Original Article

Arch width Changes with a Rapid Maxillary Expansion Appliance Anchored to the Primary Teeth

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ABSTRACT

Objective: To examine the dimensional changes after rapid maxillary expansion (RME) carried out in the transitional dentition with the primary teeth as anchorage.

Materials and Methods: Group A was composed of 31 consecutive transitional dentition patients with posterior quadrant crossbites treated with a Haas-type RME appliance anchored on the maxillary primary molars and canines. No treatment was administered after palatal expansion. Study models were made before RME (T1), at appliance removal (T2), and at least 1 year after appliance removal (T3). A control sample of 60 individuals with posterior quadrant crossbites who had had no orthodontic treatment was categorized into group B (30 individuals with an average age comparable with the treated patients at T2) and group C (30 individuals with an average age comparable with the treated patients at T3).

Results: Permanent molar crossbites were corrected at T2, and this correction was maintained at T3 in all patients. The mean permanent maxillary intermolar width was 42.6 $\pm$ 2.3 mm at T1, 46.7 $\pm$ 1.9 mm at T2 ($P < .01$), and 46.3 $\pm$ 1.8 mm at T3 ($P < .01$) in group A; 42.9 $\pm$ 2.7 mm ($P < .01$) in group B; and 44.4 $\pm$ 3.0 ($P < .01$) in group C. Premolar and canine widths were slightly wider than the control at T3.

Conclusion: To avoid undesirable treatment-induced effects on maxillary permanent molars, a stable transverse correction could be achieved with the RME appliance anchored on the primary teeth.

KEY WORDS: Rapid maxillary expansion; Transitional dentition; Haas expander; Primary teeth anchored; Crossbite; Arch changes

INTRODUCTION

Posterior quadrant crossbites are often associated with a narrow maxilla[1] and usually do not self-correct.[2,3] In addition, a functional mandibular shift can be present.[4,5] Several authors suggest an early treatment of crossbites to prevent mandibular dysfunction as well as craniofacial asymmetry.[6–8] Many appliances have been described to resolve these conditions, and the rapid maxillary expansion (RME) appliance is one of the most efficient.[9] Usually it is anchored to the first premolars and permanent molars, and the expansion causes a buccal tipping of these teeth[9–12] that partially relapses during the postretention phase.[10,13] Anchoring teeth may exhibit exostosis,[14] pulp stones,[14] and root resorption.[14–16] Clinical evidence of periodontal damage to the anchoring teeth has also been reported, with an occurrence of gingival recession three times higher than in controls.[17]

To avoid these undesirable effects on permanent teeth, palatal expansion in the transitional dentition can be achieved by using primary teeth to anchor the appliance.[18] The objective of this study was to evaluate the resulting crossbite correction and its long-term stability and to examine the dimensional changes of the maxillary and mandibular dental arches after RME is carried out in the transitional dentition in patients with posterior crossbites with the primary canines and primary second molars as anchor teeth.

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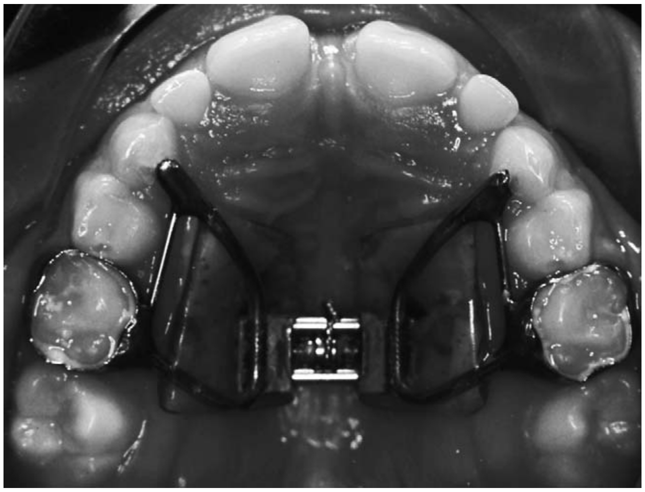

Figure 1. Haas-type rapid maxillary expansion appliance modified to be anchored on the maxillary primary molars and canines.

MATERIALS AND METHODS

Group A was composed of 31 consecutive transitional dentition patients (20 girls and 11 boys) demonstrating a unilateral or bilateral posterior quadrant crossbite. Group A was treated with a Haas-type RME appliance[9] modified to be anchored on the maxillary primary molars and canines (Figure 1). The average patient age at the beginning of expansion was 7 years + 3 months (SD 12 months). After RME, no other orthodontic treatment was performed. Study models were obtained at three observation periods: before RME (T1) at 7.6 years (SD 12 months) (Figure 2), at appliance removal (T2) 1.1 years later (SD 4 months) (Figure 3), and at least 1 year after appliance removal (T3) at a mean of 2.4 years later (SD 1 year 7 months) (Figure 4). All patients' parents were informed that the proposed treatment was aimed to preserve permanent molars and was not a customary treatment. All parents accepted and signed a consent form.

The control sample consisted of 60 individuals seeking orthodontic treatment with unilateral or bilateral posterior quadrant crossbites who had received no orthodontic treatment. The control sample was categorized into two groups. Group B contained 30 individuals (13 girls and 17 boys) with an average age (8 years) comparable with the treated patients (T2) (mean age 8 years + 4 months) at the removal of the appliance. Group C contained 30 individuals (13 girls and 17 boys) comparable with the treated patients at the time of the posttreatment control (T3) (mean age 10 years + 8 months). Furthermore, in the experimental group, it was not possible to carry out all the measurements because of the absence of some teeth (exfoliation of primary teeth and unerupted permanent teeth). With every match, the sample with the most measurements was randomly reduced so that it was comparable with the sample with fewer measurements.

In Group A all patients were fitted with expansion screws (Dentaurum, Ispringen, Germany and Forestadent, Pforzheim, Germany). The posterior arms of the screws were soldered to bands cemented on the second primary molars, and the anterior arms of the

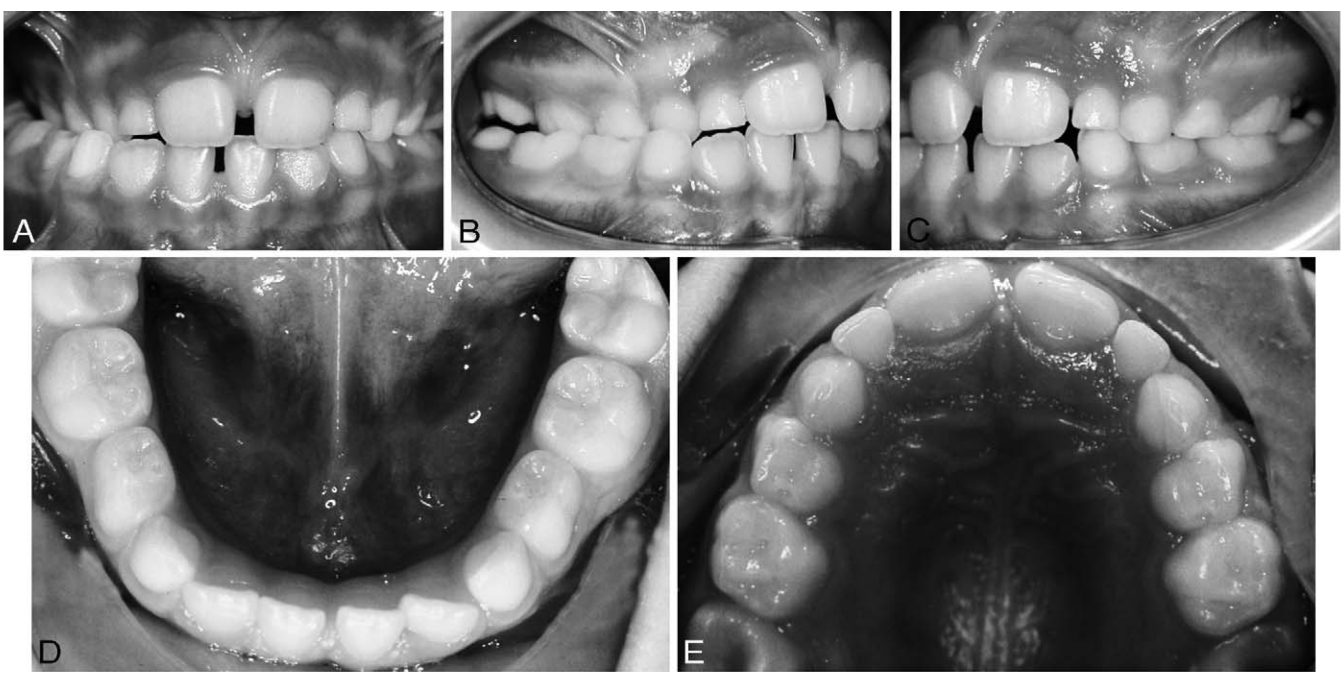

Figure 2A–E. Intraoral pictures before rapid maxillary expansion.

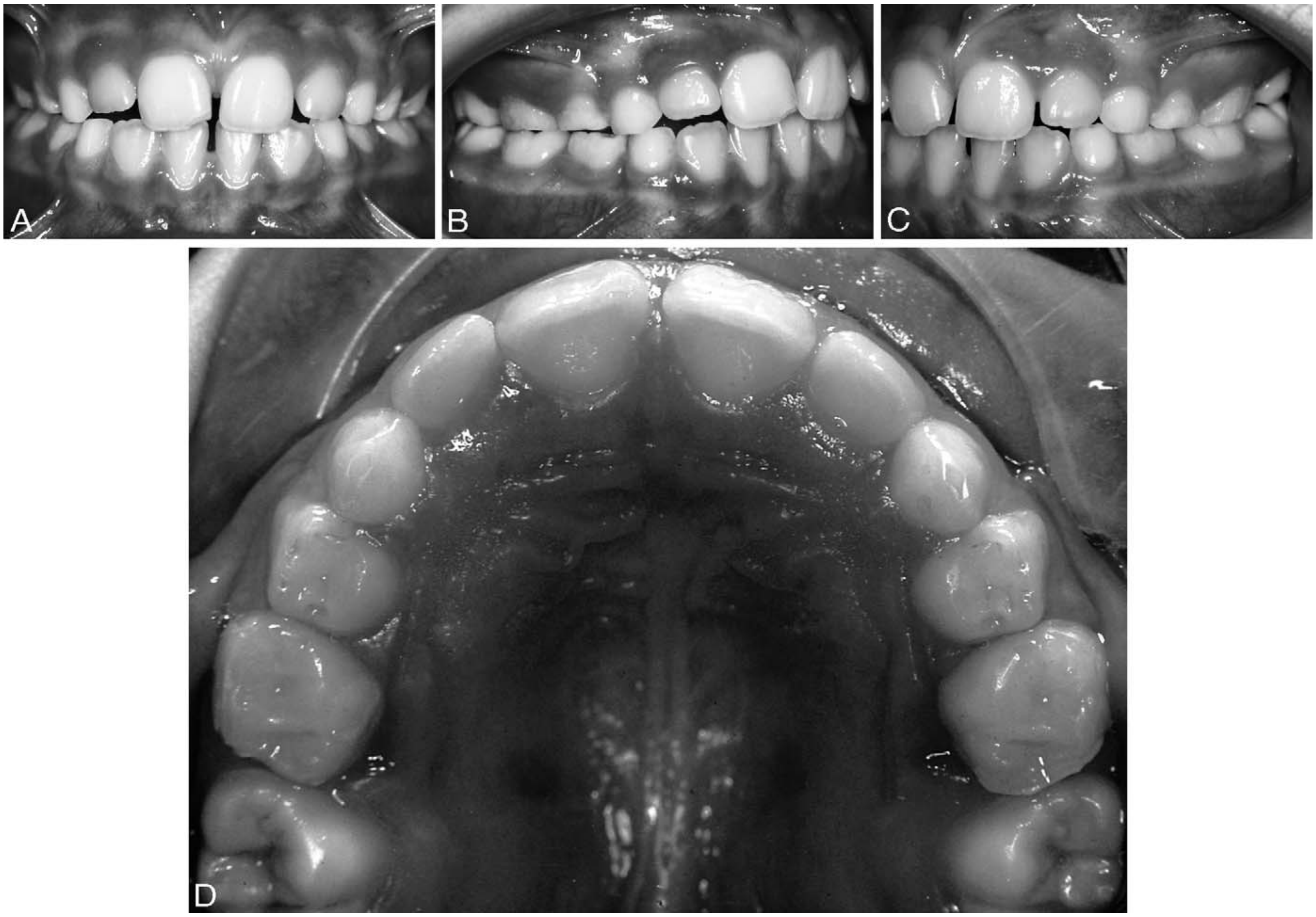

Figure 3A–D. Intraoral view after appliance removal.

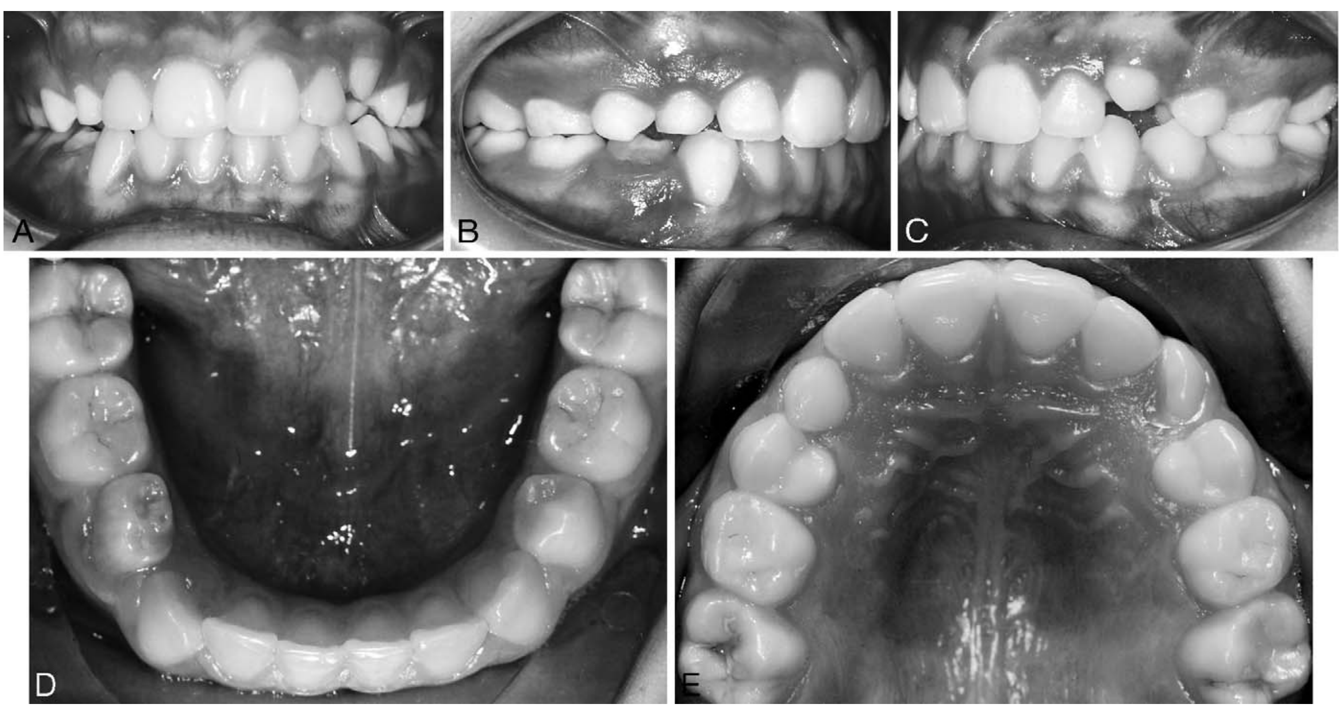

Figure 4A–E. Intraoral view at T3.

Table 1. Mean, Standard Deviation (SD), and Statistical Significance of Maxillary and Mandibular Permanent Molars, Primary or Permanent Cuspids, Primary Second Molars, or Second Premolars Distances (mm) of Test Group A at T1, T2, and T3*

	T1		T2		T3		*P* Value		
	Mean	SD	Mean	SD	Mean	SD	T1/T2	T1/T3	T2/T3
Maxillary arch width									
Permanent first molar	42.6	2.3	46.7	1.9	46.3	1.8	≤.01	≤.01	NS
Primary second molar	37.5	2.2	43.5	2.1	40.9	1.9	≤.01	≤.01	≤.01
Intercuspid	28.9	2.1	34.8	2.2	32.9	1.9	≤.01	≤.01	≤.01
Mandibular arch width									
Permanent first molar	41.6	2.7	41.8	2.4	41.7	2.4	NS	NS	NS
Primary second molar	35.8	2.6	36.5	2.8	35.9	2.7	≤.01	NS	≤.05
Intercuspid	24.6	2.5	25.5	2.1	25.5	2.3	≤.01	≤.01	NS

* NS indicates nonsignificant.

screw were bonded to the canines. The resin on the palate extended to the primary second molars with no contact with the first permanent molar.

Activation Schedule

Patients were told to activate the appliance once or twice a day. Each activation was equal to 0.25 mm. The expansion was carried out until the transverse relationship of the first permanent molars was correct. The primary teeth were usually overexpanded. After a mean appliance activation time period of 20 days and a mean activation of 6.8 mm, the appliance was stabilized and kept in place as retention for at least 8 months (average 1 year 1 month). No direct force or any retention was applied to the permanent teeth.

The following measurements were performed:

a. Intercanine width: distance between the cusp tips of primary or permanent maxillary and mandibular canines, depending on the developmental stage.
b. Primary intermolar width or interpremolar width: the distance between the center of the fossa of the maxillary and mandibular second primary molars or of the maxillary and mandibular second premolars.
c. Intermolar width: the distance between the center of the fossa of maxillary and mandibular first permanent molars.

The same measurements were also made on the dental casts of control groups B and C.

Error of Measurement

All the measurements were made with the same precision caliper (Digi-Met, Preisser, Gammertingen, Germany) by the same operator. On 10 randomly selected dental casts, a double measurement was made. The mean error was less than 0.2 mm and was not statistically significant. SD was calculated by the Dahlberg formula.

Statistical Analysis

The *t*-test for paired data was applied to evaluate the treated group (measurements carried out on the same patients at various time intervals), and the *t*-test for independent data was applied to compare the treated group with the control group (measurements of two different samples). With the paired-data *t*-test, it is necessary that the number of measurements at T1 is equal to the number of measurements at T2; for this reason, those in excess were reduced in a randomized manner.

RESULTS

Maxillary Arch

First permanent molars. Molar crossbites were corrected at T2, and this correction was maintained at T3 in all patients. In group A, the average intermolar width at T1 was 42.6 ± 2.3 mm. It increased significantly to 46.7 ± 1.9 mm ($P < .01$) at T2 and decreased a nonsignificant 0.4 mm to 46.3 ± 1.8 mm from T2 to T3 (Table 1). The net increase was 3.7 mm.

In control group B, matched by age to the treated patients at T2 whose intermolar width was 46.8 mm, the intermolar width was 42.9 ± 2.7 mm (Table 2). The difference was 3.9 mm ($P < .01$).

In control group C, matched to the treated patients at T3 whose intermolar width was 46.3 mm, the intermolar width was 44.4 ± 3.0 mm (Table 3). The difference was 1.9 mm ($P < .01$).

Primary and permanent canines. The mean intercanine width in group A at T1 was 28.9 ± 2.1 mm. It increased significantly to 34.8 ± 2.2 mm ($P < .01$) at T2 and decreased significantly to 32.9 ± 1.9 mm at T3 ($P < .01$). The net increase was 4.0 mm ($P < .01$) (Table 1).

In control group B, the intercanine width was 29.8 ± 2.6 mm compared with the 34.7 ± 2.1 mm inter-

Table 2. Mean, Standard Deviation (SD), and Statistical Significance of Maxillary and Mandibular Permanent Molars, Primary or Permanent Cuspids, Primary Second Molars, or Second Premolars Distances (mm) of Test Group A at T2 and Control Group B*

T2	Test Group A		Control Group B		A/B
	Mean	SD	Mean	SD	
Maxillary arch width					
Permanent first molar	46.8	1.9	42.9	2.7	≤.01
Primary second molar	43.6	2.1	37.4	2.4	≤.01
Intercuspid	34.7	2.1	29.8	2.6	≤.01
Mandibular arch width					
Permanent first molar	41.9	2.4	42.4	2.2	NS
Primary second molar	36.5	2.7	36.3	2.4	NS
Intercuspid	25.4	2.3	25.8	1.8	NS

* NS indicates nonsignificant.

Table 3. Mean, Standard Deviation (SD), and Statistical Significance of Maxillary and Mandibular Permanent Molars, Primary or Permanent Cuspids, Primary Second Molars, or Second Premolars Distances (mm) of Test Group A at T3 and Control Group C

T3	Test Group A		Control Group C		*P* Value A/C
	Mean	SD	Mean	SD	
Maxillary arch width					
Permanent first molar	46.3	1.8	44.4	3.0	≤.01
Primary second molar	40.9	1.9	38.3	2.7	≤.01
Intercuspid	32.9	1.9	31.5	2.2	≤.05
Mandibular arch width					
Permanent first molar	41.6	2.3	43	2.2	≤.05
Primary second molar	35.9	2.8	37.3	1.7	≤.05
Intercuspid	25.3	2.4	26.8	1.7	≤.05

canine width of the treated patients at T2 (Table 2). This difference was 4.9 mm ($P < .01$).

In control group C, the intercanine width was 31.5 ± 2.2 mm compared with the 32.9 ± 1.9 mm intercanine width of the treated patients at T3 (Table 3). This difference was 1.4 mm ($P < .05$).

Primary second molars and second premolars. The mean intermolar width between the primary second molars in group A at T1 was 37.5 ± 2.2 mm, which increased significantly to 43.5 ± 2.1 mm at T2 ($P < .01$) and decreased significantly to 40.9 ± 1.9 mm at T3 ($P < .01$) (Table 1). The net increase was 3.4 mm ($P < .01$).

In group B, the primary intermolar width was 37.4 ± 2.4 mm (Table 2), compared with 43.6 ± 2.1 mm in the treated patients at T2. In group C, it was 38.3 ± 2.7 mm, compared with 40.9 ± 1.9 mm in the treated patients at T3 (Table 3). The differences between these widths at T2 (6.2 mm) and T3 (2.6 mm) between group A and control groups B and C were statistically significant ($P < .01$).

Mandibular Arch

There was no statistically significant treatment-induced or longitudinal changes in the intermolar width in group A. However, the intercanine and inter–second premolar (inter–primary second molar) widths had statistically significant increases at T2, and the intercanine width had a significant increase at T3 also ($P < .01$) (Tables 1 through 3). In the treated patients, all changes were less than 1 mm. When comparing the treated group with the appropriate control, most differences were also less than 1 mm and statistically not significant at T2. Instead, at T3 the intermolar, intercanine, and primary intermolar widths of group A were lower with respect to group C ($P < .05$).

DISCUSSION

Effects on Maxillary Permanent Molars

An important finding of this investigation is that maxillary molar crossbites were corrected in the transitional dentition (this correction remained stable at T3) by RME with the expansion appliance anchored to the primary second molars and canines. No forces were placed on the permanent molars, and the increase in intermolar width was stable, at least for an average of 2 years 4 months after expansion. Only 10% of the increase achieved with the expansion was lost between T2 and T3, and this reduction was not statistically significant.

This behavior confirms the results obtained in previous studies[18] and can be explained by the fact that the expansion is due to the orthopedic movement of the basal bones because no direct force was applied to these teeth. This enables one to understand why these teeth do not have any buccal tipping.[18] Because the expansion was stopped when the first permanent molars were in correct transverse occlusion, their stability can be explained by the "funnel theory" of Van der Linden[19]: in crossbite cases, the molars that have achieved a normal occlusion after the expansion are maintained stable by this occlusion. When the expansion appliance is attached to the first permanent molars, there is a buccal tipping of these teeth[9–12] that partially relapses in the postretention phase.[10,13] The primary teeth seem to exhibit the same behavior when an RME appliance is anchored on them because there is a statistically significant relapse of these teeth after the removal of the appliance.[20]

Advantages of the Use of the Primary Teeth to Anchor the RME Appliance

The use of the primary teeth to anchor the expansion appliance is beneficial because it avoids the undesirable effects that have been described for permanent teeth used as anchorage. Among these, root resorption and periodontal damage are particularly relevant. Resorption of the buccal surfaces of the roots of anchor teeth has been noted by numerous authors[14–16] and is still active after 9 months of retention.[15] It has also been shown that when only one premolar on a side was connected to the expansion appliance, the nonconnected premolar did not exhibit any signs of root resorption.[15] This presumably would occur with the permanent first molars of the treated patients in this study because there was no contact with the appliance.

It has also been noted that the occurrence of gingival recession after rapid expansion is proportionate to the tipping of the anchor teeth and, over the long-term, is three times higher than in the controls.[17] The permanent teeth of the treated group in this study were not subjected to any buccal tipping. Accordingly, one can presume that there is no increased risk of gingival recession in these patients.

In group A, no early exfoliation of the primary teeth used as anchors was noted, and a normal occlusal relationship was established even in the cases in which a complete buccal crossbite occurred because of the postretention phase relapse.

Appliance

A fixed Haas-type RME appliance was preferred according to the rationale that a removable RME appliance is possibly less effective because it requires cooperation from the patient.[3] Rather than a Quad-helix, a Haas-type RME appliance was preferred because of the better skeletal results and lesser dental relapse in the postretention phase.[21] Also, this type of expander was preferred to the two-point type because it allows a bigger increase in the arch perimeter and a larger separation of the suture at the anterior level.[22] The appliance with full occlusal coverage[23] was judged to be too difficult for patients to maintain adequate oral hygiene. The Haas-type RME appliance was chosen over the Hyrax because it can more efficiently counteract the centripetal forces present during the retention phase,[13] maintaining basal expansion.[24]

Effects on the Maxillary Primary Teeth

The primary teeth to which the expansion appliance is anchored are expanded as much as the activation of the screw, and, at times, a complete buccal crossbite was created. Presumably because of their buccal tipping, they later partially relapsed until they established correct transverse occlusal relationships.

Although the relapse involved both the primary canines and second molars, the final primary intercanine and intermolar width in the treated group was larger than the width of the matched control sample. This is an expected finding because the crossbites in the control group were not corrected, and this suggests that the crossbites reflect a constricted maxillary arch.

Effects on Mandibular Arch

In the experimental group's mandibular arch, there was a statistically significant increase of the intercanine and primary intermolar width at T2. At T3, the only statistically significant increase remained the intercanine width. No variation of the permanent intermolar width was found at either T2 or T3. No significant change was found in some previous reports of other maxillary expansion investigations in which mandibular arch dimensional changes were recorded in the postexpansion period before further treatment was performed in the mandibular arch.[25,26]

In other previous studies[27,28] in which an increase in mandibular arch intercanine and intermolar width was observed after RME, fixed and removable orthodontic appliances were used in the mandibular arch. In the present study the patients were not subjected to any other treatment of either of the arches. The increase in the intercanine width at T2 and T3 found in the experimental group could be explained because several of the patients in this group had erupting lateral incisors, and during this phase one had a spontaneous transverse increase in the intercanine width.[29]

All the width measurements in the mandibular arch at T3 were significantly less compared with those in the corresponding control group ($P < .05$). The stability of a crossbite could therefore keep the mandibular arch more expanded.

Timing

Our view is that an appropriate time to treat patients with posterior quadrant crossbite by RME is after the eruption of the permanent first molars before occlusal contact of these teeth is made as long as there is no associated functional mandibular shift. Treatment could be also initiated after the permanent molar crossbite development because the crossbite at the level of the permanent molars can be corrected with no appliance on these teeth. In addition, when the correct occlusion is achieved, the result is stable. This may be because the correct occlusal relationships act to stabilize the result. An additional benefit is that incisor alignment appears to improve, possibly because palatal expansion increases arch perimeter.[12]

When a functional mandibular shift is present, earlier treatment (often involving occlusal equilibration) in the primary dentition is indicated to avoid possible development of an asymmetric mandible.[4,5] Otherwise, treatment in the primary dentition might not be necessary because the permanent first molars can erupt in correct transverse relationship even though a crossbite exists in the primary dentition.[3] Also, treatment carried out in the primary dentition does not ensure that the permanent first molar relationship will be correct, for in a reduced percentage of cases the permanent first molars erupt in crossbite.[30]

CONCLUSIONS

a. In cases with crossbite of the maxillary permanent molars, the transverse correction could be achieved by RME with the primary teeth as anchor teeth.
b. The expansion of the permanent molars, on average, was stable at 2 years 4 months after treatment, and, presumably, there were no treatment-induced undesirable effects.
c. Primary teeth, overexpanded because of their use as anchor teeth for RME, underwent transverse relapse after the removal of the appliance.

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