoplasty or bonegrafting									
Mean (SD)	53.1 (4.08)	55.5 (3.61)	2.4 (1.42)	26.1 (2.64)	27.3 (2.30)	1.2 (1.01)	27.0 (2.16)	28.2 (2.08)	1.2 (0.97)
Range	48.4–59.0	49.6–59.9	0.9–4.4	22.8–30.1	24.2–31.2	0.0–3.4	25.0–31.0	25.4–31.5	0.0–2.9
method of error			0.054			0.037			0.039
F-test ($d.f._1 = 1$; $d.f._2 = 9$)			22.6*			8.37†			14.8*
Case J.L. (primary periosteoplasty)	58.0	60.7	2.7	28.8	29.5	0.7	29.2	31.2	2.0
Case L.M. (noncleft, rapid expansion	63.3	67.5	+4.2	32.6	36.1	+3.5	30.7	31.4	0.7

* Stat. signif. at 0.005 level.

† Stat. signif. at 0.025 level.

TABLE 5. Analysis of postero-anterior cephalometric roentgenograms before and after expansion.

case	*the linear measurement in mm between the left and right walls of the nasal cavity, NL-N'R*			*linear distance* left *nasal chamber to midline, NL-X in mm*			*linear distance* right *nasal chamber to midline, N'R-X in mm*		
	before expansion	*after expansion*	*increase in width*	*before expansion*	*after expansion*	*increase in width*	*before expansion*	*after expansion*	*increase in width*
10-patient group (no primary periosteoplasty or bonegrafting)									
Mean (SD)	23.6 (2.34)	25.1 (2.06)	1.5 (0.76)	11.5 (1.50)	12.2. (1.53)	0.7 (0.27)	12.2 (1.67)	13.0 (1.37)	0.8 (0.53)
Range	20.6–27.5	22.2–28.3	0.8–3.1	9.4–14.4	10.3–14.6	0.1–1.7	9.1–15.2	10.5–15.4	0–1.6
method of error			0.03			0.026			0.074
F-test ($d.f._1 = 1$; $d.f._2 = 9$)			36.0*			17.1*			20.3*
Case J.L. (primary periosteoplasty)	24.6	26.2	+1.6	12.5	12.6	+0.1	12.1	13.6	+1.5
Case L.M. (noncleft, rapid expansion)	30.0	35.2	+5.2	15.4	19.7	4.3	14.6	15.5	0.9

* Stat. signif. at 0.005 level.

TABLE 6. Greatest increase in width on right or left side to midline after expansion in complete unilateral crossbite.

number and site of unilateral crossbite	*upper* right *first molar to midline*	*upper* left *first molar to midline*	*upper* right *nasal chamber to midline*	*upper* left *nasal chamber to midline*
Right side 2	½ + ½†	½ + ½†	2	
Left side 7	3	4	3	4
N = 10 − 1*				

* One case Veau IV with bilateral crossbite excluded.
† Right and left equal.

mm. These three measures of increased width of the nasal cavity were all statistically significant at the 0.005 level. In the case J.L. the figures of increased width of the nasal cavity were 1.6 mm, 0.1 mm and 1.5 mm respectively (Table 5).

The results of the angular measurements on the lateral cephalometric roentgenograms before and after expansion are recorded in Tables 7 and 8. In the 10-patient group point A moved forward after expansion in 5 cases but in the other 5 cases there was a posterior positioning of point A as measured on the angle SNA. Mean was −0.1 ± 1.18° in a range of −1.9 to +1.4°. The F-tests indicated that these variations occurred by chance. In the case J.L. the angle SNA increased 0.5°, while in a noncleft rapid expansion case, L.M. age 9½ years, the angle SNA increased 3°.

In the 10-patient group the mandibular plane angle NSL/ML increased in 7 cases, decreased in 2 cases and was unchanged in one subject. The average increase was +0.6 ± 0.74° ranging from −0.7 to +1.6°. Statistically the tendency for the angle NSL/ML to increase was significant at

TABLE 7. Analysis of profile roentgenograms before and after expansion.

angular measurement	*10-patient group (no primary periosteoplasty or bonegrafting), mean age 5 yr, 3 mo.**			*Case J.L. (primary periosteoplasty), age 4 yr, 6 mo.**			*Case L.M. (non cleft, rapid expansion), age 9 yr, 6 mo.**		
	before expansion mean (SD)	*after expansion mean (SD)*	*diff. mean (SD)*	*before expansion*	*after expansion*	*diff.*	*before expansion*	*after expansion*	*diff.*
1. SNA	81.6	81.5	−0.1 (1.08)	75.5	76.0	+0.5	76.8	79.8	+3.0
2. SNB	75.8	75.0	−0.8 (1.18)	70.0	70.0	±0	78.8	76.0	−2.8
3. SNPg	75.7	75.0	−0.7 (1.09)	70.5	70.5	±0	80.5	77.5	−3.0
4. ANB	5.8	6.5	+0.7 (1.22)	5.5	6.0	+0.5	−2.0	3.8	+5.8
5. NSL/PL	8.6	8.4	−0.2 (1.57)	9.5	10.3	+0.8	3.3	4.0	+0.7
6. NSL/ML	36.0	36.6	+0.6 (0.74)	34.8	34.0	−0.8	35.0	38.5	+3.5
7. NSAr	119.1	119.9	+0.8 (1.36)	129.5	129.8	+0.3	117.5	119.5	+2.0

* Age at expansion start.

TABLE 8. Analysis of angular differences in profile roentgenograms before and after expansion.

10-patient group. (no primary periosteoplasty or bonegrafting)	*SNA*	*SNB*	*SNPg*	*ANB*	*NSL/PL*	*NSL/ML*	*NSAr*
Mean (SD)	−0.1 (1.08)	−0.8 (1.18)	−0.7 (1.09)	+0.7 (1.22)	−0.2 (1.57)	+0.6 (0.74)	+0.8 (1.36)
Range	−1.9–+1.4	−2.8–+1.0	−2.0–+1.0	−0.9–+3.5	−3.9–+2.0	−0.7–+1.6	−0.9–+3.2
method of error	0.061	0.086	0.082	0.099	0.134	0.071	0.079
F-test ($d.f._1 = 1_1$; $d.f._2 = 9$)	0.71	3.58†	3.80†	2.60	0.18	6.12*	2.12

* = signif. at 0.05 level.
† = signif. at 0.1 level.

the 0.05 level. As a consequence of this the angles SNB and SNPg decreased and the angles ANB and NSAr increased in the 10-patient group. In the case J.L. the angle NSL/ML decreased 0.8° after maxillary expansion. This finding agrees with those of Thörne (*11*), and David & Kronman (*5*) after rapid expansion in noncleft patients where the angle NSL/ML decreased in some instances.

The angle NSL/PL varied greatly in the 10-patient group in response to treatment. This angular measurement decreased in 6 cases and increased in 4 cases. Mean was -0.2 ± 1.57 in a range of -3.9 to $+2.0°$. Analysis of the data revealed these changes to be nonsignificant.

Discussion

The orthopedic correction of the maxilla in the deciduous dentition period as described here mainly consisted of lateral rotation and expansion of the maxillary alveolar segments. But there was also a lateral movement of the two ossa maxillae as registered at the left and right walls of the nasal cavity.

It is of great interest to compare the expansion duration in the 10-patient group with the case J.L. operated upon with the periosteoplasty procedure (Figure 7). The mean expansion duration for the 10-patient group was 2 months 15 days, ranging from 1 month 24 days to 3 months 10 days, while the expansion duration in the case J.L. was 4 months 26 days (Table 3). Thus maxillary expansion was achieved in a patient with bony union between the maxillary segments though the expansion duration was almost twice the 10-patient group. With the exception of the time factor the case J.L. did not differ from the 10-patient group. All the other figures in case J.L. were well within those of the 10-patient group.

When maxillary expansion in the case J.L. was almost finished, the cleft areas were explored. There were no ruptures of the bony bridges between the segments nor was there any other untoward effect (Figure 7e).

It appears from Tables 4 and 5 that the increase in distance between the upper first permanent left and right molars to midline in the 10-patient group is ranging from 0.0–3.4 mm and 0.0–2.9 respectively.

The increase in width of the left and right nasal chambers ranged from 0.1–1.7 mm and 0.0–1.6 mm respectively. The question arises whether the unilateral crossbite prevents maxillary lateral movement on the crossbite side, during the expansion.

In the Table 6 the patients in the 10-patient group have been divided into subranges according to the site of unilateral crossbite. (One case Veau Class IV with bilateral crossbite was excluded.) Of 7 patients with unilateral crossbite on the left side 4 had the greatest increase in width between upper left first molar to midline and left nasal chamber to midline after expansion. However, in three of the 7 patients the greatest increase in width was on the right side.

Thus the lateral crossbite in itself does not seem to influence the maxillary expansion in one way or the other.

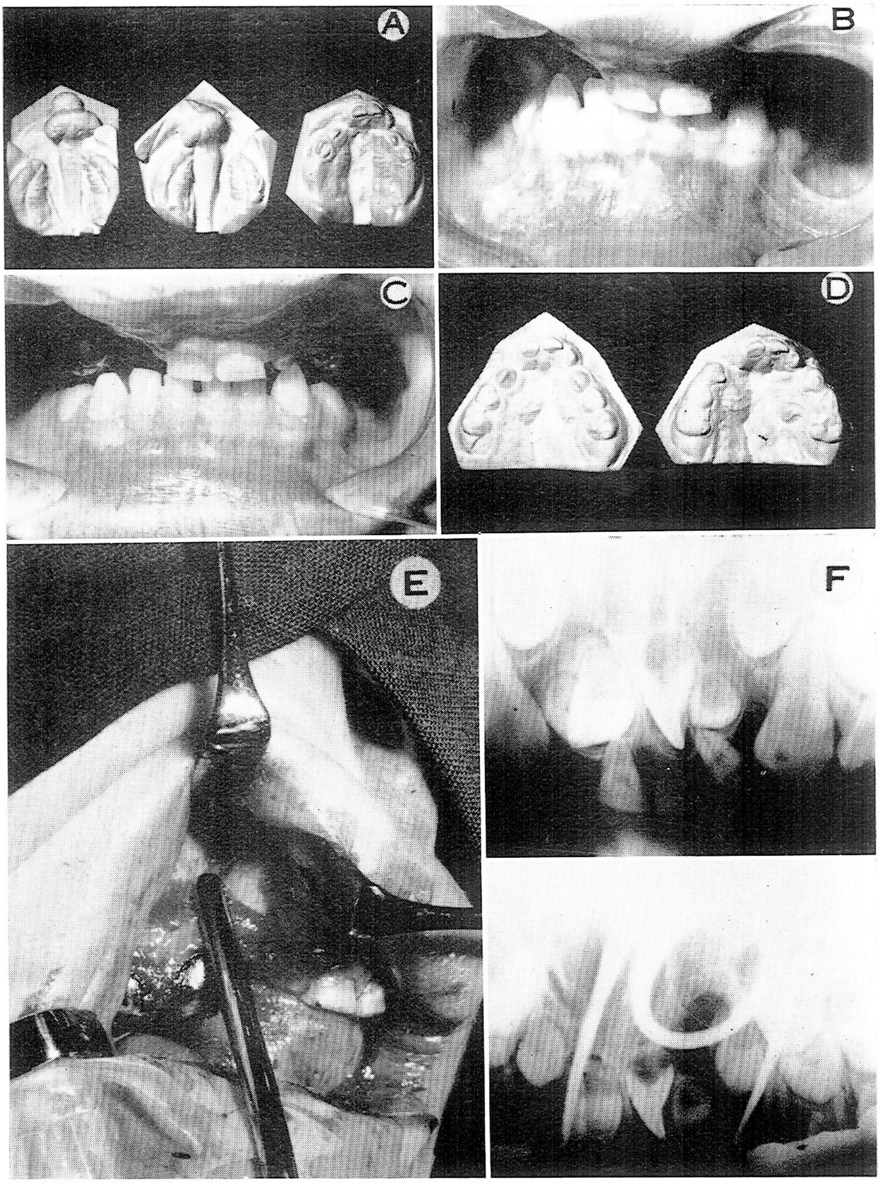

FIGURE 7. Case J.L.—4½ year old boy with complete bilateral clefts. Primary periosteoplasty was performed at the age of 2 and 7 months respectively. (A) Study models of upper jaw. *Left:* At age 2 months before lip closure and periosteoplasty on the right side. *Middle:* Before lip repair on the left side and periosteoplasty on both sides at age 7 months. *Right:* Age 21 months at time of cleft palate surgery. (B) At age 4 years 5 months in the deciduous dentition period. Complete buccal crossbite on the left side and partial buccal crossbite on the right side. (C) Correction of bilateral buccal crossbite after 4½ months of expansion. (D) Expansion and rotation of maxillary lateral segments increased interdental width of the maxillary deciduous canines and second deciduous molars 10.4 and 4.7 mm respectively. (E) Before the expansion was finished the cleft areas were explored. No rupture or other damage to the bone were to be found. (F) Panoramic roentgenograms before (upper) and after (lower) maxillary expansion. Note continuity of bone bridges across the alveolar clefts after expansion.

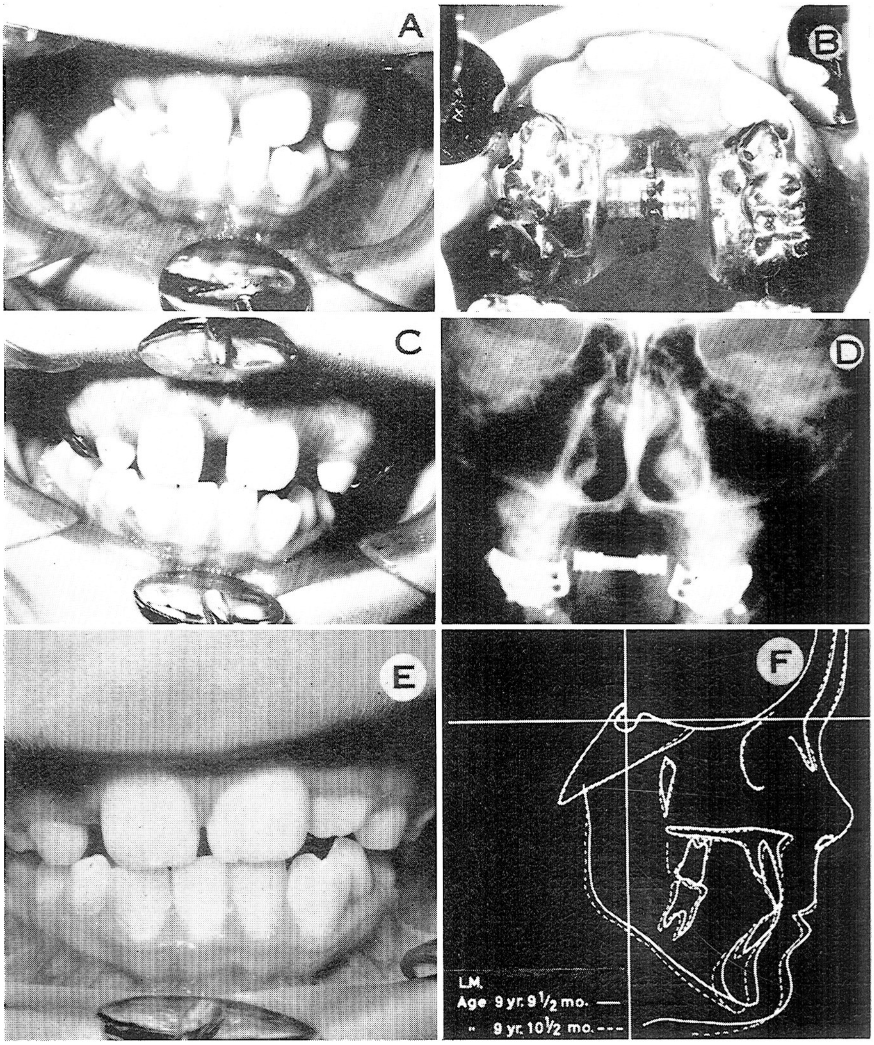

FIGURE 8. Case L.M.—9½ year old boy, noncleft patient in the mixed dentition period. (A) Severe maxillary arch deficiency in the anterior region, buccal crossbite on the right side, and anterior crossbite with a forward-right forced bite. Profile roentgenograms revealed that the SNB-angle was 77.5°. Thus the mandible was not in a forward position. (B) Fixed rigid split palate expansion appliance with jack-screw applied. The jack-screw was turned once daily, being moved 0.25 mm each time. (C) After one month sufficient expansion had been obtained. During the expansion an opening of 7 mm formed in the midline at the site of the intermaxillary suture. By moving the two maxillae apart the medial incisors were separated and both the lateral crossbite and the anterior crossbite were corrected, the latter spontaneously. The patient's breathing had also improved. (D) Postero-anterior roentgenogram after one month of expansion. Note separation of the two maxillae at the level of the nasal floor. (E) Suture opening was completely closed after 4 months by new bone formed in the suture area. The medial incisors had drifted almost into contact again. (F) Tracings of lateral cephalometric roentgenograms before and after expansion.

To evaluate whether the pressure applied to the maxillary segments was within safe limits, a comparison was made with the case L.M., a noncleft patient in the mixed dentition period in whom rapid expansion of the upper jaw was performed by the use of a fixed, rigid split-palate expansion appliance (Figure 8). The jackscrew was turned once daily with a resultant expansion of 0.25 mm each turn. The expansion duration in the case L.M. was exactly 1 month; and, the expansion rate was 6.5 mm per month (Tables 2–5).

It is obvious that less force is required to expand maxillary segments in cleft palate cases than to rapidly widen the intact maxillary suture and separate the maxillary halves in a noncleft patient. Yet the expansion rate in the rapid expansion patient L.M. was 6.5 mm per month whereas in the 10-patient group it was only 3.7 $\pm$ 0.77 mm per month. Therefore the expansion pressure applied in these patients with clefts must have been considerably less than the force exerted by the rapid expansion appliance.

Part IV. Periosteoplasty in the deciduous dentition

In the 10-patient group bone restoration of the maxillary clefts was accomplished by the periosteoplasty in 8 of the 10 cases after maxillary expansion had been completed. Of the remaining 2 patients one was bone-grafted and one is still on the waiting list for periosteoplasty. Of the 8 patients who had undergone the periosteoplasty procedure 3 were operated upon 12–14 months before follow-up, and the remaining 5 patients 7–9 months before. Of the 8 patients 6 were Veau Class III (complete unilaterale clefts) and 2 Veau Class IV (complete bilaterale clefts).

The result of periosteoplasty in the 10 clefts of these 8 patients was estimated separately with the help of intraoral roentgenograms and panoramic roentgenograms taken before surgery and postoperatively at certain intervals. One cleft showed complete bone restoration of the alveolar cleft area. In 4 clefts there was new bone formation within the cleft area including bony union between the segments but the anatomical restoration of the maxilla was incomplete in the cleft area. In 4 other clefts the roentgenograms revealed new bone, but no continous bone bridge across the cleft. The remaining one cleft showed no bone formation at all.

In the 3 cases followed for 12 months or more it was clearly demonstrated, that the formation of new bone after periosteoplasty continued over a relatively long period of time. Roentgenograms taken 12–14 months postoperatively in these 3 clefts revealed more new bone formation in the cleft area than roentgenograms taken 6–8 months after surgery.

This interesting observation may partly be explained by the gradual increase in calcification of osteoid tissue which would show the new bone more distinctly at later stages. It is also our impression that there was an actual increase in bone formation during the period of observation. Compared to the rapid formation of new bone in infancy, it seems however that the osteogenic capacity of the periosteum gradually decreases with age; the periosteoplasty procedure is therefore best carried out at the time of initial repair when the periosteum is most potent.

Summary

A report is presented on the early maxillary orthopedic procedures employed at the Cleft Palate Center of the University Hospital in Uppsala, Sweden. The sequence of the two-stage procedure in periosteoplasty is also outlined. The principles governing maxillary orthopedics in patients in the presurgical period and in the deciduous dentition period are discussed, and the techniques are described.

An account is given of the changes in the interdental maxillary arch width in a group of patients who had undergone maxillary orthopedic treatment in the decidous dentition. The increase in linear distance between the unerupted first permanent molars and the changes in width in the nasal cavity were measured on cephalometric roentgenograms. After maxillary expansion in this group of patients, bony restoration of the maxillary clefts was accomplished by the periosteoplasty procedure. Data, results, and conclusions are presented and discussed.

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References

1. 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.
2. Björk, A., Käkarnas tillväxt och utveckling i relation till kraniet i dess helhet, *Nord. klin. odont., Bind I:* 1–44. Forlaget for Faglitteratur, Köbenhavn, 1965.
3. Brauer, R. G., Observations and measurements of nonoperative setback of premaxilla in double cleft patients. *Plast. Reconstr. Surg., 35,* 148–159, 1965.
4. Coupe, T. B. and Subtelny, J. Daniel, Cleft palate-deficiency or displacement of tissue. *Plast. Reconstr. Surg., 26,* 600–612, 1960.
5. Davis, W. M. and Kronman, J. H., Anatomical changes induced by splitting of the midpalatal suture. *Angle Orthodont., 39,* 126–132, 1969.
6. Handelman, C. S. and Pruzansky, S., Occlusion and dental profile with complete bilateral cleft lip and palate. *Angle Orthodont., 38,* 185–198, 1968.
7. Harvold, E.: Cleft lip and palate. *Amer. J. Orthodont., 40,* 493–506, 1954.
8. Pruzansky, S.: Pre-surgical orthopedics and bone grafting for infants with cleft lip and palate: A dissent. *Cleft Palate J., 1,* 164–187, 1964.
9. Skoog, T., The use of periosteal flaps in the repair of the primary palate. *Cleft Palate J., 2,* 332–339, 1965.
10. Skoog, T., The use of periosteum and Surgicel® for bone restoration in congenital clefts of the maxilla. *Scand. J. Plast. Reconstr. Surg., 1,* 113–130, 1967.
11. Thörne, H., Experiences on widening the median maxillary suture. *Trans. Europ. Orthodont. Soc.,* 279–290, 1956.
12. Walker, Jr., J. C., Collito, M. B. et al., Physiologic considerations in cleft lip closure: The C-W technique. *Plast. Reconstr. Surg., 37,* 552–557, 1966.