Some Effects Of Rapid Maxillary Expansion In Cleft Lip And Palate Patients

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INTRODUCTION

Complete unilateral or bilateral clefts of the osseous premaxilla destroy the continuity of the dental arch, the alveolar arch and the basal maxillary bone. When this type of congenital malformation occurs in combination with a complete cleft of the secondary palate, the buccal segment on the affected side appears clinically rigid. Nevertheless, due to the absence of continuity, these lateral maxillary segments are anatomically capable of movement independent of the remainder of the maxilla and facial skeleton.[7] In many cases the surrounding buccal musculature does move these buccal segments medially to a position lingual to the premaxilla producing varying degrees of buccal crossbite. Such a malocclusion represents, therefore, not only a dental and alveolar crossbite but also a basal discrepancy. Since the effects of conventional intraoral orthodontic procedures have been demonstrated to be limited to the teeth and alveolar processes,[1] the desired orthodontic correction of these malocclusions is often difficult if not impossible to accomplish.

In the last decade interest has been revived in the treatment of buccal crossbites showing basal bone discrepancies by means of rapid midpalatal expansion screw appliances. This procedure was first described over a century ago and numerous case reports of the successful clinical application of this technique were published. The literature describing these early reports was reviewed recently by Haas[4] and by Thörne.[8]

Nevertheless, while the clinical efficacy of this procedure has been heavily documented, detailed descriptions of its mechanism of action and its effects on the adjacent facial skeleton have not been well described. Evidence has been reported to demonstrate that in normal palates an expansion screw can open the midpalatal suture.[2-6,8,9] No conclusive data are available, however, to show when the midpalatal suture ossifies or if this treatment procedure is effective in all age groups. Moreover, no attempt has been reported to differentiate between the resistance to expansion offered by the midpalatal suture and the resistance offered by the balance of the facial skeleton. It has also been noted that the amount of appliance opening and dental expansion has been considerably in excess of the amount of midpalatal suture opening. The additional dental arch width gained has been attributed to such factors as tooth movement,[3] alveolar bone bending[4] and differences in the rotational plane of the maxilla during expansion.[6]

Concurrent expansion of the mandibular arch as well as the unusual be-

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havior of the maxillary central incisors during the rapid expansion of normal palates have also been described.[4] It has also been reported that expansion procedures produce an increase in size of the nasal cavity and a lowering of the nasal floor, resulting in a lessened tendency to mouth breathing.[3-6,8] Similarly, a straightening of deviated nasal septums as well as an initial advancement of A point have also been noted.[4,5] No data has been reported describing the magnitude of the forces delivered by the appliance or the response of the midpalatal suture and the adjacent areas of the facial skeleton to such forces. Thus, the clinical application of the procedure has required the operator to deliver an unknown amount of force to an unknown resistance and the activation schedules that have been employed have been largely empirically derived. Consequently, the procedure has not been widely accepted in clinical practice.

The study was undertaken as a part of a program at the School of Dentistry of the University of Minnesota to evaluate rapid mechanical midpalatal expansion. Cleft lip and palate patients were selected for this phase of the study for three reasons: 1) The need for a procedure of this type is commonly present in these patients, 2) no detailed analysis of the effects of rapid midpalatal expansion on cleft lip and palate patients has been reported and 3) the complete absence of skeletal resistance to expansion in the palate allowed the effects of the appliance on the adjacent facial skeleton to be more clearly assessed.

Methods and Materials

This study was conducted on five male patients demonstrating surgically repaired complete clefts of the primary and secondary palates. The patients are identified by letter and described in Table I.

Six silver implants, one to two millimeters in length, were made from number six endodontic cones and intraorally placed in the maxilla of each patient. The implants were placed bilaterally in 1) the inferior surface of the zygomatic process of the maxilla, 2) the buccal alveolar process between the apices of the buccal roots of the first permanent

Patient	Age	Original Premaxilla Cleft	Original Secondary Palate Cleft	Posterior Segments	Anterior Teeth
A	22	Complete Left Unilateral	Complete	Bilateral Constricton	Crossbite
B	12	Complete Bilateral	Complete	Bilateral Constriction	Crossbite
C	12	Complete Bilateral	Complete	Bilateral Constriction	Crossbite
D	12	Complete Left Unilateral	Complete	Bilateral Constriction	Crossbite
E	12	Complete Left Unilateral	Complete	Bilateral Constriction	No Crossbite

TABLE I

Patient data. The age, type of oral congenital malformation and dental crossbite present in the five patients studied.

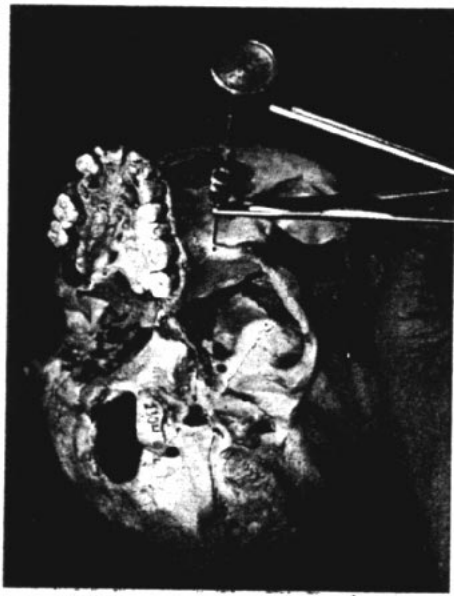

Fig. 1 Position of placement of the metallic implants.

molar and 3) the lingual alveolar process mesial to the root apex of the first permanent molar (Fig. 1). Under local anesthesia a small surgical flap was raised and the cortical plate of bone penetrated with an inverted cone dental bur. The implants were held in a blunted 18 gauge needle. A stylet, the same length and gauge as the needle, was inserted into the needle and lightly tapped with a mallet to imbed the implants flush with the cortical plate of bone. Sutures were placed only when necessary. Several days later, lateral and anteroposterior cephalometric roentgenograms, study models and photographs were obtained.

Fixed split palate expansion appliances were constructed by the direct-indirect method described by Haas.[4] Due to the severe degree of crossbite present in the anterior region of the buccal segments, the skeleton type expansion screw was positioned as far anteriorly as possible in the palate. The screw produced 0.8 mm of opening for each complete revolution. The patients were instructed to activate the appliance one turn of the activation key (producing one-fourth revolution of the screw) per day. In those cases where the maximum opening of the expansion screw was accomplished before the crossbite was corrected, the appliance was reconstructed and treatment continued. After the expansion procedure was completed, the appliance screw was stabilized and records obtained. The appliance was left in place as a retainer for approximately one month.

Results

The amount of lateral movement produced by the expansion procedure was determined from the anteroposterior roentgenograms. The total distance between identical points on analagous left and right implants was measured directly on each roentgenogram with a vernier caliper. The difference between the pretreatment measurements and the posttreatment measurements in each patient is recorded in Table II as the total amount of expansion.

In patient *A* all implants were superimposable in this plane indicating that no expansion of the maxilla resulted from the procedure. Measurements between the left and right implants of the other four patients clearly increased, however, indicating that maxillary expansion was produced as a result of treatment. In every case the measurements between the clearly defined implants directly on the cephalograms resulted in accurate reproducible data.

The relative amount of the left and right halves of the maxilla was also estimated from the anteroposterior roentgenogram. A midline was constructed directly on each cephalogram bisecting a line connecting the lateral limits of the zygomaticofrontal sutures. The distance of each implant from the midline was recorded and the difference

Patient	Lateral Implant Movement (mm)									Appliance Separation (mm) / Days of Treatment
	Skeletal			Buccal			Lingual			
	R	L	Total	R	L	Total	R	L	Total	
A	0	0	0	0	0	0	•	0		8.0/27
B	••	0.6		0.6	0.7	1.3	1.1	0.9	2.0	5.6/35
C	1.9	1.0	2.9	2.3	0.9	3.2	2.6	0.9	3.5	8.0/40
D	0.8	0.9	1.7	1.0	0.7	1.7	••	1.2		5.2/26
E	0.7	0.3	1.0	0.7	0.3	1.0	•••	••		3.0/15

• — implant rotated 180° and moved inferiorly

•• — implant moved inferiorly

••• — implant sloughed

TABLE II

Amount of lateral expansion (mm) of the implants measured on the anteroposterior roentgenograms following treatment with the expansion screw appliance.

between the measurements recorded on the pretreatment cephalograms and the posttreatment cephalograms is shown in Table II. Comparisons of these measurements conclusively demonstrate that lateral movement of the two halves of the maxilla did not necessarily occur in a predictable or symmetrical manner. For example, patient *C* with a bilateral cleft of the premaxilla exhibited the greatest amount of lateral movement on the right side. Patient *E*, on the other hand, demonstrated a left unilateral cleft of the premaxilla but revealed no tendency for the left buccal segment to more readily move laterally.

The relationship between the three implants within each quadrant was also assessed by superimposing the pre and posttreatment cephalograms registered first on the implants in one quadrant and then on the other. Except for those five exceptions indicated in Table II, the implants within each quadrant always maintained their relationship to each other. The fact that the implants in each quadrant were superimposable within their respective quadrants strongly suggests that the maxillae were repositioned laterally as a unit without any significant distortion of the bony units. Those five implants that did not maintain their relationship were considered to have not been well accepted and consequently were not included in any measurements reported in this study.

Superimpositioning of the pre and posttreatment anteroposterior roentgenograms also clearly revealed that rotation of the head about the ear rod axis occurred during the roentgenographic procedures. Therefore, no attempt was made to use these films to estimate any changes of osseous structures or implant positions in a vertical direction. Similarly, vertical changes in the floor of the nasal cavity could not be accurately estimated from these films. Attempts to measure the lateral

Direction of Movement	Implant						Patient	Appliance Separation (mm) / Days of Treatment
	Skeletal		Buccal		Lingual			
	R	L	R	L	R	L		
Anterior Superior	+ +	0 0	+ +	0 0	•	0 0	A	8.0/27
Anterior Superior	••	+ 0	+ ++	+ 0	+ ++	+ 0	B	5.6/35
Anterior Superior	+ 0	++ 0	+ 0	++ 0	++ 0	+++ 0	C	8.0/40
Anterior Superior	++ ++	+ 0	++ ++	+ 0	••	++ 0	D	5.2/26
Anterior Superior	+ ++	++ 0	+ ++	++ 0	•••	••	E	3.0/15

+ — less than 0.5 mm
++ — 0.5–1.0 mm
+++ — 1.0–1.5 mm

• — implant rotated 180° and moved inferiorly
•• — implant moved inferiorly
••• — implant sloughed

TABLE III

Relative direction and amount of movement of the implants as measured on the lateral cephalometric roentgenograms.

width of the nasal cavity revealed that increases were apparent in some instances. The lack of precise reference points, coupled with the small amount of change, however, precluded any accurate measurement of the changes observed. No significant straightening of the markedly distorted nasal septums was observed.

Similarly, no spacing ever occurred between the central incisors in these patients. This latter finding was undoubtedly due to the fact that expansion occurred in these patients in the osseous defects between the premaxilla and maxilla or the incisive suture region rather than at the intrapremaxillary suture as occurs in normal palates.

Maxillary repositioning in a vertical and anteroposterior direction was assessed using the pre and posttreatment lateral cephalometric roentgenograms. The lateral cephalograms for each patient were directly superimposed on nasion, the anterior cranial base, sella turcica and the clivus. Measurements between corresponding points of the same implants in a vertical and horizontal direction were made using a vernier caliper. Since it was not possible to superimpose two headplates within a tenth of a millimeter, these measurements are shown in Table III in one-half millimeter increments and indicate only the direction and relative amount of movement that was observed.

These results clearly indicated that maxillary movement both in an anterior and superior direction commonly occurred. Nevertheless, the relative magnitude of the changes in these directions was neither consistent nor predictable. Interestingly, patient *A*, who demonstrated no lateral maxillary movement, did show a minor amount of vertical and anterior maxillary change. The other four patients, who showed

Patient	FMA	Y-Axis	Facial Angle
A	+3.5	+2.0	-2.0
B	+3.0	+2.5	-2.5
C	+1.0	+1.0	-1.0
D	0.0	0.0	0.0
E	0.0	0.0	0.0

TABLE IV

some maxillary lateral expansion, similarly demonstrated some degree of maxillary repositioning in an anterior and superior direction. No correlation between the amount of lateral movement and the amount of vertical or anterior movement was apparent, however.

The pre and posttreatment lateral cephalograms were also superimposed, registered on the implants in the left and right sides, respectively, of each patient. Implants within every quadrant that were superimposable in the anteroposterior roentgenograms were also superimposable in the lateral cephalograms. This further supports the conclusions that the bony segments moved as a unit and that no significant distortion of the bony units occurred. Those same five implants that were not superimposable were, as with the anteroposterior roentgenograms, not utilized for any measurements reported in this study.

Cephalometric tracings of the pretreatment and posttreatment lateral cephalometric roentgenograms were also registered on sella nasion. Table IV shows the changes in the mandibular plane angle, the Y axis and the facial angle produced by mechanical expansion. It may be noted that treatment increased the vertical dimension in patients *A*, *B* and *C* but did not alter vertical dimension in patients *D* and *E*.

The arch width between available teeth in both the anterior and posterior portions of maxillary buccal segments was also compared on the pretreatment and posttreatment study models. The difference between these measurements was recorded as the amount of lateral expansion. Lateral expansion at the occlusal level of the teeth was measured between available cusp tips or occlusal grooves. Lateral expansion at the gingival level of these same teeth was measured at the level of the lingual gingival tissues. It may be seen in Table V that the occlusal of both the anterior and posterior teeth in each buccal segment expanded laterally approximately the same amount that the expansion screw was opened. The amount of lateral movement at the gingival level, however, was often not as great as the lateral movement at the occlusal level of the teeth. This indicates that a lateral tipping of the teeth occurred in some instances but that this was not a consistent finding. Moreover, the amount

Patient	Expansion (mm)					
	Maxillary Teeth	Occlusal Level	Gingival Level	Maxillary Teeth	Occlusal Level	Gingival Level
A	4—3	8.1	5.5	6—6	8.6	6.3
B	C—C	5.4	4.4	6—6	4.7	4.0
C	4—4	8.3	7.5	6—6	8.5	7.3
D	4—C	4.3	4.4	6—6	4.1	4.1
E	C—C	3.8	2.9	6—6	3.8	4.0

TABLE V

Increase (mm) in the width of the maxillary dentition at the occlusal and gingival levels of the teeth as measured from the study models.

of lateral tipping did not appear to significantly differ between cleft and noncleft quadrants.

It is also significant to note that the occluded models of patients *B* and *C* demonstrated open bites in the buccal segments following expansion (Figs. 3, 4). On the other hand, the buccal segments of patient *A* were in occlusion both before and after treatment. Since these three patients were noted to have a cephalometric increase in vertical dimension, this suggests that the open bites in patients *B* and *C* were at least in part due to prematurities created during treatment (Figs. 2-6).

Discussion

Krebs,[6] in the only previous study of midpalatal expansion using metallic implants, reported that the expansion of the normal palate of his single patient

Fig. 2 Pretreatment and posttreatment study models of Patient A.

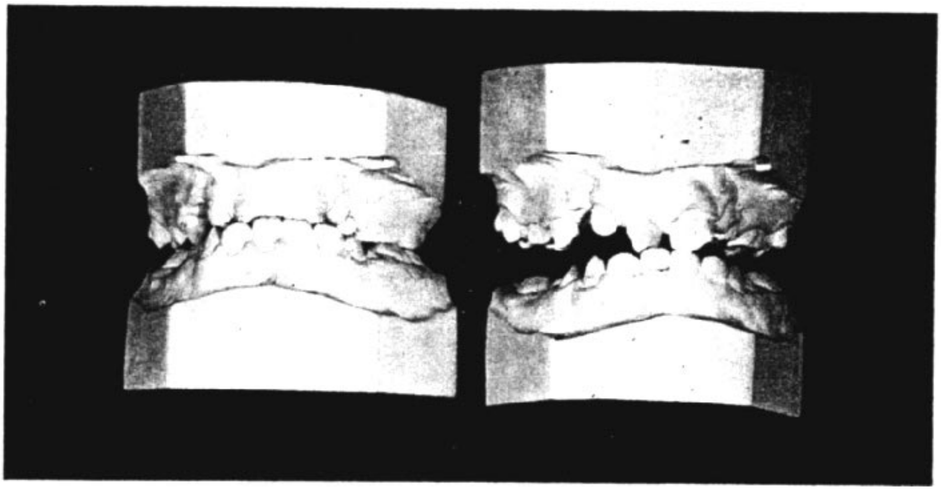

Fig. 3 Pretreatment and posttreatment study models of Patient B.

was greatest at the occlusal level of the teeth and progressively decreased toward the cranial base. He also suggested that the maxillary segments rotated in both a frontal and transverse plane. In this study, movement occurred in both these planes but no such clear rotational pattern was evident. This does not imply that rotation of the buccal segments cannot or did not occur. On the contrary, the data in Table II is suggestive of rotation in a frontal plane in some instances. The axis of any rotation, however, appears to have been variably located in different patients and even between the left and right sides of the same patient. Furthermore, the difference between the amount of lateral movement that occurred in the skeletal, buccal and lingual implants is small and, in some instances, not even demonstrable.

The data in Table III further show that maxillary movement often occurred

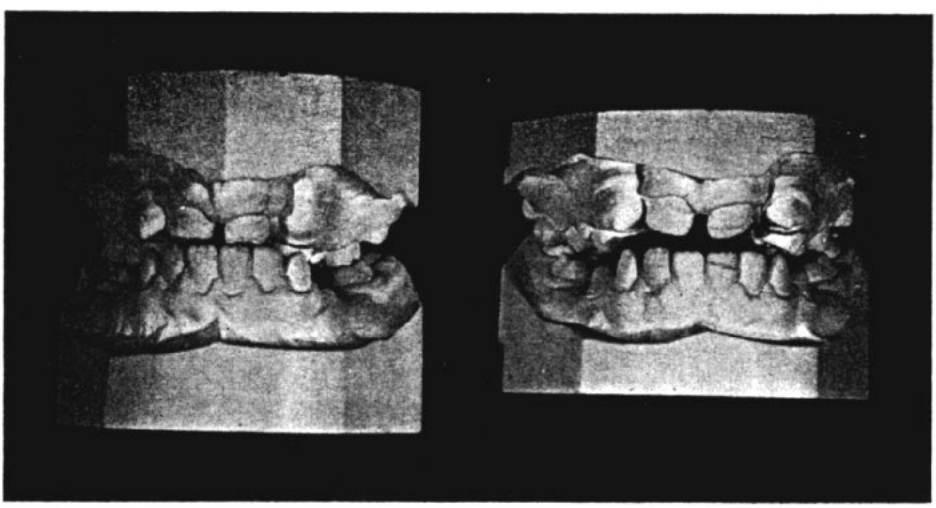

Fig. 4 Pretreatment and posttreatment study models of Patient C.

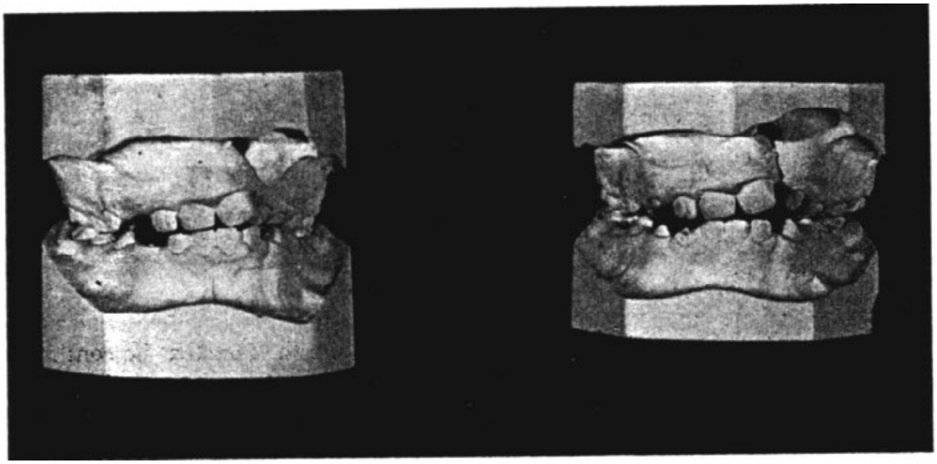

Fig. 5 Pretreatment and posttreatment study models of Patient D.

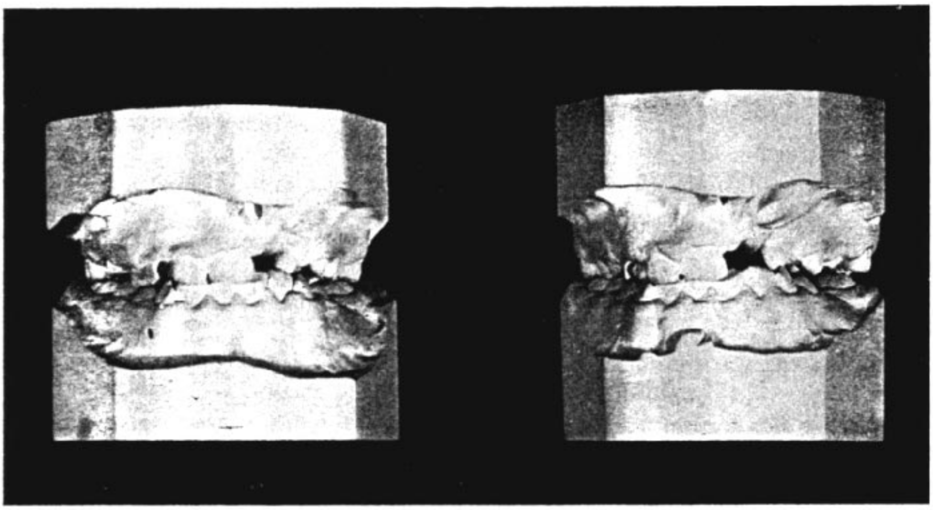

Fig. 6 Pretreatment and posttreatment study models of Patient E.

in an anterior direction also. This finding is in complete agreement with other workers who have reported that point A moves anteriorly during rapid mechanical expansion procedures. It has also been reported that the maxillary segments in normal palate patients sometimes move downward.[4] Considering the orientation of the zygomaticomaxillary and adjacent facial skeletal sutures, it is logical to anticipate that movement would occur in this direction. In this study, however, any vertical implant change was clearly in an upward direction. The fact that the implants were superimposable in each quadrant when the cephalograms were registered on the implant demonstrates that they did not move independently from the rest of the maxilla. Moreover, the total amount of upward movement was less than a millimeter in all instances where it was noted and it was consequently postulated that this movement occurred through compression and readjustment of the involved sutures during the course of treatment and retention. Therefore, the lateral movement of the maxillae of the patients in this study can only be generally described as an unpredictable repositioning of the maxillary segments through varying adjustments of adjacent sutural articulations. It was only apparent in this study that the maxillae can be laterally repositioned, but the manner by which this occurs and the response of the facial skeleton deserve considerably more investigation. It should be emphasized that these data apply only to cleft lip and palate patients. It is possible that the absence of maxillary continuity in these patients results in a compensatory strengthening of the remainder of the facial skeleton, thereby altering their response to rapid mechanical expansion.

The role of the facial skeleton as a resistance factor in midpalatal expansion was emphasized by the response of patient *A*. The fact that no lateral skeletal movement of the implants occurred strongly suggests the possibility that an age dependent increase in the rigidity of the articulations of the facial skeleton may be more important than the question of ossification of the midpalatal suture in the application of rapid expansion procedures.[7] The fact that the dental crossbite correction was accomplished in patient *A* in 27 days raises the question of how this was achieved. The implants show that no movement or gross distortion of the alveolar processes occurred. Also the amount of lateral change was too great to have occurred by orthodontic tooth movement in 27 days. However, the fact that the buccal segments were in occlusion both before and after treatment and the fact that the vertical dimension was clearly increased strongly suggests that the dental arch correction was achieved largely as a result of extrusion and lateral tipping of the buccal teeth. Furthermore, superimposition of the anteroposterior cephalograms registered on the implants also clearly demonstrated extrusion of the maxillary buccal teeth. Based on this conclusion, the principal bone changes affected were probably limited to the buccal crest of the alveolar bone. Moreover, the only appreciable changes recorded in this patient were limited to the dental structures despite the fact that he constantly disregarded instructions and, due to the absence of any pain, activated the appliance about twice as fast as he was instructed. The results recorded from this patient, however, strongly suggest that midpalatal expansion procedures should be applied to any adult with the full consideration that movement of the basal or alveolar bone may not occur.

Krebs[6] also reported that rapid mechanical expansion of his normal palate patient produced about one-half as much basal bone expansion as dental arch expansion with the lingual alveolar expansion midway between these two. In the four cleft lip and palate patients demonstrating basal bone expansion in this study, the lateral movement of the basal bone was never greater than approximately 40 percent of the lateral expansion of the dental structures at the lingual gingival level.

The lateral movements of the teeth did not show any significant differences between the anterior and posterior regions of the buccal segments as measured on the dental arch. Similarly, the right buccal segments of patients *D* and *E*, which did not include premaxillary clefts, moved laterally equally as well as the cleft left buccal segments. Also both buccal segments of patients *B* and *C*, demonstrating bilateral premaxillary clefts, moved laterally but in unequal amounts. Thus no evidence was present to correlate the location of a cleft with the relative amount of lateral movement that could be achieved. These findings further emphasize the unpredictable nature of the response of the maxillae of cleft lip and palate patients to rapid mechanical expansion procedures.

None of the patients reported any pain during the course of treatment even when questioned directly on this point. All of the patients did state that a sensation of pressure was felt on the banded teeth, the adjacent alveolar process and in the palatal vault following activation of the appliance. In every case, however, the pressure sensation diminished rapidly and was gone before the patient left the clinic.

It was also significant to note several facts regarding the use of metallic implants in this study. In no instance was any difficulty encountered in obtaining parental permission and all of the implants except the one that sloughed have been left in place in order to longitudinally follow the retention of these cases. No difficulty was associated in their placement and the four implants that were judged to have not been well accepted have not been sloughed. Occasionally, however, a small positional change was noted in the anteroposterior cephalograms around some of the implants in the lingual alveolar process. Since these implants were located close to the path of any root movement associated with lateral tipping, the possibility exists that this could affect their position. On the other hand, these changes could also be associated with the difference in vertical position between implants and the vertical error present in the superimpositioning of anteroposterior cephalograms. Nevertheless, the accuracy of the measurements obtained in this study permitted a precise evaluation of maxillary changes produced. It would appear that this or similar techniques would be of significant value in growth studies in general and in the analysis of treatment procedures in particular.

Summary

1. Five male patients demonstrating surgically repaired complete clefts of the premaxilla and secondary palate were treated using a rapid mechanical expansion screw appliance. Changes in the facial skeleton were recorded using metallic implants.

2. Expansion of basal and alveolar maxillary bone was clearly demonstrated in four 12 year-old patients. The expansion was not always symmetrical, however, and no correlation between the amount of expansion and the cleft quadrant was apparent.

3. No lateral maxillary expansion occurred in the 22 year-old patient. Evidence was presented that the crossbite was corrected through extrusion and tipping of the buccal teeth.

4. Lesser movements of the buccal segments in both an anterior and superior direction were observed in all of the cases. Only slight changes in the configuration of the nasal cavities were demonstrable.

5. Evidence was presented that the resistance of the facial skeleton is at least as important a factor as the midpalatal suture in rapid mechanical expansion procedures.

6. The need for information regarding the forces produced by rapid mechanical expansion procedures and the response of the facial skeleton to these forces was emphasized.

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