Orthodontic Management of Unilateral Cleft Lip and Palate

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Experimental and clinical findings indicate that unfavorable adaptations of normal structures occur in children with clefts. It is postulated that these deviations from normal development are reversible and can be corrected or prevented by properly designed treatment. On this basis, five hypotheses were formulated and tested on the data from the subjects included in this study. The subjects consisted of 1) 16 children without clefts, 2) eight children who had complete unilateral clefts of the lip and palate but who had not received orthodontic treatment, and 3) 16 children who had complete unilateral clefts of the lip and palate and who had been treated by the described orthodontic procedures. The mean age for each group was 16 years. It was concluded that orthodontic treatment can be designed to: 1) counteract the forces which inhibit development of the maxillary alveolar process horizontally and vertically, 2) partially prevent the reduction in the forward growth of the maxilla, 3) provide adequate jaw and dental arch relationships, and 4) establish and maintain correct position of the maxillary segments.

KEY WORDS: Cleft palate, cleft lip, orthodontics

Introduction

Craniofacial growth and development in individuals with clefts of the lip and palate are influenced by irregularities in embryonic development, which cause tissue deficiencies, and by lip and palate surgery, which results in scar tissue and contractures. These influences on growth may act directly on developing structures or may indirectly affect growth patterns through deviant muscle activity. The commonly observed findings of irregularities in the nose, palate, and pharynx may affect speech, mastication, respiration, and the positioning and movements of the tongue.

Appropriate treatment planning requires that distinctions be made between embryonic defects and subsequent adaptations of normal structures to their altered environment. Therapy should focus on providing conditions for optimum development of structures that have normal potential for development. Those structures which cannot develop sufficiently should be brought into positions that minimize the effect of their inadequacies.

A clear distinction between the primary and secondary effects of clefts on the facial skeleton and soft tissues cannot be made in children. An experimental model was, therefore, developed in our Center and has been used in a series of experiments. A cleft condition was produced surgically in normal rhesus monkeys. A complete cleft of the bony palate and alveolar process was made, and one central and one lateral incisor were removed. The maxillary segments were moved medially in order to collapse the maxilla and to prevent healing of the bony cleft. The effects of these changes on the adjacent structures were studied. The findings showed that the structural deviations which developed were comparable to those that occur in children with unilateral clefts (Chierici et al., 1973, a,b). This indicates that structures with normal growth potential may develop abnormally in a cleft environment.

Background

Stages of Development in Unilateral Clefts. Clinical studies have demonstrated that the characteristic abnormalities vary among individuals and change significantly during growth. The following developmental stages should be distinguished: 1) infancy,

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before surgical closure of the lip, 2) post-surgical closure of the lip and palate until the shedding of the primary deciduous incisors, 3) early mixed dentition, and 4) adolescent growth period.

Stage 1: Infancy, before surgical closure of the lip

The characteristic defects in the infant are primarily localized in areas bordering the cleft. These include the nose, lip, hard and soft palates, and alveolar processes adjacent to the cleft.

The nasal septum, vomer, and alae are severely distorted in unilateral clefts. The nasal septum is usually curved over the cleft, and the conchae on the side of the cleft are smaller than on the noncleft side.

The orbicularis oris musculature is interrupted, and muscle mass and fiber direction vary considerably (Fara, *1968*). There is much individual variation in width and position of the shelves of the hard palate (Garber, *1949*; Coupe and Subtelny, 1960). The soft palate also demonstrates wide variation in the extent and direction of muscle fibers (Ruding, 1964; Kriens, 1969; Latham et al., 1980). The anterior part of the large maxillary segment is usually protrusive and deflected to the noncleft side (Harvold, 1954; Pruzansky, 1955). The alveolar processes in the cleft margins are usually somewhat deficient in vertical height.

Stage 2: Post-surgical closure of the lip and palate until the shedding of the deciduous incisors

The surgically closed lip and palate approximate normal lip and palate morphology. However, the repaired lip and palate will not necessarily continue to develop favorably in either morphology or function because of neuromuscular abnormalities and scar tissue. The molding effect of the surgically restored lip on the protruding large maxillary segment has been well documented (Harvold, 1954; Pruzansky, 1955).

Medial movement of the lateral segments, particularly the lesser segment, subsequent to lip and palate closure, is also a consistent finding. The maxillary segments usually contact each other in the alveolar region by ages four to five (Harvold, 1947; Pruzansky and Aduss, 1964, 1967). This contact counteracts further medial movement of the segments unless teeth and subsequent bone in the cleft are lost. The degree of maxillary width reduction is consequently closely related to the development of the alveolar processes; and this, in turn, is determined to a large extent by the number, position, size, and shape of the teeth in that area (Harvold, 1954). Early removal of teeth in the cleft is, therefore, contraindicated.

The deciduous dentition is usually complete. Supernumerary teeth in the cleft occur more frequently than congenital absence of the teeth. The alveolar processes are generally well developed and stable as long as the deciduous dentition is intact. Crossbite of one or more teeth on the cleft side is the most usual deviation from normal dental arch form during this stage.

Stage 3: Early mixed dentition

The transition from deciduous to mixed dentition is characterized by an increase in discrepancy between maxillary and mandibular sizes and dental arches (Harvold, 1954; Ross, 1970; Bergland and Sidhu, 1974; Bishana et al., 1979). The permanent lateral incisor on the side of the cleft is frequently missing, and there is a high incidence of congenital absence of bicuspids (Bohn, 1963). The central incisor on the cleft side is on an average 10% narrower than the other central incisor, and its shape is often abnormal (Harvold, 1947). The path of eruption of the central incisors is lingual and toward the cleft, and these teeth are usually severely rotated as well (Subtelny, 1966). Further medial displacement of the alveolar process on the cleft side and an increased incidence of anterior crossbite usually occur during this stage.

When the maxillary segments are displaced medially, the tongue cannot be accommodated in its normal position in the palate. The position that the tongue acquires becomes decisive for the pattern of further development of the maxilla as well as of the mandible. If nasal respiration is adequate, the tongue may be positioned below and in contact with the occlusal surfaces of the maxillary teeth during rest. When this occurs, alveolar height is inhibited even in the absence of restrictive scar tissue. If nasal respiration is impeded, the tongue may assume a low posture in order to facilitate oral respiration. If the tongue in this low position does not rest under the occlusal surfaces of the maxillary teeth, the alveolar height will increase and result in a progressive lowering of the mandible, a more open gonial angle, and a more retruded position of the chin (Harvold, 1954; Harvold et al., 1972).

Studies on skeletal morphology and size in unilateral cleft lip and palate have shown few differences from average values for normals in the late deciduous and early mixed dentition stages (Mazaheri et al., 1967; Aduss, 1971; Nakamura, 1972; Mapes et al., 1974; Krogman, 1975). However, at this age, retrusiveness of the anterior part of the maxilla as well as progressive retrusiveness occurring during later growth have been reported (Harvold, 1954; Lande, 1970; Hayashi et al., 1976).

Stage 4: Adolescent growth period

In non-cleft children, the average yearly increase in mandibular length from six to 16 years of age is 2.5 mm. The corresponding figure for the maxilla is 1.5 mm (Harvold, 1963). Adjustments for this difference in anterior growth of the jaws take place in the alveolar processes and primarily by downward and forward development of the maxillary alveolar process. In cleft lip and palate, the adjustment mechanism is often impeded (Ross, 1970), and this becomes an important factor in jaw disproportions during active growth periods, particularly during adolescent growth.

It has been shown that forward growth of the maxilla in non-cleft children can be reduced by posteriorly directed forces such as those provided by an activator (Harvold and Vargervik, 1971) or by extraoral traction (Wieslander, 1963; Baumrind et al., 1979). Similarly, a tight, scarred lip and scar tissue bands in the palate can impede the forward growth of the entire maxilla as well as of the alveolar process. The retrusiveness of the maxilla and maxillary alveolar process becomes more pronounced during this stage.

Experimental findings. Studies on young and adolescent rhesus monkeys have demonstrated that conditions similar to those usually observed in individuals with unilateral clefts are produced by spontaneous adaptations of normal tissues to a surgically produced cleft, by loss of teeth in the cleft area, and by medial movement of the cleft segment. The ala nasi move laterally and become flattened on the cleft side. The ridge of the nose and the nasal septum, which, at the onset of the experiment, were straight, curve over the cleft, and the conchae on the side of the septum convexity become smaller. The maxillary incisors tilt lingually and deviate toward the cleft, resulting in an anterior crossbite (Chierici et al., 1973a) (Figure 1). In the mandible, the incisors become more upright and have a tendency to become crowded; the anterior alveolar height increases, and the gonial angle is more open (Chierici et al., 1973b).

These findings led to the conclusion that the palatal tilting of the maxillary incisors and the mandibular changes were adaptations to a lowered postural position of the mandible and tongue. This lowered position was necessitated by tongue displacement, which was caused by the induced reduction of the palatal vault and arch width. These structural adaptations can be assumed to be reversible since they occurred in response to well-defined environmental changes. It is postulated that similar adaptations of normal

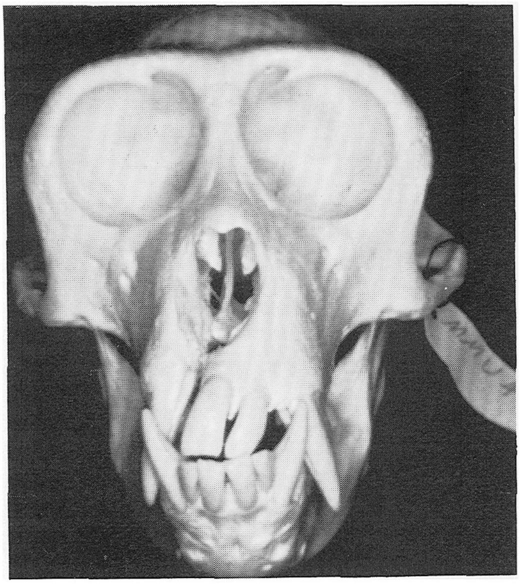


FIGURE 1. The skull of a rhesus monkey with a surgically produced cleft in the alveolar process and palate. The smaller segment is medially rotated and the teeth behind the canines are in crossbite. The nasal septum became curved over the cleft. The maxillary incisors became lingually inclined and deviated toward the cleft, and an anterior crossbite developed.

structures occur in children with clefts and that these deviations from normal development can be prevented or corrected by properly designed jaw orthopedic and orthodontic treatment. This postulate is further substantiated by clinical observations which indicate that, in the absence of surgery, there usually is potential for adequate development and forward growth of the segments in the cleft maxilla (Ortiz-Monasterio et al., 1959; Atherton, 1967; Bishara et al., 1976).

Method

HYPOTHESES. The following hypotheses are based on the postulate that reversal of the undesirable structural adaptations is possible by properly designed orthodontic treatment:

1. The inhibiting effects of scar tissue and of irregularities in direction of tooth eruption on the forward development of the maxillary alveolar process can be counteracted by applying protrusive and extrusive forces on the alveolar process and teeth.
2. The inhibiting effect that scarring and a tight lip may have on the forward growth of the maxilla can be partially counteracted.
3. The development of a dental crossbite and relative mandibular prognathism can be prevented in several ways: by extrusion of maxillary teeth which will lower and retrude the chin; by reduction of the mandibular dental arch; by anterior movement of retruded maxillary incisors; or by a combination of these factors.
4. The opening of the gonial angle, which is secondary to lowering of the chin, can be counteracted by increasing the size of the palatal vault to accommodate the tongue.
5. Medial collapse of the maxillary segments can be corrected by lateral repositioning of the entire segments.

These hypotheses have been tested on clinical data.

SUBJECTS. The subjects, whose ages ranged from 14 years, 9 months, to 18 years, three months, were categorized in three groups:

1. Sixteen individuals with good dental occlusion and no clefts.
2. Eight individuals who had complete unilateral clefts of the lip and palate but who had not had any orthodontic treatment when the records were taken. (These individuals had not been followed in the Center but were referred for consultation, or treatment, or both at this age.)
3. Sixteen individuals who had complete unilateral clefts of the lip and palate and who had received orthodontic treatment at the Center. Records had also been obtained prior to the start of treatment. The distribution of ages and sexes in the three groups is shown in Table 1.

The orthodontically treated and untreated individuals with clefts of the lip and palate represented a variety of surgical techniques performed by different surgeons. They were referred to the Center because they presented special treatment problems. Therefore, they constitute biased samples. The major factors contributing to the special treatment problems were excessive scarring, a high incidence of missing teeth either congenitally absent or prematurely lost, and maxillary deficiency. It was concluded that Groups 2 and 3 were comparable, however, with the main difference being orthodontic treatment. The criterion for inclusion in this study was availability of records at the appropriate ages. The material from these patients is considered suitable for testing of the hypotheses. However, the cephalometric measurements may not be

TABLE 1. Distribution of Subjects According to Group, Age, and Sex

	GROUP 1		*GROUP 2*	*GROUP 3*			
				Subjects with Treated Clefts			
	Non-cleft Controls		*Subjects with Untreated Clefts*	*Before Treatment*		*After Treatment*	
Sex	F	M	M	F	M	F	M
Number	8	8	8	8	8	8	8
Mean Age	16–3	16–6	16–2	8–1	7–2	167–2	16–0
Age Range	14–9	15–1	14–10	7–0	6–1	14–9	14–2
	to	to	to	to	to	to	to
	17–5	17–5	17–8	10–3	8–7	18–3	17–3

representative of the population of individuals with unilateral clefts of the lip and palate. The first group served as controls, whereas the second group demonstrated the development of craniofacial structures in the absence of orthodontic treatment. The third group was compared to the first and second groups in order to test the hypotheses. The average age of the subjects in all three groups at the time of group comparisons was approximately 16 years. Standard statistical methods were applied. Pretreatment records of the 16 children who received orthodontic treatment at the Center were also obtained and compared with available data on non-cleft children of the same age from the Burlington Growth Center.

Orthodontic Treatment Procedures. The orthodontic treatment was started when the children were in the stage of early mixed dentition at a mean age of eight years, one month, for the girls and of seven years, two months, for the boys. The first phase of the treatment involved lateral repositioning of the maxillary segment on the cleft side. The segment was medially rotated in all 16 cases. A lingual wire (.036″) was used to produce the main expansion force. This wire was attached to molar bands on either the second deciduous molars or the first permanent molars (Figure 2). The distal ends of the wire were situated in vertical tubes with a diameter of .036″ placed distolingually on the molar band. A loop was welded to the mesiolingual portion of the band and served as a lock to prevent dislodging of the wire. A .018″ wire was attached to the main wire and adjusted to contact the teeth in the segment to be moved. As the segment moved laterally, this spring followed and distributed the expansion forces to the teeth anterior to the anchor tooth.

It is known that the fulcrum of rotation of the segment is located at the tuberosity of the maxilla during the medial collapse of the segment as well as during lateral repositioning (Figure 3). A 5 to 6 mm expansion between the molars was incorporated in the main wire in order to achieve segment rotation.

It should be noted that segment repositioning cannot be achieved with a labial wire as this will always expand more in the molar than in the cuspid area. Evidence for segment repositioning rather than tooth movements was obtained from cephalometric x-rays in the postero-anterior view (Figure 4).

The second phase of treatment, extrusion of maxillary teeth, was indicated in only a few of these cases because correction of the

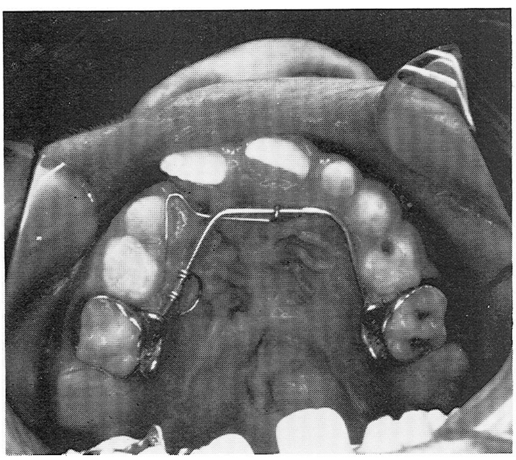


FIGURE 2. The conventionally used lingual wire with a lateral expansion spring for segment rotation is attached to the second deciduous molars in this seven-year-old child with a complete unilateral cleft.

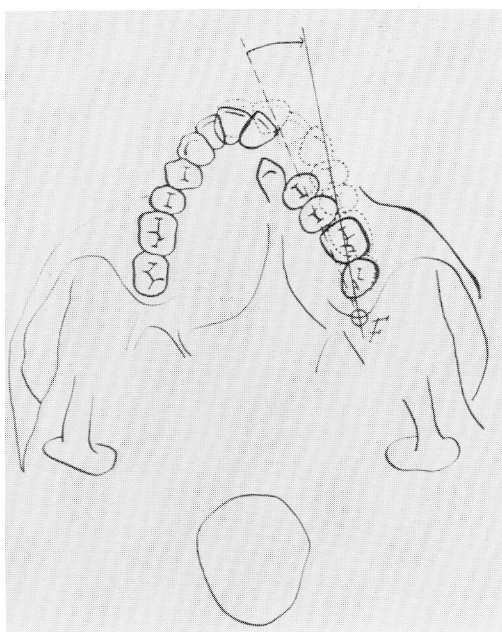


FIGURE 3. Medial reotation of the small maxillary segment, which is a common finding in unilateral clefts, has its fulcrum at the tuberosity of the maxilla. Lateral repositioning of the collapsed segment must be accomplished by rotation with the same fulcrum.

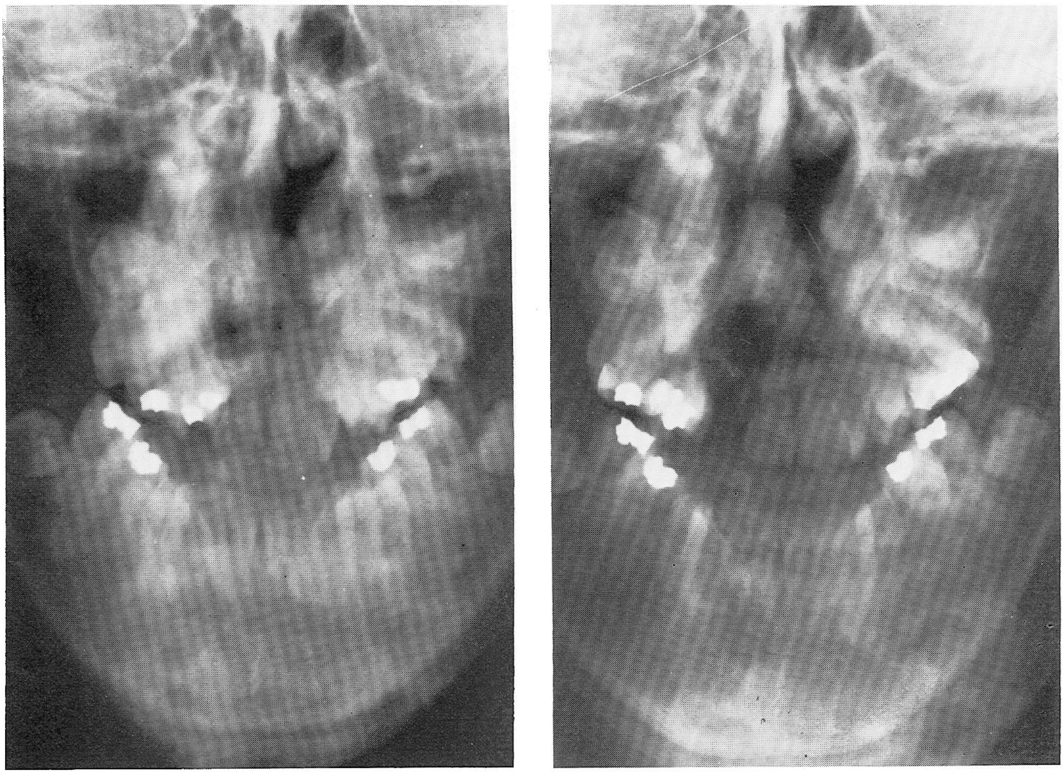


FIGURE 4. A. The maxillary segment on the side of the cleft is medially rotated and there is contact between the cuspid and the central incisor. B. After six months of treatment the segment has been moved laterally without changing the position of the teeth in the segment.

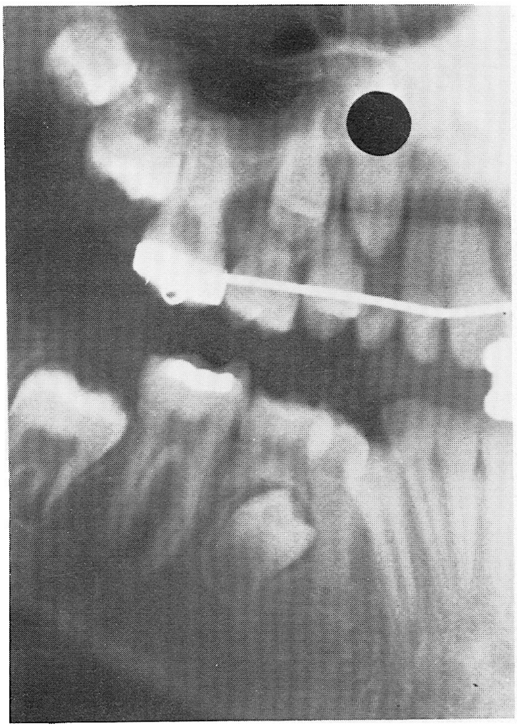
cleft segment position was accomplished early enough to ensure tongue position in the palate rather than under the maxillary teeth. The latter position often contributes to inhibition of alveolar height development in the maxilla.

The third phase of treatment involved correction of incisor position and usually consisted of extrusion combined with protrusion and rotations. The extrusive and protrusive forces were generated from springs attached to the lingual wire and acting on individual teeth.

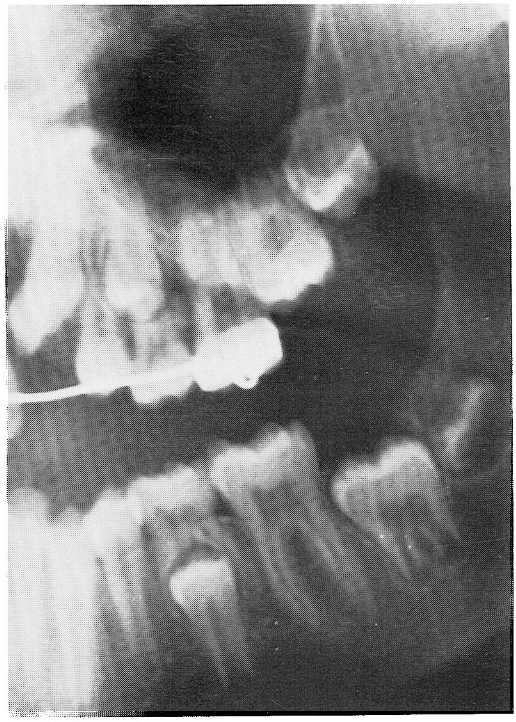
In some individuals, mandibular growth during adolescence exceeded maxillary growth to such an extent that it could not be compensated for by correction of the maxillary deficiencies alone. In these cases, the mandibular prominence was reduced by active over-extrusion of maxillary teeth, which brought the chin farther down and back. This resulted in increased face height, which was aesthetically preferable to the appearance of a retruded midface.

The mandibular dental arch was reduced in size when the above described procedures were not expected to result in a satisfactory incisor and lip relationship. If the mandibular second bicuspids were congenitally missing, the deciduous molars were extracted in order to allow closure of the bicuspid space (one subject in this sample). If all teeth were present but a crowding tendency was apparent, the mandibular first molars were extracted (five subjects). If the extraction of the first molar was done before eruption of the second molar and bicuspids, the space was shared equally between medial eruption of the second molar and distal eruption of the bicuspids (Figure 5). Extractions done at a later age involved bicuspids rather than first molars (one subject).

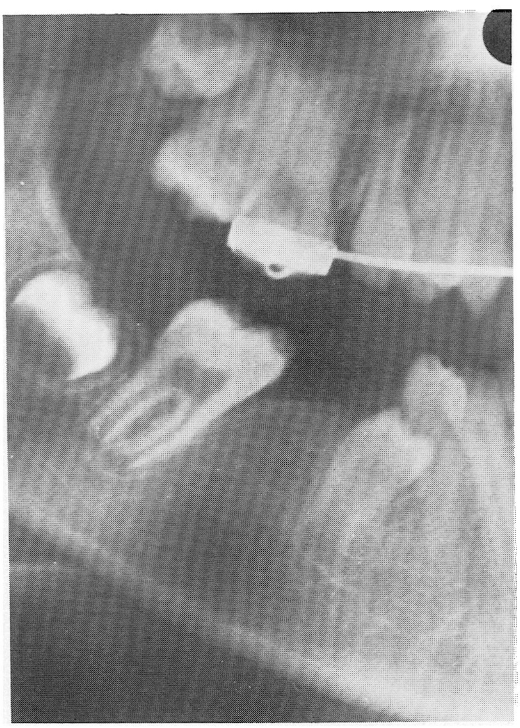
Fusion of the maxillary segments was done when most of the mandibular growth had taken place, the maxilla had been treated, and adequate size had been achieved. The treatment procedures resulting in maxillary



A (Left)



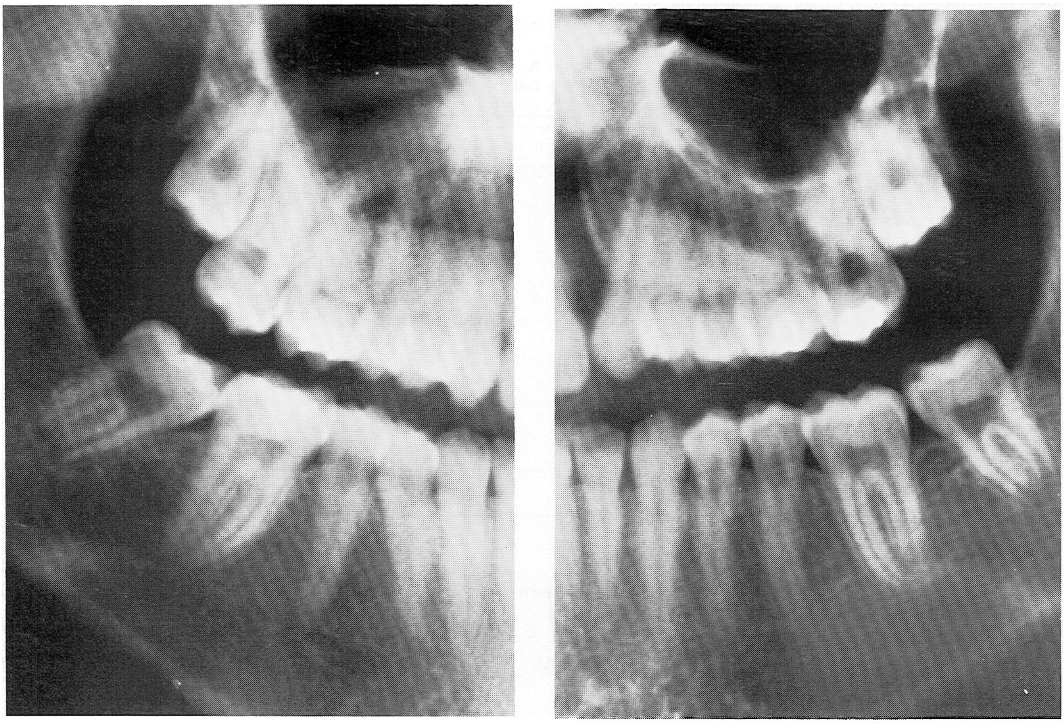
A (Right)



B (Left)

B (Right)

FIGURE 5 (continued)



C (Left) C (Right)

FIGURE 5. Extraction of mandibular first molars. A. The mandibular first molars were extracted at age 12. B. One year later. C. The extraction space has been closed by distal eruption of the second bicuspids and mesial eruption of the second molars. No orthodontic treatment has been done in the mandible.

fusion have been described previously (Vargervik, 1978).

The final phase of treatment consisted first of adjusting the alignment and interdigitation of teeth with conventional labial orthodontic appliances. Subsequently, a maxillary retainer with necessary tooth replacements was placed until the final prosthetic replacements could be made at approximately 19 years of age.

ASSESSMENT OF RECORDS. Linear and angular measurements were obtained on tracings of lateral cephalometric headfilms. Presence or absence of teeth was evaluated from oblique cephalometric headfilms, panoramic x-rays, or periapical x-rays. Assessment of crossbite was made on dental casts, and assessment of maxillary expansion was obtained from dental casts and antero-posterior cephalometric headfilms. The incidence of crossbite and congenital absence of teeth are shown in Table 2.

Cephalometric landmarks and planes are shown in Figure 6.

Results

PRETREATMENT DATA ON THE CLEFT PALATE GROUP WHICH RECEIVED ORTHODONTIC TREATMENT. Data obtained from the pretreatment records of the eight boys and eight girls treated at the Center and the corresponding values from the Burlington control material are presented in Table 3A and B. There were no significant deviations from normal values for these dimensions.

The development and position of the anterior areas of the maxillary alveolar processes were impaired, however. The retruded position of the maxillary incisors relative to the mandibular incisors resulted in inadequate incisor overbite and overjet and in anterior crossbite. The reduction in transverse dimensions was demonstrated by the high incidence of lateral crossbite (Table 2).

COMPARISON OF THE ORTHODONTICALLY TREATED CLEFT GROUP WITH THE NON-CLEFT GROUP. Data resulting from the comparison between the orthodontically treated cleft

TABLE 2. Distribution of Crossbite and Congenital Absence of Teeth

	GROUP 1 Non-Cleft Controls		*GROUP 2* Subjects with Untreated Clefts	*GROUP 3* Subjects with Treated Clefts: Before Treatment		*GROUP 3* Subjects with Treated Clefts: After Treatment	
Sex	F	M	M	F	M	F	M
Crossbite							
Cuspid only	0	0	0	0	0	0	0
Cuspid and molars	0	0	2	2	3	0	0
Incisors only	0	0	0	2	0	0	0
Incisors and cuspid	0	0	0	1	1	0	0
Incisors, cuspid and molar	0	0	6	1	4	0	0
Congenital Absence of teeth							
Lateral incisor	0	0	6	8	7	—	—
Central incisor	0	0	0	1	0	—	—
Maxillary bicuspids	0	0	4	1	1	—	—
Mandibular bicuspids	0	0	0	1	0	—	—

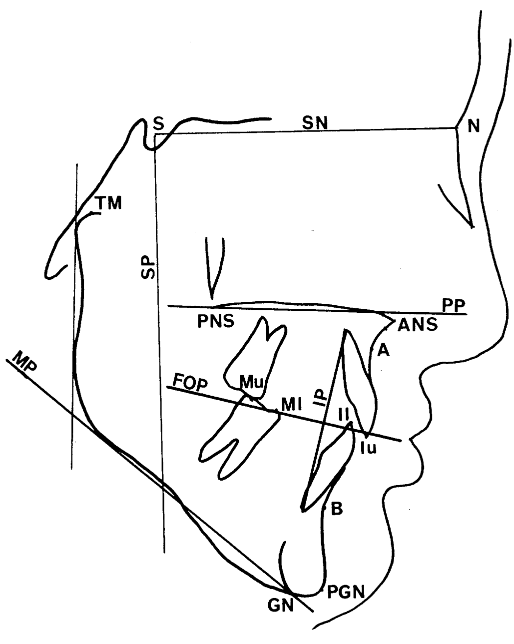


FIGURE 6. Tracing of a lateral headfilm demonstrating the reference points and planes which have been used in this study. The following planes were drawn: SN = Sella Nasion Plane, PP = Palatal Plane, FOP = Functional Occlusal Plane, IP = Incisor Apex Plane, MP = Mandibular Plane, SP = Perpendicular to SN through S.

group and the control groups are shown in Table 4 for the girls and in Table 5 for the boys. The distances from the maxillary incisor and the first molar to the sella perpendicular (Iu-SP and Mu-SP) were shorter in the male but not in the female cleft group. The distance from the lower incisor to the sella perpendicular (Il-SP) was also significantly shorter in the male cleft group.

The mean distance from the condyle to the anterior nasal spine was significantly shorter in both the male and the female cleft groups. All other dimensions and angles which were measured were not significantly different.

Lateral repositioning of the medially rotated maxillary segments was achieved in all treated individuals, and all dental crossbites were eliminated (Table 2).

Comparison of the Orthodontically Untreated Cleft Group with the Non-Cleft Group. Comparisons between normal subjects and those with orthodontically untreated clefts are shown in Table 6. All measurements of maxillary dimensions in the horizontal plane were significantly smaller in the cleft group than in the control group. All measurements of antero-posterior relationships between the jaws and the lips were also significantly different and indicated retrusiveness of the maxilla and maxillary teeth. Vertical dimensions were not significantly different.

Comparison of the Orthodontically Untreated Cleft Group with the Treated Group. The results of the comparisons of the untreated with the treated cleft palate boys are also shown in Table 6. Maxillary arch length (IU-Sp—Mu-Sp) was significantly smaller in the untreated group. The anterior nasal spine was significantly more retrusive

TABLE 3. Minimum, Mean, and Maximum Values for Length of Jaws, Difference Between Upper and Lower Jaw Lengths and Lower Anterior Face Height in the Cleft Group Before Orthodontic Treatment and the Equivalent Values From the Burlington Control Subjects for the Same Age Group

Variables	*GROUP A—BOYS Subjects with clefts before start of orthodontic treatment*			*Non-cleft Controls*		
	Min.	*Mean*	*Max.*	*Min.*	*Mean*	*Max.*
TM-ANS	80	86	90	78	84	92
TM-PGN	102	105	108	93	102	111
TM-PGN—ANS	17	19	24	11	18	28
ANS-GN	56	65	72	53	60	73
Variables	*GROUP B—GIRLS Subjects with clefts before start of orthodontic treatment*			*Non-cleft Controls*		
	Min.	*Mean*	*Max.*	*Min.*	*Mean*	*Max.*
TM-ANS	79	83	89	77	84	92
TM-PGN	101	105	109	92	103	111
TM-PGN—ANS	18	22	27	12	19	27
ANS-GN	56	62	67	49	59	69

TABLE 4. Means, Standard Deviations, and T-Values for Group Comparison of Orthodontically Treated Cleft Subjects and Non-Cleft Controls, Girls

Variables	*Hypothesis*	*Non-cleft controls*		*Treated clefts*		
		Mean	*S.D.*	*Mean*	*S.D.*	*t*
Max. post. alveolar height (MU-PP)	1 + 3	25.3	4.4	26.4	2.2	.65
Max. ant. alveolar height (Iu-PP)	1 + 3	31.8	3.3	29.7	3.2	1.27
Antero-posterior pos. of max. molar (Mu-SP)	1 + 3	31.5	5.6	29.4	7.5	.64
Antero-posterior pos. of max. in. (Iu-SP)	1 + 3	60.7	7.2	58.5	8.0	.58
Max. dental arch length (Iu-SP-Mu-SP)	1	29.2	3.6	29.1	2.8	.04
Antero-posterior pos. of max. (TM-ANS)	2	94.3	2.8	88.4	5.4	2.72*
Mandibular length (TM-PGN)	3	121.0	5.0	120.0	6.4	.48
Diff. in mand. and max. length (TM-PGN-TM-ANS)	3	26.8	3.4	31.2	4.4	2.06
Antero-posterior pos. of mand. inc. (Il-SP)	3	59.0	6.0	56.2	8.1	.81
Incisor relationship (Iu-SP-Il-SP)	3	2.1	.6	2.3	1.5	.20
Relative pos. of points A and B (ANB)	3	2.1	2.1	1.4	2.7	.52
Inclination of mand. plane (MP-SN)	3 + 4	32.9	4.1	36.6	7.9	1.19
Inclination of occlusal plane (FOP-SN)	3	16.9	5.6	14.6	4.9	.89
Occlusal plane angle (FOP-IP)	3	91.0	3.9	90.0	6.4	.38
Lower anterior face height (ANS-GN)	3	70.4	6.6	72.6	5.3	.73
Gonial angle	4	124.4	7.6	125.8	9.0	.35

relative to the condyle (TM-ANS) as well as relative to PGN (jaw length difference) in the untreated group. The average horizontal relationship between the maxillary and mandibular incisors (Iu-SP—Il-SP) was 2.6 mm in the treated group and −3.9 in the untreated group. This difference was statistically significant.

The average angle of occlusion (functional occlusion plane-incisor apices line) was 80° in the untreated group, indicating a Class III arch relationship. The gonial angle was significantly larger in the untreated than in the treated group. Maxillary and mandibular alveolar heights were significantly smaller in the untreated than in the treated group.

Tracings of lateral headfilms of a boy representing average craniofacial dimensions before and after orthodontic treatment are shown in Figure 7. Figure 8 demonstrates typical development of the craniofacial structures in the absence of orthodontic treatment.

TABLE 5. Means, Standard Deviations, and T-Values for Group Comparison of Orthodontically Treated Cleft Subjects and Non-Cleft Controls, Boys

Variables	Hypothesis	Non-cleft controls		Treated clefts		t
		Mean	S.D.	Mean	S.D.	
Max. post. alveolar height (Mu-PP)	1 + 3	27.3	2.3	28.2	2.6	.76
Max. ant. alveolar height (Iu-PP)	1 + 3	33.9	2.6	32.1	2.6	1.39
Antero-posterior pos. of max. molar (Mu-SP)	1 + 3	34.6	4.4	26.2	2.9	4.52**
Antero-posterior pos. of max. incisor (Iu-SP)	1 + 3	66.6	5.0	58.4	3.1	3.98**
Max. dental arch length (Iu-SP—Mu-SP)	1	32.0	1.7	32.2	1.9	.21
Antero-posterior pos. of maxilla (TM-ANS)	2	99.9	3.9	94.8	4.1	2.53*
Mandibular length (TM-PGN)	3	128.8	4.1	127.1	5.9	.64
Diff. in mand. and max. length (TM-PGN—TM-ANS)	3	28.9	3.7	32.1	4.6	1.52
Antero-posterior pos. of mand. inc. (Il-SP)	3	63.9	4.8	56.5	3.6	3.52**
Incisor relationship (Iu-SP—Il-SP)	3	2.7	.5	2.8	1.6	.10
Relative prominence of points A and B (ANB)	3	2.8	1.2	1.3	2.3	1.60
Inclination of mand. plane (MP-SN)	3 + 4	37.4	4.6	36.6	6.7	.26
Inclination of occlusal plane (FOP-IP)	3	15.6	3.7	16.4	5.6	.32
Occlusal plane angle (FOP-IP)	3	91.6	3.0	90.4	3.4	.75
Lower anterior face height (ANS-GN)	3	76.3	5.6	77.7	5.7	.51
Gonial angle	4	128.8	8.0	125.1	6.0	1.05

* $P < 0.005$
** $P < 0.001$

TABLE 6. Mean, Standard Deviations, and T-Values for Group Comparisons of Orthodontically Untreated Cleft Subjects With Non-Cleft Controls and With Orthodontically Treated Cleft Subjects

Variable	Hypothesis	Non-cleft controls			Untreated clefts			Treated clefts	
		Mean	S.D.	t	Mean	S.D.	t	Mean	S.D.
MU-PP	1 + 3	27.3	2.3	.24	27.5	1.9	.34	28.2	2.6
Iu-PP	1 + 3	33.9	2.6	1.47	32.1	2.3	.21	32.1	2.6
Mu-SP	1 + 3	34.6	4.4	2.19*	29.3	5.3	1.44	26.2	2.9
Iu-SP	1 + 3	66.6	5.0	4.82**	54.8	4.9	1.77	58.4	3.1
Iu-SP-Mu-SP	1	32.0	1.7	6.03**	25.5	2.5	6.00**	32.2	1.9
TM-ANS	2	99.9	3.9	4.89**	88.9	5.1	2.57**	94.8	4.1
TM-PGN	2 + 3	128.8	4.1	.46	127.7	5.1	.20	127.7	5.9
TM-PGN—TM-ANS	3 + 2	28.9	3.7	4.59**	38.8	4.9	2.86*	32.1	4.6
Il-SP	3	63.9	4.8	1.89	58.6	6.3	.83	56.5	3.6
Iu-SP—Il-SP	3	2.7	.5	3.80**	−3.9	4.9	3.66**	2.6	1.6
ANB	3	2.8	1.2	4.82**	−3.0	3.2	3.08**	1.3	2.3
MP-SN	3 + 4	37.4	4.6	1.08	40.1	5.6	1.14	36.6	6.7
FOP-SN	3	15.6	3.7	1.60	18.1	2.4	.82	16.4	5.6
FOP-IP	3	91.6	3.0	4.23**	79.9	7.3	3.73**	90.4	3.4
ANS-GN	3	76.3	5.6	.29	77.0	4.5	.27	77.7	5.7
Gonial angle	4	128.8	8.0	1.22	133.6	8.0	2.43*	125.1	6.0

* $P < 0.005$
** $P < 0.001$

Discussion

HYPOTHESIS 1. The inhibiting effects of scar tissue and of irregularities in direction of tooth eruption on the forward development of the maxillary alveolar process can be counteracted by applying protrusive and extrusive forces on the alveolar process and teeth. This hypothesis could not be rejected. The data demonstrated that the maxillary alveolar process was developed to adequate size by treatment. All anterior crossbites were eliminated, and adequate overbite and overjet were achieved in all treated individuals. In the

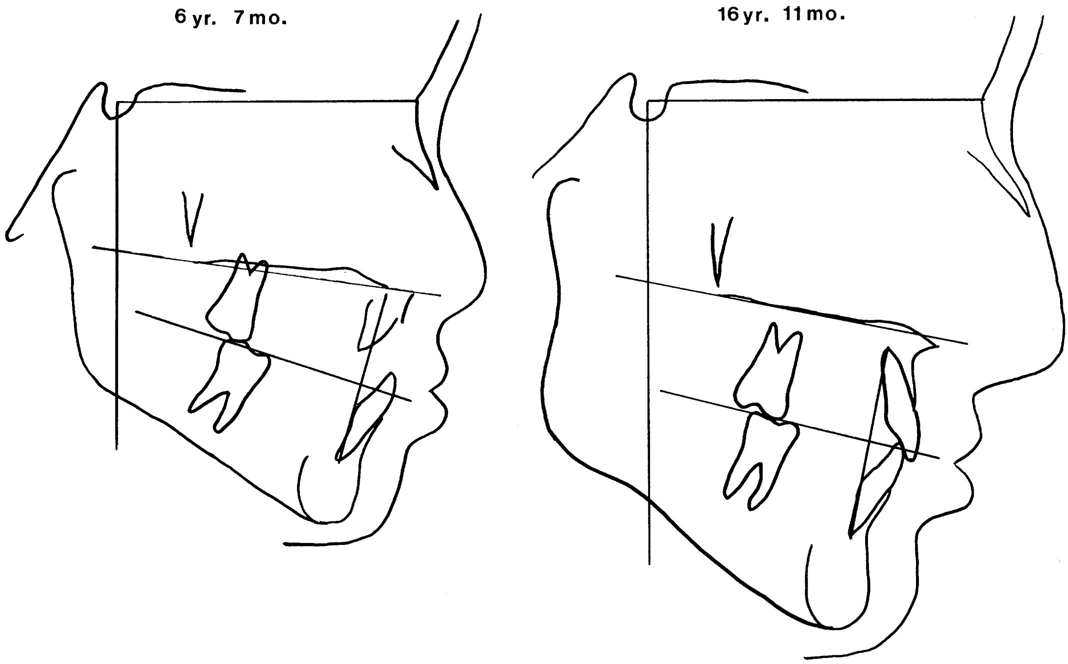


FIGURE 7. Tracing of lateral headfilms of a boy with unilateral cleft representing the average of pre- and post-treatment skeletal and dental relationships. A. Before treatment, which was started at age 7. B. After completion of treatment, at age 16 years, 11 months.

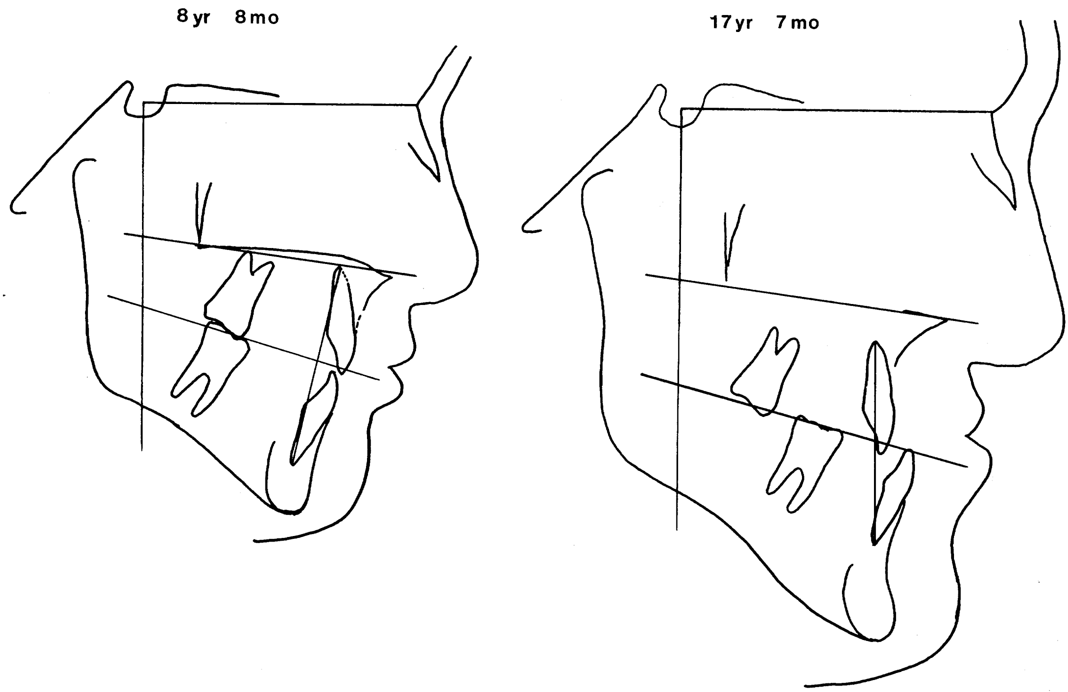


FIGURE 8. Tracings of lateral headfilms of a boy with a unilateral cleft lip and palate who demonstrates typical development of the craniofacial structures in the absence of orthodontic treatment.

group of untreated clefts, six of the eight had anterior crossbites. The mean value for maxillary and mandible incisor relationship (Iu-SP—Il-SP) was −3.9 for the untreated and 2.6 mm for the treated group. This difference was statistically significant (Table 6).

It is concluded that the factors which inhibit development of the maxillary alveolar process can be counteracted by orthodontic treatment.

HYPOTHESIS 2. The inhibiting effect that scarring and a tight lip may have on the forward growth of the maxilla can be partially counteracted. This hypothesis could not be rejected. The findings indicate that the orthodontic treatment improved the forward growth of the maxilla. The anterior nasal spine was significantly more protrusive in the treated than in the untreated cleft group. Although the distance from the condyle to the anterior nasal spine (TM-ANS) was significantly shorter in the treated cleft groups than in the non-cleft groups, the length of the maxilla relative to the mandible (TM-PGN-TM-ANS) was not significantly different between these groups. This indicated that the mandibles were also generally smaller and that the relative jaw sizes were harmonious in the treated cleft groups. In the orthodontically untreated cleft group, the length of the maxilla (TM-ANS) was significantly shorter than in the treated cleft group and in the non-cleft control group. The length of the maxilla relative to the mandible was also significantly shorter in the untreated cleft group.

These findings and the experimental data indicate that, by widening the palate and consequently providing space for the tongue in the palatal vault, the imbalance between the retrusive and protrusive forces acting on the maxilla was changed. This may have contributed to a more forward growth of the maxilla in the treated than in the untreated group.

HYPOTHESIS 3. The development of a dental crossbite and relative mandibular prognathism can be prevented in several ways: by reduction of the mandibular dental arch; by anterior movement of retruded maxillary incisors; or by a combination of these factors. This hypothesis could not be rejected. Good dental arch relationships were established in all of the orthodontically treated individuals. In three subjects, active extrusion of maxillary molars was necessary. In seven subjects, the mandibular dental arch was reduced by extractions of teeth. In all 16 subjects, the maxillary incisors were actively moved labially and extrusive forces applied.

These observations point to the conclusion that treatment can and should be designed to take advantage of the individual characteristics which can be modified by treatment. Active extrusion of maxillary teeth may be indicated in patients with overclosure resulting from inhibited vertical development. It also may be indicated when a lower and consequently more retrusive position of the chin is desirable in order to improve the profile. Extrusion of maxillary incisors is almost always necessary and will generally result in a satisfactory incisor relationship. It should be noted, however, that there is a limitation of the degree to which the incisors may be extruded. If the lower face height is markedly increased, an effort to bring the maxillary incisors down sufficiently may fail or result in root resorption. The esthetic requirement of not exposing too much of the incisors below the lip margin is also a limiting factor. An increased lower face height may be the result of an untreated and narrow palate which may cause a low tongue position and steep mandibular plane inclination. Reduction of the mandibular dental arch by extractions of mandibular teeth is often necessary. If the projected growth of the mandible relative to the maxilla will result in a moderate disproportion in jaw sizes after adolescent growth, extractions in the mandible are indicated. If the projected disproportions in jaw size are expected to require surgical advancement of the maxilla, extractions in the mandible may be contraindicated.

HYPOTHESIS 4. The opening of the gonial angle, which is secondary to lowering of the chin, can be counteracted by increasing the size of the palatal vault to accommodate the tongue. This hypothesis could not be rejected. The palatal vault was increased in all treated individuals, and the gonial angle was decreased as a result of this treatment. The angle was significantly smaller in the treated than in the untreated group. These values correspond closely to those presented by Ross and Johnston (1967).

The reverse changes were demonstrated in the experimentally produced clefts in rhesus monkeys. Following reduction of the palatal vault, the tongue and the mandible lowered, and the gonial angles increased.

It is concluded that the shape of the mandible as expressed by the gonial angle is determined by its postural position.

HYPOTHESIS 5. Medial Collapse of the maxillary segments can be corrected by lateral repositioning of the entire segments. This hypothesis could not be rejected. Lateral repositioning of the maxillary segments was achieved in all of the treated individuals, and all lateral crossbites were eliminated (Table 2).

The finding that maxillary segments can be repositioned with orthopedic forces concurs with that of other investigators (Harvold, 1947; Subtelny and Brodie, 1954; Hellquist, 1970).

In summary, the findings indicate that the five hypotheses originally postulated cannot be rejected.

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